Learning Science: Concepts and Contexts

The first chapter of this thesis presented the background of concerns in science education in general and in Indian school education in particular in which it located the research problem. The study aims at evolving a situated understanding of learning science in general and in learning the concept of matter in particular, with a special interest in the curricular problematic of the everyday world vs. the world of school. Three groups of research questions were identified and delineated. The first group related to the conceptual categories of ‘context’, ‘school and everyday worlds’ as cognitive and curricular concerns. The second group was to do with the curriculum and pedagogy of science education that children experience. The final group was to do with children’s understanding and conceptions of matter.

This chapter is directed at clarifying conceptions and constructs, and locating the study in related literature. Given the interest of this investigation in ‘situating’ learning of science, the study has multiple objects of interests to be investigated and understood. Children’s home and everyday contexts, the curriculum and textbook for studying science, the classroom processes and children’s conceptions. The axes of contexts and concepts cut across these objects of foci of study.

The purpose of this chapter is to provide a basic unifying framework and develop two key concerns that are the important focus of this study. The first is the cognitive/constructivist framework developed in a manner that enables us to engage with children’s learning of scientific concepts and contexts of learning. This is elaborated to perspectives and issues in science education in the second section of the chapter. A few significant studies that have taken place in the Indian context are reviewed. The third part of the chapter examines and reviews the constitutions of and dimensions of the issue of everyday vs. school as it has been constituted and addressed in Indian education, historically, in the space of action (science curriculum and people’s science movements) and in policy. After presenting key ideas of these frameworks, the fourth and final section of the chapter presents an approach that informs this study and the consequent sharpening of research questions.
2.1 Constructivism in Learning Theory and in Science Education

Constructivism in learning theory/cognitive development is not identifiable with a unique paradigm, but we may understand it as grounded on the proposition that children are meaning makers and construct their understanding of the world through interaction with it. The child is an active constructor of knowledge based on his/her prior knowledge. Hence teaching and learning in school should start from the child’s prior’s understanding and knowledge. Children’s learning is also influenced by socio-cultural factors, home environment and the educational environment like school ethos, curricular experiences, and class room interactions. These ideas represented a major point of departure from behaviorist approaches to the study of learning, which treated the mind as a black-box and theorized learning based on input-output, stimulus-response. Constructivism ushered in what is recognized as the ‘cognitive revolution’ in the study of child development and learning. Developments in the field and the current major threads of discussion can be traced back to the influence of Piaget and Vygotsky. A brief sketch of each which follows provides the basic contours of constructivism and the approach to cognition that informs this study.

The work of Piaget and Vygotsky contribute to the foundation for constructivism, that is, a theory of knowledge and learning. Although a distinction between cognitive and social constructivist perspectives is made, this study takes the approach that emphasizes their complementarity. “Each of the two perspectives, the socio-cultural and the constructivist, tells half of a good story, and each can be used to complement the other. ……Learning is both a process of self-organization [cognitive] and a process of enculturation [social] that occurs while participating in cultural practices, frequently while interacting with others” (Cobb, 1994).

2.1.1 Piaget’s Theory of Learning

Piaget established the central premise of constructivism that acquisition of knowledge is a process of continuous self construction. Children’s cognitive abilities develop in a series of age related stages and children think in qualitatively different ways from adults; also new ideas and ways of thinking emerge from and are based on the existing knowledge. The child’s construction of knowledge takes place through an interaction between mind and environment.
Piaget was interested in the theoretical and experimental investigation of
the qualitative development of intellectual structures in human mind and his
research was directed at elaborating upon a theory of knowledge about cognitive
development in children (Elkind, 1976; Flavell, 1985; Boden, 1994; Solso,
2001;). He called his theory ‘genetic epistemology’ and posited that the growth
of knowledge is a progressive construction of logically embedded structures
superseding one another by a process of inclusion of lower, less powerful logical
means into higher and more powerful ones, up to adulthood. Therefore children’s
logic and modes of thinking are different from those of adults. Intelligence,
understood as adaptive thinking and action, develops in a series of age related
stages. Although there is a considerable variability among individual children
as to when these stages appear, the sequence is a necessary one. Each succeeding
stage grows out of and builds upon the capabilities of the previous one. At
each level of development the child is again confronted with the task of
reconstructing reality out of his/her construction based on experience with the
world he/she put together during the previous stage. The child must not only
construct new knowledge, including concepts, but also either discard previous
concepts or integrate them with the new ones. Thus constructing reality never
starts from scratch and always involves dealing with old ideas as well as
acquiring new ones.

Piaget accounted for the development of concept (knowledge) through
the process of equilibration, assimilation and accommodation, according to
which intuitive knowledge is abstracted into, or is replaced by, canonical
knowledge. Assimilation is the means by which child interpret incoming
experience to make it understandable within their existing mental structures.
Accommodation refers to the ways in which children’s current means for
understanding the world change in response to the new experience.
Equilibration is a three stage process that includes assimilation and
accommodation. First children are in a state of equilibrium. Then the failure
to assimilate new knowledge leads them to become aware of the short comings
of their current understandings. Finally their mental structures accommodate
to the new information in a way that creates more advanced equilibrium.
Learner constructs knowledge depending on prior knowledge after resolution
of cognitive conflict on accommodation leading to new knowledge. Conflict
drives accommodation; when new information is perceived to conflict with
the existing knowledge, the latter may be modified to accommodate.
Piaget’s theory viewed a child acting on the world as one of the important aspects of knowledge creation. Children’s interaction with their environment is based on action-schemes—which develop, elaborate and alter, in the course of action and responses from the environment. These schemes and schemas, which are akin to mental maps/representations, i.e. cognitive structures, grow in complexity as the child has more and varied experiences. Furthermore, more varied and complicated ways of interacting with the environment develop, and then accommodate their structures based on the results of those actions. In this way, the child’s knowledge of its environment, and of itself, progresses over time. Eventually the child changes cognitive structures to accommodate, and account for the new experience, and moves back into equilibrium. Piaget's theory suggests that knowledge therefore is not ‘unitary’ and of only one ‘flavor’. Rather it could vary from one epistemic agent to another, according to the individual’s life experiences and stage of development.

2.1.2 Piaget’s Theory of Concept Formation in Children

The foundation for research in the area of scientific concept formation in children can be traced back to the work of Piaget (Seigler, 1998; Case, 1999). Piaget conducted a number of studies among children that were designed to reveal the details of children’s conceptual understanding and the processes by which this understanding is arrived at (Piaget, 1964; 1967; Piaget & Inhelder, 1971; Gruber & Von he, 1977). As a result of numerous investigations of children’s conceptions of space, time, number, quantity, speed, causality, conservation, object permanence etc., Piaget arrived at a general conception of concept development. According to Piaget, children are able to understand certain concepts only at certain ages and these concepts can be organized into a developmental sequence that defines discrete stages of cognitive development. Further, children’s concepts are fundamentally different from those of adults. He considered concepts from two perspectives that focus on form and content—either as logical structures or as components of a larger knowledge system (Seigler, 1998; Case 1999). As part of the larger knowledge systems concepts reflect children’s knowledge and understanding of the world. Piaget hypothesized that the form of children’s conceptual structure is different at different stages of development. Also according to Piaget conceptual development takes place in the framework of a cognitive schema i.e. concepts are assimilated into a cognitive schema and are dependent upon child acting on the world (Flavell, 1985; Boden, 1994). Children acquire their conceptual knowledge through active exploration of the world and their
initial conceptual knowledge is formed from what they see. It is acquired through the process of assimilation, accommodation and equilibration. Children construct conceptual knowledge depending on prior knowledge after resolution of cognitive conflict created in the course of assimilation and leading to accommodation and the formation of concepts. Furthermore this occurs in the advanced stages of cognitive development which are characterized by abstract, and meta cognitive reflection. While the construction of some concepts may be akin to ‘discovery’ in the case of others it is more akin to ‘invention’.

Piaget pioneered the ‘clinical interview’ method designed to explore how children’s thinking and conceptual understanding develops over time—how knowledge develops, how it changes and what laws govern these changes (Ginsburg, 1997; Posner & Gertzog, 1992). The method involved presenting a task/problem/activity to children in order to see how they work with concrete objects at hand and then interview them to determine the reasoning on which the responses were based and explore the pattern of conceptual knowledge. Final step was to look for a common pattern in children’s reasoning at different ages and treat this pattern as a clue regarding the underlying logical structure that was present.

Piagetian research continues to be a major theoretical influence on researching children and the Piagetian methods of data gathering and analysis has been useful for many decades (Confrey, 1990; Lynn & Eylon, 1998). His stage theory, his idea of the interplay of assimilation accommodation have influenced research on investigating student’s science conceptions. The clinical interview method is extensively employed in the study of children’s scientific concepts. There is a vast body of literature that falls within the constructivist paradigm, examining Piaget’s construct of concrete and formal thinking (Ausubel, 1969; Carey, 1985; Smith, 1986; Novak & Wandersee, 1988) . Education programmes in the 1970s and 80s attempted to design curricula and instructional materials to support students movement through the stages, from concrete to formal thinking in science (Driver & Oldham, 1985; Duit & Treagust, 1998). His view of knowledge acquisition as the equilibration process also influenced conceptual change studies in science education.

Inherent in Piaget’s approach is the assumption regarding the general course of development of intellectual structures hence his theory indicates conceptual structures as the same for all children regardless of where or how they live, and what is valued within their communities. Also Piagetian theories is rooted in a
framework in which conceptual understanding is regarded as deriving largely from interiorized actions; the crucial role of language and the role of social is not integrated into the theoretical framework. At best the ‘social’ is invoked in the idea of ‘cognitive conflict’ (Inhelder and Sinclair, 1979) and Piagetian education programmes emphasis the importance of peer interaction which bring forth alternative and potentially opposing points of view which can stimulate the need for accommodation. However, the larger category of interaction with the environment for purposful meaning making as the key driver of cognition itself is an important way of thinking about the centrality of ‘context’ in education.

2.1.3 Vygotsky’s Theory of Learning

The theoretical tradition in which children’s cognitive abilities has been studied from a socio-cognitive perspective originated with the work of Vygotsky (Daniels, 2001). This informs the basic notions of ‘social constructivism’ that emphasizes the social nature of learning. The main proposal of Vygotsky’s theory is that social interaction is an essential aspect in the process of cognitive development and it is impossible to separate learning from its social context (Vygotsky, 1978). All cognitive functions originate in and must therefore be explained as products of social interactions. Central to Vygotsky’s theory is the idea that children’s participation in socio-cultural activities with the guidance of more skilled partners allows children to internalize the tools for thinking and for taking more mature approaches to problem solving.

Vygotsky was interested in the origins of what he termed as higher mental functions: thinking, reasoning and understanding (Vygotsky, 1978; Vygotsky, 1987). Vygotsky viewed the development of these higher mental functions in humans as fundamentally social rather than individual process. Every function in the child’s cognitive development appears twice: first, on the social plane and, later on, on the individual plane. That is to say, first, between people in interpsychological processes, and then inside the child, as an intrapsychological process. This applies equally to voluntary attention, to logical memory, and to the formation of concepts.

Vygotsky distinguished between two developmental levels: the level of actual development and the level of potential development (Chaikilin, 2003). The level of actual development is the level of development that the learner has already reached, and is the level at which the learner is capable of solving problems
independently. The level of potential development signifies the level the learner is able to reach in collaboration and in the company of more capable peers or a teacher. In between is the “zone of proximal development” which signifies the potential of the individual for collaborative and guided teaching-learning. This is based on the realization that the range of cognitive capability that can attained with adult guidance or peer collaboration exceeds what can be attained alone. It recognizes the fact that other people play important roles in helping children to learn, providing objects and ideas to their attention, talking while playing and directing cognition while playing, reading stories, asking questions.

Vygotsky emphasized the role of language and culture in cognitive development (Vygotsky, 1978, 1987). Language and culture play significant roles both in human intellectual development and in how humans perceive the worlds—these are the two frameworks through which human experience, communicate and understand reality. Linguistic abilities enable one make sense of the perceptual world by defining them and ascribing meaning to them. The conceptual schemas are transmitted and shared by means of language. Thus human cognitive structures are essentially socially constructed which implies that knowledge is not simply constructed but it is co-constructed. One link between the learning of science and the use of language is the development of specialized vocabulary for representing concepts and describing processes.

According to Vygotsky (1978) “school learning introduces something fundamentally new into the child’s development” (p. 85). School learning encourages intellectual processes. The teacher, as well as, peers guide and provide assistance that helps students to learn by extending and challenging the learner’s initial conception through refocusing and redirection to new ideas.

Education research has adopted two main perspectives from the Vygotskian theory (Daniels, 2001). The first takes from his attempts to characterize the interpersonal interactions that take place in learning settings and involves the conception of ‘zone of proximal development’ and ‘scaffolding’. The second draws from his attempt to develop a cultural psychology in which learning is seen to depend upon mediation by social, cultural and institutional process at many levels. In a wide range of ways, adults mediate the world for children and make it possible for them to get access to it. The ability to learn through instruction and mediation is characteristic of human intelligence. With the help of adults children can do and understand more than they can on their own.
2.1.4 Vygotsky’s Theory of Development of Scientific Concepts

Vygotsky’s theory on development of scientific concept is an attempt to give explanation about the development of what he called the higher mental functions and, in particular, decontextualized thinking (Vygotsky, 1987). The theory brought out the relationship between speech and thinking, between instruction and development, between development of decontextualized knowledge, formal thinking and school instruction. Vygotsky separated children’s concepts into two categories that reflected the context in which they were formed: everyday (spontaneous) and scientific (non-spontaneous). Both differ in their manner of acquisition and in their defining characteristics (Wells, 1994; Palmer, 1999; Wellings, 2003).

Everyday concepts are acquired and appropriated spontaneously by the child through the social interaction that occurs in the course of engagement in jointly undertaken activities in child’s immediate environment/in the course of naturally occurring activities in the home and community. These are formed through the interactions with the real world, related to the world of experience, and based on the experiences encountered by the child outside formal school settings formed through independent thinking. They are perceptually bound, based on the physical appearance and characteristic of the phenomena encountered in everyday experience, centering on the phenomena being represented and not on the act of thought.

Scientific concepts are developed as a result of deliberate and systematic instruction in an educational setting (Wells, 1994). They are learned in school and learned as part of a system of relationship. They can only be mastered with the aid of instruction, that is both systematic and teacher-directed. They are formed through the functional use of the word, or any other signs as a means of focusing on one’s attention, selecting distinctive features, analyzing and synthesizing them. They are not directly tied to the phenomenon or object, and are defined in a generalized fashion, and are abstract. They are systematic, hierarchical knowledge as opposed to the non-systematic, unorganized and context bound knowledge gained from everyday experience. The main features of scientific concepts are its generality, systematic organization, conscious awareness and voluntary control.

Conceptual change is an ongoing process in which the child in collaboration with a teacher or other students integrates everyday concepts into a system of related concepts and transforms the raw material of experience into a coherent
According to Vygotsky (1987), concept formation in science involves the specific use of words as functional tools to solve problems, create products or complete tasks. Neither scientific nor everyday concepts are taken in all at once in a completed form; both develop over time. Teaching scientific concepts in school is not an end but the beginning of the development of a concept. There is movement back and forth in the child’s mind between the spontaneous and non-spontaneous concepts until they come together in a system.

At the everyday level, concepts are learned as a result of interacting directly with the world – developing intuitive understandings of how to do things (Shepardson, 1999). These everyday concepts lay the foundations for learning scientific (or academic or schooled) concepts. Everyday concept formation and scientific concept formation are strongly connected to each other (Wells, 1994). However, everyday concepts cannot be easily transferred to other contexts. When children simply learn scientific or academic concepts at school away from the other context in which they are used, understanding of such scientific concepts may be limited to abstract thinking. That is, the everyday concepts grounded in the day-to-day life experiences of children and adults create the potential for the development of scientific concepts in the context of more formal school experiences. Similarly, scientific concepts prepare the structural formations necessary for the strengthening of everyday concepts. As children bring together their working everyday knowledge with their scientific knowledge, they transform their everyday practice.

2.1.5 Constructivism in Science Education

Constructivism in science education views children’s learning of science as a constructive process (Fensham, Gunstone & White, 1994). The central premise of the constructivist view on science learning is the idea that the conceptions held by each individual child influence his/her understanding of science and effective teaching of science needs to be rooted in an understanding children’s prior conceptions and also on the understanding of how student learn science (Driver, 1983; Tobin, 1993; Driver et al., 1994). Children come to a learning task with relevant knowledge, concepts, language, labels and explanations of why things behave the way they do (Roth & Roychoudhary, 1994; Gilbert, Osborne & Fensham, 1982; Gilbert, 2005). Thus science learning is not a mere transfer of knowledge but learner actively constructing, creating his or her knowledge on the basis of the already existing knowledge. Learning actively generates meaning.
from experience. Learning has to start from already existing conceptions and the learning process must lead a student from these preconceptions towards the science conceptions to be learned (Ausubel, 1968). In addition there are social aspects of construction process (Solomon, 1987). Children construct their own meaning of science; the process of meaning making is embedded in the social setting of which the individual is a part.

Various form of constructivism shaped research in the area of science education with some focusing on the individuals child’s learning and other focusing on social aspects of science learning (Mathews, 1998). Constructivist ideas in science education were developed by merging various cognitive approaches which were influenced by the Piagetian idea of interplay of assimilation and accommodation, Kuhnian ideas of theory change in the history of science (Kuhn, 1962), social constructivism outlined by Vygotsky and radical constructivism advocated by von Glaserfeld (1989), constructivist epistemologies, and educational constructivism (Mathews, 1998). All these approaches view knowledge as constructed by children in different ways. Constructivism’s perspectives on the role of the individual, on the importance of meaning making, and on the active role of the learner are the elements that influenced science educational researchers.

Constructivist theories in science education focus on the question as to how an individual learns (first in an individual child then in a group children) and find ways to facilitate that learning in the context of a science classroom i.e. it attempt to address the issue of translating theory of learning into a theory of practice of science teaching and learning in a classroom (Mintzes & Novak, 1998; Mintzes & Novak, 2000). Researchers have investigated students’ pre instructional conceptions in physics (Driver et al. 1994, Duit, 2004) (for example, electric circuit, force, energy) in chemistry (for example, chemical bonding, combustion, particulate nature of matter) and biology (for example, photosynthesis and respiration, genetics, evolution). These studies propose that children are not simply passive learners but make sense of new information in terms of their previous ideas and experiences. One outcome of such learning is that learners’ knowledge is not consistent with the accepted scientific view or scientists’ science. These conceptions are referred to as children’s science or misconceptions or alternative conceptions dependent on the author’s philosophical position (di Sessa & Sherin, 1998). Furthermore these views are often firmly held, are resistant to change and present difficult challenges for teachers of science and researchers of science education (Carey, 1985).
2.2 Learning Science

Learning science includes learning scientific ways of thinking and knowing. This involves the development of conceptual knowledge, procedural knowledge and scientific reasoning skills (Harlen & Elstgeest, 1993; Zimmerman, 2007). Conceptual knowledge is the understanding of the basic concepts, principles, and causal relationships of the domain of science. Procedural knowledge refers to the skills needed to carry out tasks and operations. Scientific reasoning broadly defined comprises of thinking skills involved in inquiry, experimentation, evidence evaluation, inference, argumentation etc.

Concept formation or the development of conceptual knowledge is an important aspect of science learning (White & Gunstone, 1992). Research in the area of children’s science learning comprises of concept specific and conceptual change studies, problem solving studies, novice expert studies and Piagetian stage research (Lynn & Eylon, 1988; Confrey, 1990). These studies identified learner’s prior knowledge as a central variable affecting subsequent learning (Driver, 1989a; Driver, 1989b). Children develop their own concepts about the world, explanations for scientific process and phenomena, meanings for word used in science and strategies to obtain explanations for how and why things behave as they do. These categories of children’s beliefs, theories, meanings and explanation constitute children’s conceptions (Driver, 1985; Driver & Bell, 1986; Garnett & Hacking, 1995).

Research on children’s conceptions comprises of three major theoretical traditions each of which has its own epistemological assumptions (Confrey, 1990). These are Piagetian studies in the tradition of genetic epistemology (Hawkins, 1979; Shymansky & Kyle, 1988), application of philosophy of science to the study of conceptual change (Carey, 1985; Vosinadu, 1994; Vosinadu, 2002; Nersessian, 2007), and the information processing approach (Fischer & Lipson, 1986; Fischer, Wandersee & Widemann, 2007). Piagetian studies focuses on the learner’s domain-specific concepts, and investigates how these concepts change through interaction with external and internal stimuli such as instruction, cognitive conflict, and meta-cognition. According to the science learning as conceptual change approach, learning is like inquiry and is best viewed as a process of conceptual change. The basic question addressed in this approach is how students’ conceptions change under the impact of new ideas and new evidence. The information processing approach focuses on the learner’s use and application of domain specific concepts to solve a problem, and the use of
scientific processes to acquire scientific knowledge. The approach emphasizes rule governed behavior and views conceptual change mainly in terms of strategy use, addition or deletion of strategies, increase in the complexity or sophistication of strategies or changes in the range of applicability of strategies.

2.2.1 Science Learning as Conceptual Change

According to the constructivist view, learning is not only about students acquiring ideas, but also about students developing or changing their existing ideas (Carey, 2000). Learning involves conceptual change where there is creation and alteration of mental representations (Thagard, 1992). This happens when existing concepts are adjusted and reorganized to accommodate new information. During conceptual change the meanings of the concepts change in relation to other concepts and the world. The notion that students learn science through conceptual change indicates that if conceptual change does not happen while learning the old schemas remain powerful in the child.

The conceptual change approach was brought to the field of science education research from the domain of history and philosophy of science by educators who saw analogies between theory change in the history of science and students learning of science (Özdemir & Clark, 2007). The term conceptual change is used to characterize the kind of learning required when existing concepts need to be reorganized to accommodate new information or when the new information to be learned comes in conflict with the learner’s prior knowledge. In such cases the meaning of concepts changes in relation to other concepts and the world.

In the classical conceptual change model that emphasize students’ epistemologies, learners use their existing knowledge to determine whether a conception is intelligible (knowing what it means), plausible (believing it to be true), and fruitful (finding it useful) (Posner et al., 1982; Hewson, 1992). Student’s dissatisfaction with a prior conception initiates conceptual change. This notion is embedded in the constructivist epistemological views with an emphasis on the individual’s conceptions and his/her conceptual development.

Conceptual change can be approached from an epistemological, ontological and an affective perspective (Treagust & Duit, 2008). Conceptual change viewed as epistemology examines how children think about their world, conceptual change viewed as ontology examine the ways they view reality and conceptual
change studies that look at affective factors emphasize on the affective variables such as interest, self-concept, emotions, motivation and the social aspects of group work as essential in fostering conceptual change.

The studies that examine children’s conceptual understanding of science from a cognitive perspective, view science learning as children building mental representation through solitary activity. These study concepts as mental objects, that belong to individuals. These studies employ a learner centered approach, and view science learning as individual children constructing concepts, based on interaction with the world and child’s own mind/cognitive system. The emphasis is on naturally occurring forms of scientific thinking, and this is based on an assumption of universal nature of development, taking a global view of the learner, and focusing on “what develops” and how individual conceptions change over time. These studies locate children’s conceptual systems within the mind of an ‘*ab initio solitary*’ than an individual born in a social milieu, without reference to the environment or context to which they belong (Pea, 1993).

2.2.2 Socio-cultural Approaches to Science Learning

Socio-cultural theorizing that emphasizes the importance of ‘context’ is relevant to science education in conceptualizing learning of science (Lave, 1988). By taking the child as inseparable from the socio-cultural context, teaching and learning are conceptualized as taking place in a socially created setting and involving participation in the ‘community of practice’ (Vygotsky, 1978; Vygotsky, 1987; Lave, 1988). Social interaction and cultural practices are sources of thinking and therefore play a major role in science learning and conceptual understanding which occur through the interaction between the child and the structure of the objective world. Conceptual development is the result of constant internalization and externalization of culturally valued resources and concepts (Karpov, 2003).

Science learning and acquisition of concepts of science by children are viewed as a social process. Science and scientific knowledge production are endeavors conducted within social and cultural interaction and institution of science (Latour & Woolgar, 1986). The socio-cultural and political context within which the activities of science happens, influence the conduct and content of science. Likewise science learning is mediated through the social interaction and cultural practices of school. From a socio-cultural perspective on learning *language mediates social interaction and scientific knowledge is socially*
constructed, negotiated, validated, and communicated in the context of the specific discourse practices of science classroom (Driver et al., 1994). Science concepts are taught and shared within the group of the science classroom, peers, and teacher. Lemke (1990) calls this, learning of science in a classroom as children entering a new community of discourse and a new culture which is the culture of school science. According to Aikenhead (1996) the conduct and language of school science is different from that of science which is suggested as a subculture of science. The instructional practices of science are embedded in various discourses, particular ways of knowing, doing, talking, reading and writing about science, which are constructed and reproduced in social and cultural practice and interaction of school and science classroom (Roth & Lee, 2004).

Socio-cultural theories view scientific concepts as cultural artifacts (Vygotsky, 1997; Karpov, 2003; Wells, 1994; Kozulin, 1998). Scientific concepts are not possessed by individuals; rather, they are part of a social and cultural resource, which individuals learn to use for their own purposes. Scientific concepts are tools developed for particular purposes, they should not be thought of as universally appropriate for all types of problem solving. Also scientific concepts as components of a system of concepts, have been proposed, revised and improved over many generations by the community of professional scientists in order to increase their understanding and possibilities for action (Nerssesian, 2010).

According to this framework children’s concept must be seen in a context that includes the social and material history of the culture of which the child is a part—material tools, linguistic and symbol systems that the culture has developed over the year for interacting with each other and with the environment (Vygotsky, 1997; Karpov, 2003; Wells, 1994; Kozulin, 1998).

Concepts are learned when the learner is engaged in solving a problem and in his/her efforts towards achieving a solution (Gauvian, 2001). The social environment structures the practices in which children engage, and provides the symbolic tools for problem solving. Each culture has a language, fashions its own tools and has found ways to transmit its knowledge to the next generation through language and social institutions such as school. Children’s conceptions are constructed through the interaction with the physical as well as social environment. This comprises the child’s daily activities, language, interaction with adults—parents, teachers, members of the community, peers, physical and social spaces that are accessed by the child, cultural resources of the community etc (Rogoff, 1990).
Socio-cultural theories invoke the role of language in the process of science learning (Lemke, 1990; 2000; 2001). Teaching and learning of science involves not only acquisition and development of concepts and but also the language of science. Language forms the foundation for an individual’s conceptual ecology as well as a means of conceptual growth (Jones & Brader-Araje, 2002). All cultures have developed conceptual tools for making sense of the events in their daily lives, which are embodied in the language they used to co-construct their understandings. Language serves to mediate higher order thinking (Vygotsky, 1978; Wertsch, 1985). It also serves as a psychological tool that can cause fundamental changes in mental functions. During the course of learning science, children develop an understanding of scientific concepts and at the same time also develop an understanding of the language and practices of science that eventually ‘enculture’ them into the culture and practices of science (Brown, Collins & Duguid, 1989).

Classroom processes and science textbooks are central to the enterprise of making the culture and practice of science available to children (Lee, 2001). Science textbooks are written to give learners access to making sense of the world through scientific explanations and to the specialized language of science. This includes the use the language of science, ways of thinking, and understanding phenomena through scientific concepts. Learners are prepared to use specialized scientific vocabulary (Sarukkai, 2003)—the specialized words unique to science, words which acquire different meaning when used in science, also learning to read scientific symbols and diagrams and bridging the everyday language of children to the vocabulary, structure, form and genres of science.

This occurs through various processes and activities of a science classroom, textbooks, through the use of instructional tools and processes such as observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, explaining, rephrasing, predicting, reasoning, evaluating etc.

While science textbooks may adopt some of the features of a scientific text, these are rewritten and towards children’s learning of science, content is selected, organized and appropriated for the requirements of a science classroom. They are graded and adapted to the needs of younger children or novice learners of science.

The important features that can be elicited in the case of a school science textbook are that it selects, sequences, simplifies and consolidates contents
according to the cognitive abilities and age of the learner. It frequently portrays and establishes the knowledge as ‘facts’ without reference to the original process and context of its creation (Koulaidis, 1996). These facts are simplified and incorporated to the school science learning in a particular order. Textbook are designed in such a manner that there is a progression in the hierarchy of concepts that the students must learn and master. The textbook start with the basic concepts considered as elementary taking into account children’s cognitive abilities (Dawani, 2010) in order to reach to the complex ones towards the fulfillment of the objectives and content fixed by the curriculum. The transition that occurs in the school science textbooks is that of gradual introduction of students to the specialized content and language of science as they proceed from primary to secondary school.

Science textbooks are written in accordance within the guidance set by a science curriculum by a single author or group of authors. Textbooks are also under the influence of norms set by the state and notions of the particular social, economic, and cultural context. Thus the way of writing and therefore reading of school science textbooks and classroom processes reproduces the scientific knowledge to cater to the needs of the school science and a science learner. Scientific knowledge developed in the scientific community has to be recreated to accommodate to the space and time that exist within the context of a school and science classroom.

According to Bernstein (2000) the construction of school science is characterized by a process of change of the context within which science meaning become operative. Bernstein calls this process as ‘recontextualisation’ by distinguishing between the primary context that refers to the production of scientific knowledge and the secondary context that refers to the process of its reproduction. Recontextualisation basically involves reconfiguring and reordering existing scientific knowledge so as to retrofit it for a different discursive reality.

Thus the socio-cultural perspective on science learning takes account of the child’s learning experiences in a science classroom against the background of child’s lived experiences outside the classroom and looks at the significance of social, cultural and physical world of the child in the learning of science. This is viewed as a process in which students crossing cultural borders from the subculture of their peers and family into the subcultures of science and school science (Aikenhead, 1996).
2.2.3 Key Indian Researches

In the Indian context, there are few studies that are built on, or elaborate, the axis of home-school. This section is aimed at reviewing seven of these studies as they are of relevance to this research study. These studies explored the difference between the school learning and learning happening at home and also attempted to locate children’s learning in the socio-cultural context.

In a study that probed middle school student’s ideas about plants (Natarajan et al., 1996), it was found that there exists a wide gap between student’s spontaneous ideas about plants—which were varied and rich in ecological content—and the knowledge about plants developed from the textbook. The study also suggested that mere presence of plants in the environment did not result in student’s being aware of them. Everyday use of and interactions with plants and plant products had a greater influence on students ideas about plants. The study also found that tribal students have a richer and more varied knowledge base about plants both in comparison with the textbooks at their level and than urban students. The direct dependence of tribal cultures on forests for shelter, food and medicine, was reflected in their positive attitudes towards plants and in their more detailed knowledge of ecological interdependencies as compared to urban students. The study was done with middle school students and both urban and tribal students belonged to grades 5 and 6.

In an ethnographic study conducted to examine the relationship between everyday practices and mathematical understandings among working class children in three different settings of school, newspaper vending and pan selling, it was proposed that children’s mathematical understanding is embedded in a context that is meaningful, thus it is successfully internalized and incorporated (Khan, 2004). Children were compared on their knowledge of the number system and their competence and understanding in solving a set of mathematical word problems. Theirs is a functional mathematics of not very complex levels that can be mastered with minimal levels of engagement in instruction. The analysis of their daily practices at the non-school context of newspaper vending and pan selling revealed that the mathematical competence and skills exhibited by children are demanded of them by the context of the world of work. The vendors although constrained by their lack of understanding of the mathematical knowledge have a competent understanding of the mathematical principles and computations that their everyday practices entail whereas school children demonstrated a more mechanical application of rules.
Sarangapani’s (2003) study about the children of Kasimapur village explores the nature of the child’s construction of school knowledge and the relationship between schooling and everyday knowledge. The study uses the tools of anthropology to reconstruct knowledge about a government school and processes of schooling. The study present a detailed account of the social context in which the schooling takes place and why schooling is important in the village, the ideology of childhood, activities, discourses in the school and classroom, the construction of pupil and teachers identities, regulation of knowledge in the classroom and different aspects of children’s epistemologies. According to the study, the classroom’s overwhelming emphasis on learning through telling and simple memorization overruns all considerations of empiricism, even the pedagogic utility of experiments. Ultimately, what is learnt in school is linked only to life within the boundaries of the school. It has little to do with the life outside it.

In an ethnographic case study done among grade VIII students of a government rural middle school in the state of Madhya Pradesh, Sharma (2007) argues for a more culturally responsive science education that preserves hopes for personal and societal peaceful progressive change through education for underprivileged students in India. The study analysed children’s experiences and knowledge of their local material world, and contrasted them with a critique of school science to understand how well school science corresponds with learning needs and resources of students in rural India. The study brings out the gap between school and out of school knowledge and also highlights the gap between the learning needs and resources that students bring to the science classroom and the learning opportunities that school science offers. The study presents a narrative account of an ethnographic exploration of students learning process of electricity in an eighth grade classroom. It is shown how students having a rich experience with household electric circuits attempt to negotiate their roles as students and participate in school science discourse; and the study proposes that the students actions expressed agency that was contingent, situated and aimed at selective appropriation of school science discourse for their own purposes and such expression of student agency indicate rich possibilities for meaningful learning of science in rural schools in India, provided school science is made relevant for their lives and concerns. It recommends a science education that enables rural kids to acquire better tools to understand, question and manipulate the material world around them.

In a study conducted among the H o tribal children to examine the idea of ‘home-school polarity’, Singh (1995) brings out the gap that exists between the
knowledge imparted through Social Studies in the school and equivalent domestic knowledge. The study brings out tribal children’s experiences of schooling and discontinuities between their traditional ways of life and the ways of the dominant culture imparted through schools, syllabus and textbooks. It shows that knowledge and skills offered at primary schools in India are of little relevance to the immediate environment of the tribal communities and is dysfunctional for tribal socio-economic development. The tribal children are taught from the same books which form the curriculum of non-tribal primary school children in urban areas. The textbook content used in the primary schools has little appeal to tribal children who come from many different socio-cultural backgrounds. The study concludes that there is a gap between the knowledge required to participate in children’s own existing agricultural economies and the knowledge imparted through school teaching in tribal areas.

Sarangapani’s (2003) study among children of Baiga tribal community inhabiting the forested regions of Central India examines the relationship between the formal school curriculum and the local/indigenous knowledge and pedagogic tradition of the Baiga. It engages with the school vs. home dichotomy and suitability of the inclusion of indigenous knowledge in Indian school curriculum policy. It explores the significance and potential of the continuities and discontinuities between Baiga knowledge traditions and the traditions and practices of the institution of formal schools. The study brings out the disjunction between Baiga knowledge systems and formal schooling whose pedagogic practices and curriculum presume a literate tradition: where knowledge is decontextually presented in texts and children are already socialised to accept pedagogic/adult authority. The Baigas pedagogic tradition supports the transmission of this knowledge from expert practitioner gurus to their chelas or novices, where the knowledge system is local and oral. The pedagogic tradition and socialisation which supports its transmission is marked by its subsistence level of production and the lack of centralised authority in the organisation of the tribe, and in children’s lives. Thus the study raises questions on the epistemological feasibility of inclusion of indigenous knowledge systems in the regular school curriculum.

The result of the study on children’s perception of “Sarkar” (government) (George, 2004) showed that there were contrasting images gained by children from the social world with the images presented in the textbooks and this posed a major difficulty for children to grasp the concepts of a civics text book.

The above studies also suggest to us that the significance of context in the Indian situation brings out the complexity of language, culture and socio-
economic context as well as interpretations of the significance of education and its relationship to economic and cultural contexts. Caste hierarchies, economic status, gender relations, cultural diversity influences children’s participations and learning in school.

2.3 Some Features of Indian Schools and School-Science

This section discusses some of the key features of Indian school science learning that are relevant to the home/everyday-school problematic that is the subject of this thesis. It draws on two main sources for this purpose—research studies and policy-action—to identify key themes that are relevant to characterizing the home/everyday-school polarity and are also key influences on addressing this polarity.

Science forms a core subject of the Indian school curriculum from the primary grades upwards. Although since the 1990s, there has been a concerted effort to ‘integrate’ science and the social sciences in the form of a subject called ‘environmental studies’ in the primary grades, yet the content of the school curriculum and learning (hence science curriculum and learning) is found to be largely discontinuous/alienated from the child’s immediate social context, everyday realities and knowledge (Kumar, 1991; Kumar, 1997; Misra et al., 2004). The knowledge and skills offered by the science classroom seem to be of little relevance to the everyday lived experiences of children outside the boundaries of school. The policy response to was addressed in the Yashpal committee report (MHRD, 1993) that pointed out the lack of meaningful learning in schools, how children are being burdened with voluminous information to memorize, how textbooks were poorly conceptualized and written, and the problem of non-comprehension of subject matter from both textbook and classroom makes learning extremely difficult and alienating for majority of children. According to the report “The feeling of academic burden arising out of non-comprehension of subject matter included in the syllabus is indeed a serious problem as it is a major hurdle in the achievement of the target of universalisation of elementary education”.

2.3.1 Between Cultures: ‘Modernity’ and ‘Tradition’

According to Kumar (1997) one of the key factors that contributes to this disconnect between the science learning at school and the everyday world of the
child is to do with its content and aims. The content of science learned in schools through textbooks with the help of a teacher is different in its structure and form from the everyday knowledge of the child i.e. ‘what is learnt’ and ‘what is considered as knowledge’ in the context of the science classroom is distinct or removed from child’s own everyday reality. School science learning privileges western science (Jegede & Okebukola, 1991; Aikenhead, Allen, & Jegede, 1999) and the curricular aims of which in the Indian context are inculcating ‘modernity’, ‘scientific temper’, ‘rationality’, ‘objectivity’ in children (NPE, 1966; NPE, 1986; NCF, 2005). Such a critique is also found in science studies literature which challenge “western science’s traditional claims to be value free, objective, and universal truth, revealing instead the socio-cultural construction of scientific knowledge, and its coexistence with other various and multiple local/indigenous versions of science” (Carter, 2008).

Furthermore, the premises regarding nature of knowledge, process of teaching and learning and views of childhood which inform schooling are different the community’s views (see Sarangapani, 2003; Vasantha and Pappu, 2010).

This home-school difference i.e. between the world of school/school science learning and child’s everyday world (the world of home, community, its socio-cultural resources, language) has been defined using terms such as ‘gap’, ‘polarity’, ‘contradiction’, ‘distance’, ‘discontinuity’ (Sarangapani, 2003; Singh, 1995). This disconnect has cognitive implications for the process of science learning. Children must work through the structures of everyday life (experience based knowledge) as well as structures of the formal classroom learning of science—both are of different in nature—in the course of constructing knowledge (Cobern & Aikenhead, 1998; Layton, 1991). Science teaching in schools typically treats scientific knowledge as a body of facts and objective truths far removed from child’s context and everyday world. If we take a socio-cultural perspective of learning—learning and cognition happening in everyday practice is distributed, stretched over and not divided among mind, body, activity and culturally organized settings which include other actors (Lave, 1988).

According to Resnick (1987 in Gassert, 1997) the differences between learning that occurs inside and outside school is that, in school learning tends to be solitary, based on symbols and the abstract, and divorced from real-world experiences, with little or no connection with the actual objects or events represented. In contrast, out-of-school learning more commonly involves the accomplishment of an intellectual or physical task by a group that is interacting,
using real elements, which allows learning to take on greater meaning. Another major difference is that learners in an informal setting are intrinsically motivated to gain personal meaning from their learning, which has greater value than memorizing facts or doing well on a test (Gassert, 1997).

2.3.2 Social Aims of School Science

Indian science curriculum often views the home-school polarity between child’s everyday context and the context of schooling as a disadvantage as the every world of the child is filled with values that are different from that of schooling, especially that of science. Curriculum and textbook perceive child’s everyday world as filled with commonsensical, intuitive, spiritual, imaginative, and superstitious knowledge. “The most common message that children get from the textbooks is that the life ordinary people live is ‘wrong’ or irrational” (MHRD, 1993)

According to the curriculum and policy documents development of scientific temper is crucial to the learning of science in schools (NPE, 1968; NCERT, 1988; NCF, 2005). Curriculum also views science as a subject that promotes rational analysis, inductive and deductive reasoning, problem solving and decision making ability etc; it also functions with the assumption that introducing children to the scientific skills and knowledge can instill rational thinking, reasoning ability and confidence in them, which will inspire an individual to challenge the existing beliefs, prejudices and practices of the social world.

“Science education programmes will be designed to enable the learner to acquire problem solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life”.

National Policy on Education – 1986

Another important emphasis of the Indian science curriculums and policy documents is the transformative role of science education i.e. science for social change. This is the belief that science carries the possibility of progress and that it has the power to bring changes in societal attitudes and to emancipate the masses not only from poverty but also from superstitions, irrational beliefs and various other social issues facing Indian society. While this view is predominant in the Kothari Commission’s report (Government of India, 1965), it was asserted even as recently as the 2005 curriculum framework:
“The science curriculum must be used as an instrument for achieving social change in order to reduce the divide based on economic class, gender, caste, religion and region. We must use textbooks as one of the primary instruments for equity, since for a great majority of school-going children, as also for their teachers, it is only accessible and affordable resource for education”.


2.3.3 Delegitimisation of ‘Local’ and Dependence on Rote

The historical root of the alienation of the science curriculum from the child’s everyday world has been traced back to a colonial education system (Kumar, 1991). The origin of the Indian system of school education and science learning that is modeled on a western (British) system has its origin in the minute written by Macaulay to on the introduction of Western Science and English language, and the exclusion of indigenous knowledge, in the Indian education system. British education system and method marked the beginning of ‘modern education’ in India. The colonial curriculum was divorced from the experience of the Indian child and social milieu, and thus represented a discontinuity. The colonial system of textbooks and examinations perpetuated a pedagogy which promoted memorization. It has been noted that traditional Indian learning was also based on memorization (Sarangapani, 2003), however the fundamental disconnect between textbook knowledge and everyday experience, along with the delegitimisation of the everyday as irrational and unworthy of curricular inclusion, was a colonial development.

According to the Yashpal Committee (MHRD, 1993) report the distance between the child’s everyday life and the content of the schooling accentuates the transformation of knowledge into a load that makes learning ‘joyless’. Also the alienation of science classroom from child’s everyday world take the ‘form of esotericisation of the subject’ of science. This also turns the curriculum and science learning a bag of facts and learning a ‘load of learning’ that views teaching as successful delivery of known facts where a lot is taught but little is learnt or understood and results in the ‘confinement of classroom life to a narrow orbit’.

Moreover the very manner in which textbook and classroom treat the subject matter is another factor that leads to alienation of knowledge from the child’s world.
Classroom knowledge assumes total independence from the child’s own experience and knowledge of the world. As a consequence of this decoupling, children begin to compartmentalize knowledge into two categories; that which has currency in school and classroom, and the other which has uses and relevance outside the school. Necessarily, the knowledge in the first category ceases to have any ‘life’ and becomes increasingly ritualistic and burdensome. Teachers also carry the same kind of categorization in their mind; very few of them are able to help the child make bridges between what is learnt at school and what is required to face real-life situations. One researcher who tried to make such a bridge in a lesson about letter-writing was asked by a Grade VI child: “Madam, shall we write it the way we write at home or in the school way?”

2.3.4 ‘Universal and Abstract’ to ‘Decontextualised’

One of the important aspects that the above point towards is the manner in which school science, textbook and classroom processes treat knowledge and content of science. It treats knowledge as independent of the situations, and the activity and context in which learning takes place is far removed from the context in which it is used. The primary concern of the school science often seems to be the transfer of ‘abstract’ and ‘universal’ formal scientific concepts, principles and laws. As a consequence, scientific knowledge is decontextually presented by the science classroom. Embedded within the Indian textbook-culture, children are socialized to accept pedagogic authority of the teacher, textbook and curriculum (Clarke, 2001; Sarangapani, 2003). The centrally written textbooks and school science instruction based on it often fail to draw child’s attention to observe and learn based on the everyday phenomenon, process or examples from their immediate context (Sharma, 2007). Thus it fails to develop in children, the skills of observation and reasoning based on the real world and it also fails to highlight connections between science learning and the student’s lives. This de-contextualized learning process (Koul & Dana, 1997) of the science classroom is in contrast to the everyday way of learning based on experience.

2.3.5 Separation of Knowing and Doing

School science learning in Indian classrooms also exhibits a separation between knowing and doing (Ramdas et al., 1996). One of the important feature of science as a subject is the opportunity that it provides to conduct experimentation. Meaningful science learning in the classroom depends on the application of scientific process, method, and skills of investigation,
critical thinking, imagination, intuition, etc. for which conduction of experiment are an important criteria.

A major structural problem of school science education in India is the lack of experimental facilities. Experiments are often not conducted in the classroom. Instead they are described, illustrated and explained in textbooks, and very infrequently demonstrated by teachers in the classroom. Children usually have no access to any equipment, even if the school has functional laboratories for higher classes. This raises the question whether bookish science can in fact achieve curricular objectives such as autonomy, independent thinking and scientific temper.

“As a subject that demands experimentation and independent inquiry by the learner, science is associated with freedom of judgement and equality between the student and the teacher in the presence of objective facts. Science education is supposed to be conducive to secular values precisely because it makes ascribed authority redundant. But if science is taught in a traditional manner, with the authority of the textbook and the teacher’s word, and without opportunity for experimentation, it would cease to have a secular character and value. Once it loses its original character, owing to the application of conventional pedagogies, science can well become an instrument for authoritarian control in the classroom, and later on in society. The practice of science in a context that does not permit equality or open questioning can potentially lead pupils into imbibing values that are antithetical to science.”  

(Kumar, 1992).

This is not withstanding the observation that the scientific inquiry tasks that are given to students in schools may themselves not reflect the core attributes of authentic scientific investigation (Chinn & Malhotra, 2002). That is, the cognitive processes which are used in conducting science experiment in a classroom for pedagogic purposes may differ qualitatively from the cognitive processes needed to engage in real scientific experimentation. Hence the epistemology of many school inquiry tasks may in fact be antithetical to the epistemology of authentic science.

2.3.6 Predominance of the Textbook and Curricular Standardisation

Among the most important components that contribute to the distancing of the child from school science learning is the science textbook itself. Frequently the language, content, vocabulary, structure and formal approach of the
textbook is new and unfamiliar to the child, is also distant and far removed from child’s everyday life and knowledge. Indian school curriculum is a ‘textbook curriculum’ as the textbook and evaluation schemes almost completely determine the day-to-day pedagogic activities of the classroom. It is also bookish as it involves rote learning for the purpose of examinations. The voice of the child, and even the teacher and the contexts are frequently absent. Kumar (1991) calls the prescribed textbook as the “defacto curriculum” as it is the prime curriculum resource in the classroom and an indispensable tool for classroom instruction and learning, and it represents the curriculum for teachers and children. Textbook is used in science classroom for content introduction, explanation of new scientific terms/vocabulary, describing-diagrams/experiments, solving problems given at the end of each chapter, answering to the questions given at the end of each lesson and any new problem solving. Thus the whole classroom processes and science learning by children are confined, dependent and are limited by the single science textbook. Also a prime goal of the teaching and learning processes is completion of the content of a textbook with the allotted time and testing children on the content learned.

Another important aspect that contributes to the home-school dichotomy is the standardized nature of Indian science curriculum versus the locally relevant contextualized curriculum. The processes, cultures and manners of the schooling, textbook, classrooms, evaluation and children’s learning throughout India is determined by National Council for Education Research and Training (NCERT) with its curriculum development taking place at the National center and the states adopting the National Curriculum (Ramanathan & Siddiqi, 1994). This approach results in children learning science through a schooling process that doesn’t pay attention to the specifics of social and cultural context of the child. This has been pointed out as a ‘canonical approach’ or a ‘controlling paradigm’ (Koul, 1997) on curricular development by determining the curriculum, teaching and learning processes of science classrooms from the center. This curriculum developer directs the teacher to act and mediate the curriculum in the classroom also support the intended learning aims and changes made in time periods.

We can see from the discussion above that there are multiple reasons contributing to the basic dichotomization of school and home realities of children. Some of these reasons can be traced to colonially influenced and constituted delegitimisation of the indigenous and everyday milieu of colonized people.
Others can be traced to practices that have arisen in relation to a perception of what constitutes the discipline of science and the nature of science learning, and also in relation to roles attributed to science in post colonial, independent Indian phase, as well as to structural limitations of schooling in India.

The science education space in the Indian context has been significantly shaped by a few important curriculum experiments/innovations that have tried to address themselves to the problematic that was outlined in the above section. In particular the need to improve the science curriculum and design it to the needs of Indian child and his/her social milieu. The discussion in this section of the chapter continues and is now built on ideas germane to the problem of context and milieu, that have emerged from some key spaces of action and policy from the post independence period. The ideas presented below are organized with reference to (a) the Hoshangabad Science Teaching Programme (b) the People’s Science Movement and (c) the National Curriculum Framework 2005.

2.3.7 Hoshangabad Science Teaching Programme (HSTP)

The Hoshangabad Science Teaching program began in the 1970’s, brought together scientists from the Tata Institute of Fundamental Research, Mumbai, Delhi University, Delhi and other universities and colleges of Madhya Pradesh to interact with two Non Government organizations in Madhya Pradesh, the Friends Rural Centre, Rasulia and Kishore Bharati, Hoshangabad, with the objective of creating a middle school science curriculum that would be relevant to the context of the child and learnt meaningfully. The textbooks were called as ‘Bal Vaigyanik’ or child scientist, and the three year science curriculum aimed at teaching content in ways that were relevant to the context of the child, conceptually within the child’s grasp and through the method of ‘doing science’ as opposed to learning science from text. The books were basically workbooks and the exercises were based on children conducting experiments, observations and field trips. They gathered data, organized it, and speculated, reasons, made hypotheses and ‘did science’ in order to learn science. This experiment is unique in the history of curriculum in India both for its scale and for the length of time that it ran. It was also notable for its controversial closure. The note below is restricted to culling out some key insights that are relevant to the home-school question that this thesis is engaged with.
The science curriculum developed by the HSTP tried to address the relationship between the school science and the world of the child’s home and community and examined the feasibility of contextualizing learning of science and materials to the child’s local context and familiar everyday environment by developing locally relevant textbooks, science experimental kits and conducting systematic teacher training programs. There were many scientists and university students involved in this program. The HSTP’s attempt to decentralize capacity building in village schools is often cited as a model program towards contextualizing science learning through partnership between community, governmental and non governmental organizations; also for the development socio-cultural specific and activity/discovery based curriculum and instructional materials.

Among the key ‘learnings’ regarding science learning in particular and school curriculum in general included the problem of the language of formal science—both nominalization as well as representation in the form of illustrations, the importance of interacting with the local context and ‘doing inquiry science’ with more than the textbook, and in a community of learners along with the teacher.

(a) Language and representation. The team of scientists and teachers experienced the alienating effects of sanskritised basis for formal scientific terminology. In the course of evolving a response to this problem, they not only learnt of the importance of the inclusion of everyday discourse of children in the text. They also altered the naming of formal objects of science towards terms that were more intuitive and seemed more familiar to children. Illustrations in previous science textbook too proved to be ‘alienating’ to children many of whom were first generation school goers. The texts soon included a variety of forms, to present information, and to introduce children gradually to formal illustration and its idiom.

(b) Interaction with the local context entered the textbook with local familiar situations being invoked to introduce ideas, or asking children questions about them. Science, especially the study of the environment, was built around field trips during which children had to go out along with their teachers to collect samples which would then be brought back into the classroom for study.

(c) Each class was further provided with science kits, and children had to do experiments together in groups. Following discussion, they would record observations and findings in their text-workbooks. This inquiry basis of
the curriculum led to the opening up of classroom discourse. The unpredictability of experiments particularly when handled by children themselves, also led to a situation where children could raise questions that had not been anticipated, shifting control of the content and pacing of the classroom from a teacher centric one toward a shared control.

(d) The programme in addition made an important contribution in exploring aspects of local knowledge that merited inclusion in science textbooks. Units on soil and agriculture were important departures from conventional formal content of science books, particularly in the 1970s.

Not only was the textbook thus displaced from its authority in the classroom, a mode of examinations which required inquiry and reasoning rather than repetition effectively worked against rote based system for learning.

This above description is a brief attempt to highlight features of the HSTP curriculum that are relevant to our problematic of the everyday world of the child in relation to the school. It is instructive to note that this very issue that the curriculum required children to go outdoors, to engage with the ‘local’ and to collect local specimens for classroom study, was cited as a ‘problem’ by a local elected representative who called for the closure of the curriculum.

2.3.8 People’s Science Movement—the case of KSSP.

The people’s science movement as exemplified in the activities of the Kerala Shastra Sahitya Parishad (KSSP), Tamil Nadu Science Forum and the All India Peoples Science Network, emerged in the 1960s and 70s through the activities of scientists attempted to bring science ‘to the people’, involved in the popularizing science among the general public and aimed to enhance the quality of people’s life through science. These movements also designed programmes which attempted to link promotion of science teaching in schools through the community route especially at the rural level. They developed low cost experiments for use in schools that followed an “inquiry” or “discovery approach”.

The KSSP’s philosophical orientation is taken up for greater discussion in this section as it is particularly relevant to this research study itself, as the study is conducted in the context of a School at Kerala, where the social context, pedagogic and school processes were significantly influenced by the work and activities of KSSP.
The Kerala Sastra Sahitya Parishad was formed in 1962, an organization that focused on popularizing science among the masses and to bring benefits of science to the everyday life of common man (Kumar, 1977) with a slogan “Science for Social Revolution” and aimed to “take science to the people” (KSSP). KSSP attempted to make people believe in science and rationalist principles through its publication of science literature in Malayalam, and various science popularization programs. KSSP viewed science as a means to enhance quality of life and uplift society. It also aimed to establish an egalitarian society through interventions in everyday life of people by emphasizing on the scientific approach and the development of a rational attitude toward social norms. According to (Kumar, 1977) “It strives to inculcate a genuine scientific outlook among the people believing that to be the only beginning of real progress and change in society. Hence the parishad’s slogan “Science for Social Revolution.”

KSSP adopted a campaign mode of mobilization (Sooryamoorthy & Ganrade, 2001) and aim was to involve people and mobilizing their resources. People were organized and mobilized through cultural programs through which the movement attempted to impart scientific temper in common man. KSSP members during the 1980’s and 90’s conducted regular visits to houses, jathas, meeting, and the use of posters, arts, cultural programs and competitions to attract people and get them involved in its program. Jathas formed a key component of KSSP’s program and it included street performances on their routes and had been an effective medium to disseminate the message of science to the people and retain interest of the participants in their program. Local committees at the districts, panchayats and ward levels mobilized local leadership and people. The ward-level committees selected voluntary trainers, monitored progress of the program and mobilized local resources and KSSP’s programs became a people’s program. KSSP also took part in the total literacy campaign and was credited with organizing the extensive program for total literacy campaign in the entire state.

KSSP got involved with the issues related to interaction between nature, science and society and fought for matters related to the environment and conducted studies to examine issues of the large scale development projects which were having adverse ecological effects. KSSP focused on protection of forests, campaigns against pollution—especially by chemical industries, education on environmental impact of wrong use of land, popularizing agro foresting methods of soil protection, and acting as a consistent champion of protecting the environment for the future generations. KSSP led the campaign
to declare the Silent Valley, an evergreen tropical forest in the Palakkad district of Kerala, a protected area to save the forest and environment from a hydroelectric project. The movement attempted to raise the environmental awareness level of the entire Kerala Society, through campaigns popularizing good environmental practice and KSSP’s concern about the environment is linked with the idees of sustainable development.

During the course of time KSSP undertook several educational experiments. The long history of public involvement in education in the state has been catalyzed by the Kerala Sastra Sahitya Parishad (KSSP) during the course of its work on science popularization. Teachers were the main cadres of KSSP. The teachers who were members of KSSP were trained so that they had a role to play in the propagation of scientific temper and in encouraging science education among children. A large number of teachers were involved KSSP’s activities and scientists and teachers lectured to teachers in the 1970s when 1,500 school science clubs were started. A 45-day literacy programme for children called ‘Akshara Vedhi’ was started with support from parents and teachers. The organization also started school science clubs, first outside and then inside schools and put up science fairs and quiz programmes. Its periodicals ‘Eureka’ and ‘Sastra Keralam’ were popular among school children and teachers. This, combined with a ‘hands-on’ approach with lots of experiments, got other teachers as well as parents attracted to KSSP’s work. Also KSSP conducted an examination among school children named “Vigyanotsavam” from 1990, which is an improved version of an earlier experiment of the KSSP from 1970 onwards called the Eureka Competitive examination. What this experiment aimed at was to present a better model of education and examination system. KSSP’s interaction with school teachers and engagement with science education created an environment where teachers were able to work as resource personnel to work on science content. KSSP built resource groups and centers at various levels within the system. Over time, KSSP experimented with textbooks by choosing content that explored linkages science, society and nature and drawing examples from everyday world of the child. Many resource persons emerged from this process who worked closely with the state during the phase of DPEP curricular innovations and textbook renewal.

KSSP influenced the public life and Kerala education scenario in

(a) Bringing science ‘to the people’ and popularize science among masses to enhance the quality of people’s life through science
(b) KSSP’s work in the area of “science-society interface” and involvement in the environmental conservation, literacy promotion, healthcare, and cooperation with the state in the areas of literacy, educational reform, science education and science curriculum development.

(c) Publication of journals, magazines, and books in Malayalam for different age groups aimed at popularization of science

(d) Development of low cost experiments especially using local resources for use in schools that followed an “inquiry” or “discovery approach”. KSSP built resource groups and centers at various levels within the system

(e) The KSSP’s approach on nature conservation and its views on interaction between nature, science and society influenced science curriculum and content of the school science chapters on environmental impact of wrong use of land, agro foresting methods of soil protection, protecting the environment etc.

(f) KSSP’s experiments and models in the area of science content development drawing example from society and nature.

(g) The resource personnel emerged out of the working in the science popularization activities contributing to the science curriculum, textbook content and science teacher training program. Also the teacher who were the members of KSSP worked in the rural areas also among children in the propagation of scientific temper and in encouraging science education among children

(h) Promotion of science teaching in schools through the community route especially at the rural level.

2.3.9 National Curriculum Framework – 2005

A major attempt by the state to the contextualized school learning, the National Curriculum Framework developed in 2005 (NCF, 2005) sets out a number of principles that it regards essential to the reform of Indian education in general, and science education in particular. Within the broad thrust for a learner centered and activity oriented curriculum and pedagogy which can make education and learning meaningful, engagement with the child’s socio-cultural context and
milieu is a central idea. In part (a) that follows, I will discuss the broader approach to science education which is recommended. In part (b), I will focus on questions pertaining to the ‘local’ as formulated in this document.

(a) In the National Curriculum Framework of 2005, the notion that science education is a mere accumulation and memorization of facts of science, was sought to be replaced by a curriculum and pedagogy that laid emphasis on the process of science learning through activity method, discovery and critical thinking. National curriculum framework-2005, designed in accordance with constructivist theories emphasizes ‘child centered’ learning and activity oriented pedagogy, attempts to link science learning in the classrooms to everyday life of the child. The context-based and activity-based approach to teaching and learning is an attempt to promote formation of meaningful concepts, facilitate application of concepts to realistic settings, and to make instruction more attractive and motivating. Child centered pedagogy gives primacy to children’s experiences, voices and their active participation; the direction is to plan learning in keeping with the children’s psychological development and interests.

According to the document meaningful learning is a generative process, of representing and manipulating concrete things and mental representations, rather than storage/retrieval of information. Learning is active and social in character. Thinking, language and doing things are intimately intertwined. Finally, conceptual development is thus a continuous process of deepening and enriching connections and acquiring new layers of meaning. NCF also take into cognizance the complex social processes in India that have profound implications for the suggested learning and teaching process—the complex reality that exists outside the school, into which the child is born, and which shape the attitudes and dispositions of the children’s, parents, neighbors, peer groups, siblings towards learning.

NCF-2005 identifies three critical issues in the complex scenario of science education in India. Firstly, science education is still far from achieving the goal of equity enshrined in our constitution. Secondly, science education, even at its best, develops competence but does not encourage inventiveness and creativity. Finally, the overpowering examination system is basic to most, if not all, fundamental problems of science education. It recommends that the curriculum load should be rationalized and the
tendency to cover a large number of topics of the discipline superficially should be avoided. Both teacher empowerment and examination reform are seen by the NCF-2005 as pivotal enablers of change in the teaching and learning of science.

There is a shift in the aims of science learning i.e. shift in emphasis from the product to the process of and factual information to interesting, relevant and meaningful acquisition of scientific knowledge and process skills. The document identifies six types of validity\(^3\) for a science curriculum and learning process. These are cognitive validity, content validity, process validity, historical validity, environmental validity, and ethical validity. There is a major shift in the aims of science teaching and learning from the previous curriculum document which are,— enhancing the process skills and mental abilities of the child through joyful learning of science, nurturing curiosity of the child about natural environment, develop basic cognitive skills along with psychomotor skills through hands on activities. The purposes of science education are also identified as development and use of science process skills in a variety of settings, the development and application of science knowledge and understanding, appreciation of the relationship between science and society. It also aims to create a citizenry who are scientifically literate, who can connect concepts and principles learned in the science classrooms to real life situations. The curriculum also proposes different method of teaching and learning process- to introduce elementary concepts, principles and ideas of science through familiar experiences, working with hands, designing and making, activities and experiments, by analyzing on issues surrounding environment and health. The characteristics of science teaching and learning emphasized are that it must be child friendly, environment based, life oriented, process oriented, must provide scope for free expression of children’s ideas. Children must be directed to conduct out of school activities, open ended investigations, survey on various aspects of environment, health, agriculture, farming etc. Children must acquire not only scientific knowledge but also get hold of scientific methods, ideas, attitudes, values and process skills that involves several inter-connected steps: observing, classifying, measuring, communicating, using number relations, using space time relations, inferring, predicting, making operational definitions, formulating hypothesis, controlling variables, interpreting data and experimenting, looking for regularities and patterns, making hypothesis,
devising qualitative or mathematical models, deducing their consequences, verification or falsification of theories through observations and controlled experiments, and thus arriving at the principles theories and laws governing the natural world etc.. It recommends evaluating children based on a comprehensive and continuous mode of evaluation.

Constructivist methodology, as it is emphasized in the NCF-2005, is subjective, locates itself in the agency of child in the classroom, interacting with the outside environment, inside and outside the classroom in the process of construction of knowledge. Knowledge is constructed and not fed to the students as a finished product, and it is holistic, and integrative. The element of critical pedagogy is also introduced, which provides an opportunity to reflect critically on issues in terms of their political, economic, social and moral aspects. It also facilitates collective decision making through open discussion and by encouraging and recognizing multiple views. The combination of construction of knowledge and critical pedagogy thus appears to provide the core of NCF-2005, and forms its approach to contextualization in the curriculum.

(b) The idea of ‘location’ and ‘local knowledge’ entering into the classroom curriculum frame mainly through the agency and judgment of teachers and the agency of children is a central idea in the NCF 2005. This needs to be distinguished from the ‘nationalistic’ strain perceived in the NCF-2000 (NCERT, 2000), which sought to assert ‘Indianness’ and Indian ownership of some ideas of western knowledge and also valorize Hindu/Brahminical world view (see Sahmat, 2000 and Sarangapani, 2009). Local knowledge however is not treated as an unproblematic category. The NCF debate which problematised ‘local knowledge’ as a category in the Indian context, drew attention to the problematic aspects of what is ‘known’ in the community. ‘Community’ and the ‘local’ can be the seat of superstition and incorrect traditional knowledge, supporting practices and stereotypes pertaining to gender and caste which have been rejected in the course of the formation of the Indian State. The function of school cannot be to integrate children into this knowledge. Yet can the school be formed into a space that can engage with and deal with such knowledge? Can the intellect and the agency of the teacher be depended upon to negotiate such ‘local knowledge’ which is bound to be politically charged? At the same time the NCF 2005 accepts that not all ‘local knowledge’ is to be
rejected, and that there may also be valuable local knowledge which needs to be retained, rather than lost through schooling.

In addition to ‘local knowledge’ there is a larger question of ‘location of the knowledge experience’, ie situating cognition by connecting cognitive acts to the immediate physico-environmental-social-cultural space, the habitat. The NCF 2005 regards this an important principle for the design of curriculum and the form of pedagogy, which emerges out of constructivist learning theory. Such located cognition is regarded as an essential part of meaning-making.

2.4 Approach and Framework for the Study of Children’s Science Learning

2.4.1 Approach

Science learning is a gradual process during which the initial conceptual structures based on children’s interpretations of everyday experience are continuously enriched and restructured in the context of a classroom. While studies on children’s scientific conceptions based on cognitive developmental research can provide us with important information about the process of learning science and the individual mind of the child, it does not tell us how the external environmental, social and cultural variables can facilitate science learning and the situated nature of science learning in a social context.

For a holistic understanding of children’s science learning, a detailed characterization of the factors that influence children’s learning of scientific concepts need to be brought out. Tomesallo argues that cultural learning is an important contributor to what makes human system humane. What is needed is a framework for examining children’s science learning and conceptual understanding that bridges science education research, cognitive developmental research and cultural psychology. This puts forth the need for an approach that takes into consideration the individual mind of the child while also situating the child in the socio-cultural context in which teaching and learning of science happens. Such a framework will be helpful to describe the mechanisms that can take a child from one level of cognitive performance in terms of science learning and conceptual knowledge to the next and relate
them to social and cultural factors. The questions that are addressed along with this framework are (a) what constitutes the term ‘social’, ‘cultural’ in the context of learning of science? and (b) how can we characterize the major components of the child’s social and physical world outside the classroom that influence the process of learning science.

The present investigation focuses on cognitive aspects of learning science, content of children’s conceptions, and the individual child’s conceptions situating the child in the context of the teaching and learning of science. Children’s science learning from a socio-cultural and cognitive perspective requires approaching it from the multiple interacting aspects of a science learning environment- the kinds of learning activities, the roles each member and learner takes, material and social resources for learning, the knowledge distributed within the social networks and the practices for exchanging information. The social context comprises of both in and out of school factors i.e. school, science classroom and the social world of the child.

The study approaches children’s science learning at various levels:

1. The context of the larger social life of the child outside the school
2. The nature of the school and classroom experiences and the curriculum and the textbooks within which these experiences are framed
3. Science learning process
4. The mind of the child

The context of learning in this study is characterized by the following factors

1. The context of the school where teaching and learning happens which encompasses the school culture, classroom process, science curriculum, teacher, textbook, learning materials, peers, language in which teaching and learning of science happens
2. Social and cultural background of the child that includes the community, members of the community, occupation, and skills of the parents and members of the community, tools developed by the community for the transmission of skills and knowledge, physical and social spaces children can access and the local environment of the child
This approach will help us to understand the relationship between the individual child’s science learning and the environment, the conditions under which they can exert reciprocal influence.

**Research Questions:**

1. How does the school science curriculum approach the dimensions of ‘everyday’ and ‘school’—both as a source of knowledge and also as a context of learning? To what extent does the textbook and curriculum support children to negotiate this transition? Related is the question of the extent to which the approach in the school science curriculum may be regarded as founded on constructivist principles of learning, and supportive of meaning making in science education? To what extent is the child’s everyday world (including culture and language) included and interacted with, in the context of school? Is Gender or Caste or other socio-cultural categories significant in differentiating children’s experiences of science education?

2. What is the treatment of the concept of matter in the school curriculum especially with regard to the child’s everyday experience with and access to the material world?

3. What are children’s conceptions of matter? How do they compare with the scientific concepts? Is there any relationship with their gender, caste or other socio-cultural variables? To what extent can their conceptions be related to their everyday experience of matter/material world? What are the pedagogic practices of school and the science classroom, with respect to the ‘distance’ between the child’s home culture and school culture?

**2.4.2 Framework for the Study of Contexts and Concepts**

1. To examine middle school children’s learning of science in a science classroom with a socio-cultural and contextual framework

2. To examine children’s conceptions of matter and factors that influence children understanding of the conception of matter and the process of science learning.
Dimensions of the problem.

1. The curriculum, textbook and classroom for studying science, the classroom processes and children’s conceptions.

2. The social world of the child: the larger socio-cultural context of the school and everyday contexts of the child, their home and community from which they come from.

3. The child’s conceptions of matter and learning of the concept from the textbook, classroom and everyday material world.

Question

I. Learning Science

a) What is the structure and what are the characteristics of the pedagogies that children experience in the teaching and learning of science?
   i. Curriculum and policy
   ii. Textbook: Teaching and learning using textbooks
   iii. Classroom: setting of the classroom, immediate physical and social aspects of the science classroom, experimental procedures and materials used, textbook, writing materials and concrete materials used, mode of teaching, conduction of experiments and activities, participation of teacher and children in the classroom

II. Socio-cultural Context of Learning Science

a) What are the constitutive elements of ‘social’ and ‘cultural’ in relation to the process of teaching science?

b) What are the elements of social and cultural contexts within and outside the schools and how do these aspects of the child’s life interact with their learning at school?

c) How do we theorize the character and consequences of school-home or everyday difference that exist for learner from the point of view of learning?
   iv. Everyday Experience
   v. Everyday material world
   vi. Language
a. Language of science-understanding the words unique to science, words which acquire different meaning when used in science, also learning to read scientific symbols and diagrams and bridging the everyday language of children to the vocabulary, structure, form and genres of science

b. Everyday language

vii. Social interaction-interaction with adults (parents, teachers, peers etc.)

physical and social spaces

viii. Everyday social and physical environment

ix. Informal learning situations surrounding the child

III. Nature and Structure of Children’s Learning of Science Concepts and Scientific Thinking and the Content of Matter Understood by Children

a) What is the treatment and approach given to the concept of matter in the textbook? To what extent does this draw upon and involve the child’s everyday experience of matter and everyday language?

b) What is the treatment and approach adopted by the classroom for teaching the concept of matter? To what extent child’s everyday world is drawn into the science classroom?

c) What are children’s understanding and explanations related to the concept of matter?

d) What are children’s ideas of matter that are formed in relation to the classroom and everyday understanding of the concept of matter?

e) Children’s understanding of the key conceptual categories relating to the concept of matter which are: (1) substance (2) solid (3) liquid and (4) gas.

2.5 Conclusion

This chapter began with a detailed presentation of constructivism as is relevant to both the study of concepts and contexts of learning science. The discussion began with Piaget’s theory and centrality of ‘action/interaction’ and ‘the world’ in cognitive development as portrayed by his theory. The contribution of Vygotskian theory to the elaboration of the idea of socio-cultural context was
then discussed, drawing attention to both the dimension of ‘interaction’ with more capable peers/adults as well as cultural tools—language and text—in enabling children to access the resources of the discipline. The section on science learning developed these cognitive/constructivist theories to dwell on educational issues of learning science and in particular the question of the formal discipline of science which is mediated, recontextualised and made available to children, by textbooks and classroom processes. This part ended with a review of some significant studies in the Indian context. The third section of this chapter drew on studies which bring out various dimension of the ‘home-school’, ‘everyday-school’ tension in Indian education. The multifarious dimensions of this tension as constituted both by the historical experience of colonization as well as practices of ‘rote learning’ were discussed. This was followed by a brief discussion of three important field/policy experiments/experiences which are defining of the way in which school-home dichotomy has been problematised and addressed in Indian education in general and science education in particular. This is the Hoshangabad Science Teaching Programme, the People’s Science Movement and finally the National Curriculum Framework, 2005. This discussion is useful as it broadens the basic question of home-everyday and of socio-cultural contextualization of school learning (and science) into the complex Indian educational and socio-cultural scenario. The chapter ends with using these discussions to evolve an approach to the issues which are of concern to this thesis and ends with a section devoted to sharpening the research questions.

Endnotes

1 Piaget divided the stages of development as sensory-motor, pre-operational, concrete operational and formal operational periods. During stage 1, sensorimotor stage (birth to 2 years), cognitive development focuses on motor and reflex actions. The child learns about herself and her environment through sensation and movement. The next stage which is called pre-operational (6-7 years), the main focus of the child’s intellectual development is language and using symbols (e.g., pictures and words) to represent ideas and objects. The child does these intuitively. The child at this stage has an active imagination and vivid fantasies. It is not uncommon for him to personify objects. It is during concrete operational stage (6 to 11), children begin to process abstract concepts such as numbers and relationships but they need concrete examples to understand these concepts. If before they could manipulate objects only physically, now they can do so mentally. During stage 4, formal Operation, the child begins to reason logically and analytically without requiring references to concrete applications. This symbolizes the reaching of the final form of intelligence. At this stage, the child is also capable of hypothetical and deductive reasoning.
a) Cognitive validity requires that the content, process, language and pedagogical practices of the curriculum are age appropriate, and within the cognitive reach of the child.

b) Content validity requires that the curriculum must convey significant and correct scientific content. Simplification of content, which is necessary to adapt the curriculum to the cognitive level of the learner, must not be so trivialized as to convey something basically flawed and/or meaningless.

c) Process validity requires that the curriculum engage the learner in acquiring the methods and processes that lead to generation and validation of scientific knowledge, and nurture the natural curiosity and creativity of the child in science. Process validity is an important criterion since it helps the student in ‘learning to learn’ science.

d) Historical validity requires that science curriculum be informed by a historical perspective, enabling the learner to appreciate how the concepts of science evolve with time. It also helps the learner to view science as a social enterprise and to understand how social factors influence the development of science.

e) Environmental validity requires that science be placed in the wider context of the learner’s environment, local and global, enabling him/her to appreciate the issues at the interface of science, technology and society and preparing him/her with the requisite knowledge and skills to enter the world of work.