CHAPTER 8

Conclusions

8.1 Overview

This thesis mainly addressed the question how the multidimensional cultural world of the learner makes a substantive difference to the science that children learn in school, and how experiences outside school came into interaction with school experiences. The Indian school is believed to have a strongly framed curriculum, where everyday knowledge and school knowledge are separated by a strong boundary. Yet a concept like ‘matter’ in the middle school science curriculum is very much available to children in every day experience.

This study of children in a middle school in a village in Kerala was designed to examine their conceptions of ‘matter’ by taking a socio-cultural situated approach to learning in general and to science learning in particular. The study examined children’s lives and interactions with ideas of ‘matter’ both within the school and classroom and outside the school at home, observed their science classes, analyzed their textbooks and conducted Piagetian clinical interviews around specially designed tasks (one of which was also carried out in the site of the home). The study attempted to factor in the socio-cultural dimension of learning by paying specific attention to context of learning—the school and the science classroom vs. the context of everyday world.

Following a Vygotskian approach of situating learning, the cognitive, socio-cultural and science education approaches were seen to be enveloping and related frameworks which can be used together to understand children’s emerging scientific conceptions. This science knowledge was accessed by children mainly in their science classrooms, and was given shape by the science curriculum, the textbooks and the pedagogic work of the teacher. The cognitive perspective was brought in while examining the individual child’s understanding of conceptions of matter. The socio-cultural perspective along with the science education perspective was drawn upon to understand the context as constituted by the science curriculum and textbooks of the State of Kerala, pedagogic activities as shaped by the textbooks and carried out by the teachers in the science classroom. In
addition, language of the children and the language of the school science were also examined.

Given the ambitious scope of the objectives, multimethods were used for the investigation. These included qualitative observations of the village, the school and science classrooms, and cluster teacher meetings, document analysis of the curriculum, textbooks and teacher handbooks, and tasks for children to carry out, along with clinical interviewing. The findings of the thesis were laid out in four chapters: introduction to the village, the curriculum and textbooks, the classroom and finally children’s conceptions.

In this concluding chapter of the thesis, I will first gather together the various findings as laid out in the last four chapters. I will then reflect on the implications of these findings, firstly for the conception of ‘everyday’ in science curriculum and science learning, and secondly for drawing out pedagogical and curricular implications. I will end with some suggestions for future research that have emerged.

8.1.1 Everyday World and School World

Chapters four, five and six showed that the textbook, teachers, science classrooms and pedagogic processes of the present school in Kerala presented a picture quite contrary to the popular stereotyped perception of Indian government schools which are believed to follow a rote based, strongly framed curriculum. The design of the curriculum and the pedagogy both showed a strong emphasis on bringing everyday and familiar world of children into the classroom and in science learning. Teachers were active in making this happen in their science classrooms. This was possible as the content of the textbooks frequently invoked the everyday and familiar. More importantly in the classroom processes and activities, experiments and demonstrations were actually executed and involved bringing in common and everyday materials. In the projects, seminars and maintaining a science diary too the emphasis was on bringing the everyday into the classroom.

In Chapter six, the classroom was studied and showed how science classrooms were structured to initiate children into the culture of school science. The science text book certainly proved to be a major instructional tool through which children were ‘encultured’ into the form, content and language of school science by providing activities, experiments, discussions, questions, problems and writing practices. The curriculum recommended, the classroom, text book
and teacher draw upon the familiar materials available in child’s everyday world, based on which and through which the ‘enculturation’ happens.

The science textbooks contextualized school science knowledge (also the concept of matter) in the everyday and familiar world of the child. The pedagogic aim of the textbook was to initiate children to the scientific world of matter by means of drawing on familiar everyday world. The textbooks attempted to connect the concept of matter to the everyday material world of the child by drawing on and by fixing discussion of topic around examples, materials, phenomena and process that were familiar to children. Each unit began by invoking the everyday world of the child. The topics related to matter in the fourth and fifth grade were limited within the familiar everyday examples and everyday terms; in later grades it progressed to formal scientific terms and to complex and abstract concepts. Text book design of grade IV to grade VII was in such a manner that there was an attempt to sequence concepts with everyday examples which would lead the learner to learn about the concept through an example from everyday context to that of science. Moreover the pedagogic methodology adopted and inquiry learning framework chosen by the textbook had several explicit teaching-learning strategies all of which provided ample scope for connecting learning with everyday world.

Yet, though the curriculum, textbook and classroom process included a great deal of the everyday world of the child, still we can say that the child’s everyday world and the world of science are two distinct worlds and the manner in which the two worlds approached the material world are also distinct. The aims, purposes and processes in which the material world is approached—nominalised, categorized and viewed—were different. In the everyday world, children construct concepts about materiality and objects based on their functions, by acting on them; by seeing what they can be used for, or what happens to them when an action is performed. Science has its own conceptual categories, process, structure and language to talk about the material world. The words such as dravyam (matter), padartham (substance), kharam (solid), dravakam (liquid), and vathakam (Gas) are unique to the science classroom. Children encountered these words only within the domain of the classroom and the very nature of the word imposed on the child the need to recall the form, content and conceptual categories of a science classroom or textbook and not the categories of their everyday material world. We may say that the aim of the lessons on matter was to integrate the child to the form, content and language of science. While every day examples were used, they were aimed at initiating and integrating children into the world of science. The everyday world as invoked in the science classroom was to fulfill
this purpose; i.e. as a tool or medium through which the scientific world was
introduced to the children. In the school the everyday world was appropriated for
school purposes and the science class room imposed its conceptual categories,
processes and language of science. In other words, the school science
‘recontextualised’ the everyday. The everyday world was not in a similarly position
of power to impose on children any ‘recontextualisation’ of school reality.

Proponents of experiential learning argue that is vitally important that
the skills and knowledge which students learn in classroom need to be integrated
fully into their lives and vice versa. This seemingly simple and obvious value
is far more complex and subtle when we examine how, even in the case of this
Kerala science classroom, where the everyday world is being almost constantly
invoked, the two worlds are still distinctive. At best we may say that the everyday
is appropriated by the science classroom, the reverse is hardly in evidence.
Whether the two can ever be seamlessly integrated into one reality for the
child is still a question.

8.1.2 The STS Approach in Science Curriculum

Chapter four brought out the significance and depth of the educational reforms
that have been underway in Kerala since the 2000s. The Kerala State Board
introduced several changes in the schooling process: the curricular approach,
classroom practices, pedagogic methods, textbooks and teaching material,
teacher training and empowerment, new evaluation methods and community
participation. These reforms were initiated as a part of the District Primary
Education Program and continued through the Sarva Shiksha Abhiyan. The
important aspects of these changes has been a major curricular revision, its
focus on decentralized and participatory planning where the community link
to schools and devolution of power to panchayats were expected to improve
the quality of education. There was explicit encouragement and valuing of
learning through the use of resources of the environment and the community.
The programme of curriculum revision was supported through the development
of new textbooks, hand books for teachers and a course of in service teacher
training workshops for teachers, to be conducted and supervised by the block
and cluster resource centers. The new curriculum introduced a learner-centered,
activity-based and process-oriented pedagogy and adopted a scheme for
comprehensive and continuous evaluation. The new curriculum and pedagogic
process reached the school and classroom through rigorous teacher training
program, teacher handbooks and active participation of various institutions such as SCERT, DIET, BRC, CRC, local community and teachers, in planning, educational management and implementing the programmes.

Chapter five brought out the chief characteristics of the Kerala science curriculum which subscribed to what may be characterized as a ‘progressive view’ of children’s learning, emphasizing joyful learning of science, children’s interests and curiosity as the basis and aim of curriculum and pedagogy. It drew on (social) constructivist ideas of learning, and proposed a teaching method that is ‘child centered’. These ideas follow the broad pedagogic and curricular reform that was called for by the Yashpal Committee Report (MHRD,1993) and informing the DPEP curriculum reform agenda. While in the DPEP itself, curricular and pedagogic principles were more loosely stated in terms of progressive ‘child-centered’ ideas, (Dhankar, 2003, Sarangapani, 2010), in the case of the Kerala curriculum, cognitive concerns seems to be more directly recognized and stated. The new curriculum developed recommended for linking children’s learning of science within and outside the classroom. This was believed to be essential from the point of view of the child’s cognitive development. Developing the ‘interest’ and ‘curiosity’ of the child, to be instilled through the treatment of central themes and ideas, was a key feature of the curricular reform. The new approach recognized child’s own active role in the learning process and emphasized a facilitating role for teachers in the process.

The inclusion of the process aspects of science learning and its formulation of the Kerala science curriculum is very much in the lines of the UNESCO sourcebook of science education (Harlen & Elstgeest, 1992). The process skills such as observation, measurement, problem solving, and interpretation of data—doing science etc. were in accordance with those emphasized by the UNESCO source book. What was noteworthy in the science curriculum objectives was it’s emphasis on connecting learning to ‘outside the classroom’ world of the child, and the development of ‘scientific attitudes’ and values. There was an explicit concern regarding societal and environmental issues, as also towards creating a citizenry who are scientifically literate, and who can understand how science, technology and society influence each other. Such an understanding, it was argued, will enable the learners to become better informed decision makers in everyday life situations.
These objectives of the curriculum can be considered as features that mark a curriculum for ‘Science and Technology Literacy’ as formulated by UNESCO (Holbrook, Mukherjee & Varma, 2000) and also within the People’ Science Movement. Two out of the five stated aims of the science curriculum elaborated this commitment. This aim, although not totally displacing learning of ‘formal science’, nevertheless places it in the foreground. An overall ‘practical’ and ‘relevant’ science, consonant with a system of mass compulsory education oriented toward the creation of a scientifically literate citizenry was emphasized in the curriculum. Generally there were more ‘utilitarian’ and application oriented/STS orientation to school science in the primary and middle school grades with chapters that dealt with STS/environment/health issues. Again, the content of the science had an STS approach. This science education was envisaged to cater to and include children from all backgrounds, and be of relevance to children who may not opt to pursue higher education in science.

The curricular principles recognized doing science and the role of experimentation as important process skills. But there was little said regarding formulation of generalizations, abstraction, theory and model building which are also essential aspects of science learning. Thus while making science learning ‘active’, experimentation and activities were promoted, and their role in proving hypotheses or confirming principles was recognized, but not in integrating the inquiry to theory building. Theorizing which is an integral part of science learning that must follow an empirical investigation did not find any explicit mention/place in the curriculum and in the teaching-learning process.

There was little attention paid by the Kerala Science Curriculum to the concerns raised by the international science education research and curricular approaches post the 1970s, which have brought in the significance of teaching the nature of science, or the limitations of science and scientific methods in school science curriculum. This is despite the extensive writing in the area of history, philosophy and sociology of science, and its significance for science education. This was also contrary to the views of the Kerala science curriculum which intended that science promote development of ‘scientific attitudes for an enlightened citizenry’.

Derek Hodson argues that

‘failing to provide every student with an adequate understanding of the nature of science runs counter to the demand for an educated citizenry capable of responsible and active participation in a democratic society. A proper understanding of science and the
scientific enterprise is a key component of scientific literacy, and is just as essential as scientific knowledge (i.e. conceptual understanding) in ensuring and maintaining a socially-just democratic society’ (Hodson, 1998, pp192)

8.1.3 Curricular and Pedagogic Reform

The manner in which the state of Kerala implemented the new curriculum through a systematic, rigorous and compulsory in-service teacher training program is noteworthy. The process of implementation bringing in and coordinating with various bodies from the state level to the individual school level can be considered as a remarkable achievement. Teacher training helped the teacher to plan the classroom teaching and processes; also plan each unit of the textbook prior to teaching. This eventually helped teachers to implement the curriculum objectives in a systematic manner; to structure the classroom activities in discussion with the colleagues and share ideas with each other. The sessions trained the teacher on every aspect of pedagogy and also teach science keeping strict adherence to the processes suggested in the teacher’s sourcebook and contents of the textbook. The training sessions demonstrated to the teachers how to conduct science classes through activities and experiments. Teachers got a prior understanding of materials required, the method of setting up an experiment and how to introduce content in the classroom through activities and experiments. Thus it supported the teacher to be prepared for classroom teaching of science according to the new pedagogic strategies, to implement the new curriculum and to use the handbook. Teacher training programs also attempted to enhance teacher’s understanding of the new constructivist and student centered pedagogy, and also helped in transforming their attitudes towards children.

While textbook determined the content of what is to be taught, the teacher handbook determined the manner in which it has to be taught. It scripted and planned all aspects of the classroom transaction of the content and curriculum. The teacher’s handbooks intended to facilitate teacher’s work by elaborating the curricular and learning objectives to be attained, the content to be taught and the pedagogical methodology to be adopted in the science classroom. The scope of each topic, intended learning expected from each topic and method of treatment of the content was all specified in the teacher handbook. Textbook together with the teacher handbook served as significant tools for the transaction of curriculum in the classroom through the teacher.
The teacher’s handbook was also a very detailed document supporting all the topics contained in the textbook. Although not detailed at the level of lesson plans, the teacher handbook supported the teacher to structure the content and activities of each lesson to be conducted in the classroom. The handbook also elaborated on the manner in which new pedagogic methods such as projects, seminars and experiments have to be conducted; as also the mode of evaluation. The handbook listed systematically several generic activities that were to be used to design the learning in all the chapters of science textbooks. It provided scripts and plans for every aspect of the classroom transaction of the content and curriculum; also the manner in which children has to be evaluated according to continuous mode of evaluation. Thus the teacher handbook in a great extent determined the manner in which content has to be taught and the activities that has to be conducted in the classroom.

What can be noted is that when the teacher handbook scripted the classroom processes for the teacher, the teacher training session trained the teacher how to follow the script. Thus every aspect of the classroom processes was controlled and predetermined by the curriculum designers and implanted systematically to the classroom through a rigorous and compulsory teacher training processes. This in a way constrained the creativity and teacher’s own role, approach and thinking towards the science teaching to be exhibited in the classroom which in a way put the agency and role of the teacher in question.

What can be noted in the case of Kerala model of curriculum development is that, curriculum was devised at the state head quarters by team of experts and disseminated to schools via directives, guidelines, and teacher handbooks and enforced through resource people visiting and monitoring the classroom processes, checking children’s science diaries, seminars reports, projects, answer sheets, evaluation sheets etc. The curriculum developers specified the knowledge and skills required to implement the new curriculum and imparted them to teachers through rigorous in-service teacher training programs that were made compulsory for every teacher. The curriculum was spelt out in remarkable details in the teachers handbook that provided lesson by lesson directions, manner of conducting every activity, experiments, projects, seminars and manner of evaluation, in an effort to render curriculum ‘teacher proof’ (Hodson & Barnett, 2004). This made the role of the teacher similar to that of a ‘performer’, who job was to perform according to the script, teach in a way prescribed by others and asses students learning in a way that is designated by others. This approach has been called as
the “Engineering model of change” (Elliot, 1994 in Hodson & Barnett, 2004) which Hodson’s paper illustrates as the tradition and model that existed during the 1970’s “The Engineer designs a system which will fulfill certain precise function or goals, and then supervises its implementation. The plan enables the engineer to control the process of development by communicating his/her requirements to the workforce, and providing criteria for monitoring and supervising progress” (Elliot, 1994)

8.1.4 Approach to the Content and Pedagogy in the Science Textbooks

Chapter five presented a detailed analysis of the Science textbooks from grades IV to Grade VIII. The overall approach and pedagogy of the science textbooks promoted integrating science with the everyday world. In primary and middle school, there was a significant inclusion of familiar world of the child, as well as explicit opportunities were provided by the textbook for children to connect and situate their learning of science in child’s familiar everyday world, as a part of the pedagogic innovations of the curriculum. This could be seen firstly in the form of the examples invoked by the textbook, secondly in the instances of process and phenomena, and thirdly in the ‘contextualization’ of science content by the various activities that were actively incorporated as pedagogic strategies. The textbooks were replete with requirements of ‘inquiry based activity learning’—requiring children to conduct surveys, collect information, do experiments, observe, conduct seminars and maintain a science diary. Thus the pedagogic approach reveals significant innovative efforts of bridging the school and everyday contexts.

Regarding content and topics, on the whole it may be observed that there were distinctive transitions in content and overall approach, from primary to upper-primary/middle to high school science. In primary and middle school the content tends to be more everyday and utilitarian science, which was oriented towards understanding and explaining the everyday, that progressed towards formal and conventional science in high school. There was also a shift in the manner in which the textbook introduced the concepts in middle school and high school. While the primary and middle textbook introduced the concepts based on inquiry and activities, the high school textbook adopted a traditional content oriented approach.

A review of the textbook topics and disciplinary areas into which the topics fall into suggested that, in the Grade IV science content is distinctly ‘pre-
disciplinary’ in its form. Topics were of a general science/nature/environmental studies character. There is a general ‘functional’ or ‘utilitarian’ and a ‘value’ dimension to the topics and an overall ‘relevance to everyday life’ base for these topics. There were also topics that were introduction to descriptions of phenomena and introduction to a science view of and naming of the everyday familiar world. The middle school science content (Grade V to VII) can be more consistently and systematically divided into ‘pure science’ which basically draw content from physics, chemistry and biology and ‘applied/useful science’—environment and health. The identification of topics which can be directly understood as ‘agricultural sciences’, ‘food technology’ ‘environmental sciences’ and ‘health sciences’ was an important feature of this stage of schooling and content was with a disciplinary character, and applied character. In the high school, as represented in grade VIII curriculum, the entire content was drawn from disciplinary sciences—biology, chemistry and physics. There was a distinctive absence of environmental science, agricultural science and health science from this curriculum and it adopted a very conventional approach to the content of science learning.

Experiential/ inquiry based learning and activities were prime pedagogical devices employed by textbooks. The textbooks provided a framework/format for self learning and directed children to explore the world around them, learn through activities, and record their learning in the textbook and eventually reach the intended learning objective. All units of middle school science contain a number of practical work and activities that has to be conducted both within and outside the classroom. The instructional criteria included children learning science through teacher’s lectures, working in groups on activities, exercises, conducting projects, surveys, seminars, participating in club activities etc.. The content of learning was presented through open ended and creative activities, also through everyday examples, explanations, comments, and practical exercises. The skills and knowledge targeted through various activities that took place in the classroom and outside the classroom were linked together through the textbook. Also the textbook provided the format and space to record children’s observation. The textbooks also guided children to make detailed observations in their science diary. The textbooks did not tell all that was to be known, but suggested activities through which children could arrive at conclusions rather than provide readymade answers that had to be memorized. Thus textbooks were open-ended, e.g asking for , what happens when egg shells are added to lime juice; water is added to quicklime; observe the changes happening to sugar when heated. The textbook
expected that students would perform these activities with the help of the teachers in order to draw their own inferences or reach at conclusions.

8.1.5 Treatment of the Concept of Matter in the Science Textbooks

Chapter Five also showed how Kerala science textbooks organized the concept of matter. There was a progression of the concept from familiar everyday to the formal science, concrete to abstract, from macroscopic to microscopic from the middle school to the secondary school. The concept progressed from properties of matter, its states, pure substance and mixtures, elements and compounds, physical and chemical changes to atomic structure. In terms of the content coverage, the textbooks were rich and covered all significant concepts related to matter both in chemistry and physics. The textbook also introduced advanced, abstract and complex concepts of science at an early stage. However, the conception of ‘materiality’ was distinctively absent. What was evident in the seventh and eight grades was the numerosity and complexity of the concepts related to matter in the science textbooks. A range of topics such as acids and alkalis, the language of chemistry, the relation between chemical energy and energy change, speed in chemical reactions, the world of chemistry, chemical formula, rate of reactions, peep into the atom, compounds and valency, water, solutions, acids and bases and heat that includes kinetic theory of matter were introduced in these grades. It has to be examined the kind of learning arrived by the child with respect to these topics and concepts; also whether content is age and stage appropriate. What more the textbook has to do is: prior to introducing the concept of matter the textbook has to provide a format to understand children’s existing conceptions of matter, based on which meaning of matter has to be introduced to students with more conceptual clarity. The textbook didn’t make any approach to invoke child’s prior knowledge of the concepts under study. Designing instruction and introducing content based on child’s prior knowledge is one of the important suggestions of a constructivist mode of pedagogy.

With regard to the content and its selection and organization, especially related to the fundamental topics of science, there seemed to be less innovation and exploration in the case of Kerala science textbooks. The development of a systematic strategy for curriculum innovation requires research in the planning, sequencing and selection of content based on significant concepts of science, also based on the cognitive abilities, and age of the learner. This also requires design of pedagogic strategies to introduce content, new teaching learning materials, evaluation of the effectiveness of teaching learning strategies, and
devising methods of implementation of different components of the curriculum. Such work has not been undertaken systematically in the case of the Kerala Science Curriculum and textbook, especially in the case of the choice of content, sequencing and organizing it based on the cognitive abilities, and age of the learner. What was also noted is the fact that there was not much difference in terms of the selection of fundamental science topics between these textbooks and the ones that were used prior to DPEP days or 2005. In fact this selection and organization of the contents of fundamental science present in Kerala science textbook is fairly standard and followed across the country in all syllabi produced prior to 2005. It seems that the implications of constructivism and child-centeredness got applied primarily to pedagogy but not the choice of content itself.

8.1.6 Language of Science

Chapter five also discussed the preponderance of Sankritised Malayalam in the science textbooks. The science textbooks of Kerala State Boards were written in Malayalam which is the mother tongue of children. However the language was formal and sanskritized, and therefore quite different from the language spoken by the child in the everyday and home context. The influence of Sanskrit goes to the very foundation of the scientific Malayalam. Like Latin in Europe and elsewhere, Sanskrit has been used by the educated classes in Kerala for literary and religious purposes (Joseph, 2000). Thus science textbooks have a sophisticated language which is unfamiliar and difficult to the child. With respect to the concept of matter, majority of the terms were coined in the Sankritised Malayalam. It is not only that Sanskrit was dominant in the text book vocabulary, but also English, Latin and Greek terms. Terms such as neutralization, valence, electron, proton, pipette, burette, isotope, nucleus, proton, electron, neutron, colloid, emulsion etc. didn’t find a parallel Malayalam word and hence the textbook continued to use the same word in Malayalam. Thus while learning science in Malayalam: children are developing an understanding of scientific concepts along with developing an understanding of a new language of science in scientific Malayalam which is a combination of the languages of Sanskrit (concepts), Latin (scientific names) and Malayalam (text). Moreover scientific vocabulary in Sankritized Malayalam has the influence of a European dimension and the historical development of science in the local context. If we examine the concepts related to matter and its translation: Matter- Dravyam, Substance-Padartham, Solid-Kharam, Liquid-Dravakam, Gas-Vathakom, Elements-Moolakam, Compound-
Samyuktham, all these words translate to Sanskritised Malayalam. These words when first encountered were so rarely heard that children find it difficult to comprehend, retain and recall. Thus learning science in Malayalam is similar in complexity to learning science in a new language as it involves understanding of concepts that are more Sanskritized than have similarities to or words drawn from everyday Malayalam.

8.1.7 Dominant Pedagogy in Middle School Science Classroom

What was evident in the middle school science classrooms was that, of all the instructional strategies that were recommended by the teacher handbook, the ones that the middle school teacher was found to employ were four:—demonstration, discussion, projects and seminars. In the classroom process, even those focusing on activity/demonstration primacy was given to teaching the content, and the activity was treated as a method for making the content realistic and interesting. The practical activities were done in the classroom to note down observations, make phenomena more real, interesting and connected to the everyday world-materials and instances, and reinforce content of what is to be taught. The teacher initiated, controlled and directed the discussions that happened in the classroom, and discussions were structured around the content. The children responded to the teacher initiated discussions. Teacher tends to begin the class by asking questions to the whole class and then move on to teaching through demonstration or explanations. Towards the end teachers emphasized the important conclusions that the children need to be remember from the experiments. Also while activities were being conducted by the teacher, children knew what they were expected to write in textbook tabular column or notebook, which was a general format followed for all lessons. Here it was not explicit in teacher’s instruction about when the children should make notes in the tabular columns of the textbook or write in the notebook. The process was understood by children from the previous lesson.

For each science classroom session the teacher had a fairly clear lesson objective and predetermined plan and came into the classroom with apparatus and materials required for conducting the experiment. The structure, content and process of the science classrooms and discussion, adhered to this predetermined plan of the teacher, as also content and learning sequence provided by the textbook and directions provided by the teacher handbook. The classes were structured in such a manner that it introduced the topic, conducted demonstration through
which concepts were introduced and then moved on to discussion with children about the concepts. Children’s contributions were invited to closeended questions that related closely to the objectives and content of the lesson. Other observations of children that were outside the limited content of the lesson were not engaged with. The answers from children were taken as prompts to continue/enrich the discussion that was within the limits and content of the lesson.

The science classroom mainly focused on transaction of the content of the textbook in a manner as described by the teacher handbook. Even though activities and demonstrations were the prime pedagogical devices, we cannot say that it got translated into the classroom in a meaningful manner as the science classroom treated the activity as having a particular outcome and conclusion and the activities were done as a simple proof to establish the facts. Activities were used as a way of verifying the ideas or principle given in the textbook rather than as a means for open ended investigation. Student learning happened through watching demonstration done by the teacher. Even if children got a chance to do experiments independently they followed the instruction provided by the teacher and textbook, that directed children which particular observations to focus on and the inference was also told to them. Teacher described and explained the experimental procedure in great detail while demonstrating. The tabular column provided in the textbook gave all details that had to be observed. Thus while doing a demonstration the content of the textbook was translated into a set of physical activities by the teacher. In doing all this, the teacher was following a script or recipe while doing science classroom activities. The textbook decided the content to be taught and hand book decided mode of transaction. There was little autonomy for teacher. Every activity conducted in the classroom and examples used by the teacher were the ones given in the textbook and the handbook scripted the conduction of classroom processes for the teacher. Thus we can say that science classroom processes were heavily scripted and the invoking of everyday was predetermined by the handbook and textbook. Teachers followed the scripts of the handbook.

Connecting to everyday life: - In science classrooms there were many opportunities for the teacher to draw upon children’s everyday experiences through her questions. This was seen in demonstrations, even lectures and in project mode etc. The range of activities in the science classroom was impressive and the seriousness with which they were conducted by the teacher was also commendable. But at the same time it must be noted that the examples were used to further the objectives of the lesson and thus used in more circumscribed ways. Children were not invited to speculate on theories and reasons very much.
In all the classroom episodes we noticed several references to everyday experiences of children being invoked by the teacher. The materials that were employed for the experiments and activities were ordinary materials chosen from child’s everyday world that were familiar for children. The use of familiar everyday concrete materials or examples gave contextual meaning to the science experiments and content.

The project and seminar were methods employed by the science classroom to reinforce the content of the units by relating it to an application or everyday phenomenon. The projects did engage children with investigations of their everyday life and this was a valuable source of connecting with the world around. However, the units in which such projects were present seemed to be limited to the topics that dealt with STS related units (health, agriculture, environment) and less with those which may be classified as ‘basic science’. None of the chapter on fundamental or basic science in middle school grades had projects. What can be noted in the case of the seminar was that it was also conducted for topics related to environment, health, and agriculture. What is to be thought over is whether teaching of fundamental science through project method is difficult to achieve or what kind of preparedness it demands from the teacher, textbook and curriculum.

**Recontextualisation of everyday**: In the science classroom episodes, what we noticed was the use of everyday materials to introduce the concepts that were exclusive to the domain of science (i.e. materials such as sugar, water etc was invoked and used in the context of a science classroom to introduce concepts such as ‘elements’ or ‘liquid pressure’) which we can say everyday familiar world of the child was recontextualised in the context of a science classroom. What can also be noted is the translation of classroom activities, experimental procedure, conclusions and discussions into a written format in children’s notebook which was the manner through which children were trained to the language structures and vocabulary of science. Moreover while converting these to a written format, everyday example, concepts and language was being ‘recontextualised’ to that of language and procedures of science.

One of the aspects that need to be examined in the present science classroom is that of engaging learners in meaningful/authentic scientific inquiry that will also introduce children to the fundamental concepts of science by relating it to the everyday world of the child. The investigatory approaches were employed more in environmental related, socially relevant topics that can be generally
categorized under STS. The topics tend to prepare children who are aware of the environmental problems, who also know ways to find solutions for the problems.

In classroom observations, there was no attempt made to accommodating instruction to an individual child—accommodation that takes into accounts the experiences and knowledge of the individual child. Another aspect that was noted was appropriating students’ knowledge as an integral part of instruction was missing. Invoking children’s prior knowledge was totally absent in any of the classroom observation which is the marked characteristic of science learning as advocated by constructivist science curriculum.

Observations of the science classroom and discussions with the middle school science teacher suggested that teacher and classroom processes were in consonance with the spirit of the new curriculum and pedagogic methods. One of the major constraints noted towards the implementation of the new mode of pedagogy was the strict time tabling of the school day into forty five minutes sessions which had to be strictly followed by teachers. This constrained science teaching according to an inquiry or new mode that required grouping children, distributing materials or taking children out of the classroom, conducting discussions, etc. Every inquiry or exploratory mode of learning requires its own time depending on the nature of the activity. While it was noted that the classroom environment was on the whole supportive, the gendering of the classroom is also an important aspect that must be noted.

The efforts and teaching learning process of the science classrooms have shed some light on the challenges and opportunities of building constructivist and project-based science curricula and classroom that accommodate everyday world of the child, and support inquiry-based teaching and learning in schools. The range of pedagogic strategies which were a part of the curriculum and pedagogy was impressive in terms of the range of experiences it provided for children and the opportunities it gave to bring in relationship with everyday life experience.

### 8.1.8 Children’s Conception of Matter

**Conceptions of substance:** What was evident regarding children’s conception of ‘substance’ was that children’s initial understanding of substance was very much based on perception—seeable and tangible matter. These initial conceptions were quite different from the concept of chemical substance that was the target of the middle school curriculum. Children’s initial conceptions of substance were
characterized by a lack of appropriate categories for substance and their interaction. They cognized the relation between substance, material, object, or a thing, but were not able to explain the relation in a clearer manner. Further more children found it difficult to explain in words the distinction between the ideas of object and materiality—perhaps this difficulty was compounded by the fact that in Malayalam there is only one term vasthu for both material and object. Children cited not only substance/materials kinds, but also objects such as table, pen, and chair as examples for ‘padartham’ where water, stone, iron, sugar, salt etc. were being the more frequently cited examples for ‘padartham’. There was no significant conceptual progression observed between children of different grade levels as there is tremendous overlap in conceptions among students of different grade. In retrospect, seen through the eyes of the children, this concept also in fact seems to be far more abstract than at first sight. The concept of ‘substance’ seems to be akin to a super ordinate concept which itself has limited scope for direct meaningful conceptual engagement. While it seems to be the logically basic level term in the scientific development of the concept, psychologically it seems to be limited in allowing children to grasp its meaning or finding it useful in organizing their experience of the material world. What was noted in the clinical interview was that though children found it easy to give examples for substances they found it difficult to define substance; they in fact seemed to shift and provide multiple definitions to define substance during the course of the interview. Children were seen to systematically connect their own everyday term ‘Vasthu’ with the formal science textbook term ‘Padartham’ and assert, apparently tautologically that vasthu is padartham i.e. substance is a material or object. “Vasthu” is a word that is used in Malayalam simultaneously for an object or the material from which an object is made. “Padartham” in contrast was the term used in the science text book. Children intuitively explained what a “padartham” was by recalling examples from the textbook and by connecting examples to the definition of a substance. It was also noted in the interviews that definition for substance was also given based on the textbook defintion, which is “padartham is solid, liquid and gas”. Children were also clear about the distinction of it terms of solid, liquid and gas; also examples for solid, liquid and gas. The definition also evolved from a consideration of examples and non-examples. Children didn’t consider living things or anything that has life or can move as examples for substance.

Children’s conception of ‘substance’ which was the key concept focused on, in this study, is found to be elusive for children, having the characteristic of
a super ordinate concept rather than a basic one. Children have difficulty separating the idea of materiality from object distinction of which is the key to the understanding of the concept of substance and of matter. The examples that children provided for substance was dominated by everyday examples and science textbook examples that were objects, material kinds and substances. As shown in the children’s attempts to define ‘substance’ they did not find adequate everyday language to capture the idea of substance/padartham. Instead they tried to use textbook language. Those children who provided more appropriate examples for padartham were also found to be the same children using textbook language to define the concept. Rather than interpreting this as rote memorization, we suggest that given the abstract character of the concept and its irrelevance to everyday life, the science language from the textbook was necessary for children to be able to convey their understanding of the concept. This was especially so, given that in the everyday language, there is insufficient distinction between the ideas of object, materiality and substance.

Conceptions of solid, liquid and gas:- With regards the conceptions of solid, liquid and gas, solid was by far the concept with which students related most easily. Stone seemed to be a prototypic solid with ‘hardness’ being a prototypic property. The properties that dominated children’s thinking of solid were everyday experiential properties and they did not support the children in differentiating the idea of solid from the idea of object. For example both table and wood; iron box and iron dominated children’s example for solid. The idea of ‘liquid’ seemed to drawn from the instance of ‘water’ and from the property ‘flow’. Liquid was also very much an everyday experiential conception. Gas was by far the most of elusive concepts, with hardly any real life examples that children could give for it. But they attempted to explain the concept mainly through the examples of smoke and vapor.

Conception of Solid:- Concept of solid was cognized through a prototypical property and a prototypical example. These results were in accordance with previous studies conducted among school children on the concept of solid (Stavy 1990; Mortimer 1993; Krnel, Watson & Glazar, 1998). What was noted in this case, which is also similar to the above studies was that children cognized the concept of solid through salient properties such as “having a shape”, “hardness” and “heavy/has weight”. The prominence of stone as the example of solid was very evident in children’s examples. Over 95% of children named ‘stone’ as an example. This was followed by ‘wood’ and ‘iron’. The examples children named
for solid can be categorized into two types—those which are materials, and such as wood, iron, gold, glass etc. and those which are objects such as table, chair, bench, box, etc. In the first example, first five examples and total examples named, frequency of occurrence of stone, wood, iron are high and are the mostly cited examples. The group of stone, wood and iron functions as archetypal examples for solid. Stone has both the characteristics of ‘material’ and ‘object’ simultaneously. The absence of powders and least occurrence of soft materials, pliable materials in children’s examples for solid were noticeable. The rigid solids were successfully named by majority of the children as an example for solid, but they left out the non-rigid solids. Materials or objects that are heavy, hard, and rigid and have a definite shape were the ones that were mostly named by children as examples for solid. Children cognized the concept of solid not only through prototypical properties of shape, hard and heavy, but also through prototypical examples such as stone and iron. These materials seemed to have the essential qualities associated with the idea of solidity. Children defined solids based on certain properties which they considered to be essential to the idea of ‘solidity’. These essential properties include having a definite shape, heavy, and hard. The other related properties were: sinks in water, has weight, has color, insoluble in water, visible, strong, won’t flow, has a form, floats in water, needs space, immobile, knowable by touch/hold, malleability, density, rigid, unbreakable, smell, won’t flow, won’t fly, not slippery, like stone, conduct electricity and heat, sound, it is natural/artificial, can’t be destroyed, etc.

Assignment of non-rigid solids:- Assignment of non-rigid solids and powders into solid category was found to be difficult for children. It was noticed during the Piagetian Clinical Interview that children tend to regard any rigid material as a solid, but non-rigid material such as sponge, cloth, paper, powder etc as “like solid” i.e. they tend to put non-rigid solids, powders, soft, pliable, thin solids under a new given category of ‘like solids’. Children considered non-rigid, soft, pliable materials not as good solids and preferred to put in under the category of “like solid”. Identification and reasoning process associated with correct classification of these materials according to the categories given by science classroom that are not consistent with the everyday or real life conceptions seemed to be more demanding for children. Children found it quite difficult to bring together an iron cube/copper cube, and a sponge/ cotton/cloth piece to a single category called “Solid”.

Labels essential to the idea of solid:- Children experience solids by acting upon them for example checking its breakability, solubility, whether can be
powered etc. and tend to represent solids as something that has a shape, hard, rigid and is unbreakable. Children rightly classified rigid solids such as stone, iron as solid whereas non-rigid solids paper, thin plastic, clay, cotton, sponge, cloth were less successfully classified. Classification of powders seems to be even more problematic. From this we can infer that the essential labels ascribed to the idea of solid are hard, that which has a shape, heavy and rigid—terms which relate to direct tactile sensing. What was observed was, among the several properties described, hard is the most distinct property children considered essential to idea of solidity. Thus we can say that the word solid is being used by children as an adjective to describe the extent of the hard substance in an object. An everyday conception of solid, which was based on this property as its key defining property hence seemed to be interfering with the scientific conception, which they were also learning in school.

**Conception of liquid and gas:** The most important feature identified for liquid by the children was that liquids flow. This was followed by absence of definite shape and finally by taking the shape of the container in which they are placed. They also elicited properties such as no color, cannot be held, not hard, drinkable, has weight, needs space, and can’t fly. Children also used ‘water’ like a prototype for liquid and they used this in definitions saying ‘like water’.

The concept of gas was defined in terms of its properties. The key characteristic considered for gas was that it lacks shape followed by characteristics such as invisible, no color, no smell, floats/fly, breathable, spreads everywhere etc. Others were properties that seemed to suggest how elusive ‘gas’ was for them to experience—being colorless, with no smell. Children also tried to explain with several other characteristics which were more to do with establishing that gas exists (it is everywhere) and that it is ‘useful’ (it is essential for life), etc. However, this was clearly a very difficult concept for them to grasp.

**Classification of materials:** The classification task conducted with children shows how children approached and assigned categories to everyday familiar materials.

Regardless of the grade in which children studied and their familiarity with the idea of matter, ‘solid-liquid and gas’, almost all children used experiential and external characteristics of materials in order to classify materials. Their classification was dominated by natural criteria based on material, property, and function. Children’s direct action on material seemed to be the chief instrument
to develop material conceptions. Children approached their everyday world of materials from functional criteria and properties, and the major way they saw their world is through the materiality that makes it. The range of properties that they examined in this was quite wide and impressive and they used multisensorial tests to examine each material.

Children used multiple strategies for classifying and linking the materials together. The final categories formed by the 27 groups (64 children) were based primarily on three criteria: materiality, properties and functions and based on the general category-solid, liquid, and gas. They used mainly concrete categories while approaching materials and towards the formation of groups. The categories children formed included materiality (it is made of wood, or iron, or plastic, or cotton, etc); perceptual categories (such as color, form, shape (definite shape, that changes shape), bend, solubility and insolubility, floating and sinking in water, heaviness, hardness, softness, smoothness, brittleness, breakability, that which can be powered, natural and man-made, those that melts, burns, sticky and viscous materials, transparent, translucent and opaque); functional categories (such as used in the kitchen, decorative items etc) and also textbook categories (such as solid, liquid, and gas). Mainly they approached, identified and categorized materials from functional criteria and properties, and the major way they see their world is through the materiality that makes it.

Another factor that got enunciated in the interview was children considered the activity of classification as a task that is specific to school context as in everyday life the act of classification was not done intentionally. In everyday life classification or category formation is not done as a main goal of an ac. Rather categories are formed for a functional aspect and done implicitly. It is the school or a formal context that demands a task like classification.

The classification task also showed how actions have been instrumental in developing children’s material conceptions. Children identified unfamiliar materials by acting upon them, by seeing what they can be used for, or what happens to them when an action is performed on them. Examples of such actions include smelling, listening to the sound, feeling in hand, touching, holding and weighing, checking material for its breakability, solubility in water, floating and sinking in water, heating the material, burning etc. A quick and successful way of identification was possible by comparing properties of an object or material with a familiar material/object or a material they previously encountered. Children easily categorized solids; especially those which are rigid, heavy and which have
a shape. These are also the materials that got primary attention in almost all groups for primary classification. Children easily identified materials made up of wood, rubber, stone, metals, marbles, brick etc. whereas materials such as carbon rod, ebonite rod, certain liquids, fabric paint, gels etc. turned out to be unfamiliar material for them. It was fairly straightforward for grouping liquids. The materials that posed challenge for identification and classification were gels, creams, powders, cotton, soft materials ebonite rod, carbon rod etc. Overall the tasks suggest that there is no significant difference in the manner which children approached the task or the categories formed at the context of home.

**Difficulty of classifying materials according to the category of solid, liquid and gas:** - Children found it difficult to classify all the items into categories such of solid, liquid and gas. One of the observations made during the task was that, children who opted to do the classification according to the category solid, liquid and gas found it difficult to classify all the materials sticking on to this category names i.e. they weren’t able to stick on to the same category till the end of the classification and classify all the given materials. Material types such as powders, gels, sponges, papers, cotton, rice flakes, leaf, flower, etc. posed difficulties. Children then shifted to a new category based on property or any other concrete characteristic of the material (such as creams, or materials that can be burned, soluble, insoluble) during the course of the classification to accommodate above the material types. Children invented new categories between solids and liquids in order to accommodate powders and gels. Powders got a distinct group or category and children found it difficult to put it under the group of solid. Similar was the case of gels and creams. Clearly the physical experience of these materials had not been assimilated into the science categories of the three states of matter. Thus powders or gels got distinct group apart from solids. Similar was case of cotton, sponge etc as many children found it difficult to bring an iron block, copper cube, a cotton, thin paper, cloth, stone, salt/sugar crystals into one group called solid.

What can be proposed is that children’s everyday understanding of materiality and sensorial experiences of matter had not been reconciled with the scientific concept of matter. The difficulty of classifying the materials employing the category state of matter (solid, liquid, gas) draws attention to the fact that these are not important categories, or significant categories from the point of view of the everyday material world. Rather results from schooling and science education i.e. the categories solid, liquid and gas are very ‘school-
science’ categories. On the whole it can also be observed that science classroom concepts had very limited use in enabling children to approach and handle the real everyday material world. ‘Matter’ and its ‘classification into solids, liquids, gases remained as concepts of the science classroom and school. In everyday children never invoke the classification of materials as solid, liquid or gas. Rather they approached materials based on their materiality, functions and characteristics and by performing certain actions on it. Though matter, solid, liquid and gases are something that permeates children’s everyday world very much, the invocation of these categories is not on the lines of ‘science’. What we can conclude is that science classroom concepts are very limited in approaching and handling the needs of the everyday material world.

8.2 ‘EVERYDAY’ and School Science Education

The efforts undertaken by the Kerala science curriculum, textbooks, science classrooms and teaching-learning processes to extend the science learning beyond the acquisition of textbook facts to the everyday world of the child employing the innovative pedagogic methods and procedures is commendable. The new pedagogic approach of the curriculum and textbook brought in new topics that are related to science, technology, environment and society with rich possibility of everyday application of what has been learned. However, the emphasis was more towards an understanding of the principles of general science and application of scientific inquiry in daily life and environmental issues. It is also based on a notion of science for enhancing quality of community/everyday life.

There were two categories of topics that were present in the Kerala science textbook, one that belonged to the everyday—applied science or topics related to science, technology, and society and one that belonged to the discipline of science—that dealt with fundamental science concepts. A divide existed between the fundamental science topics and applied science topics in terms of the pedagogic approach and presentation of the content. The everyday world of the child entered to the science textbook content in form of applied science or in topics related to science, technology, society not in the chapters related to the foundational science. While the STS topics employed new pedagogic strategies such as projects, seminar, surveys, field study etc to introduce the environmental issues, solve everyday world/life problems, the need to conserve environment and apply what is learn to the everyday life; the fundamental science topics adopted a conventional mode of pedagogy. The fundamental science topics drew on instances (examples,
phenomenon and processes) from everyday world to introduce the subject matter, but didn’t find a way to contextualize the content of learning (employing pedagogic strategies such as project, field survey etc ) in the child’s everyday world.

Thus we can say that the curricular and pedagogic innovations have not breached into the chapters related to fundamental science topics. The textbook or classroom processes didn’t find a way to employ ‘everyday’ as a tool to integrate children to the discipline of science and to teach fundamental concepts of science in an innovative manner. There was not much of a change observed in the method of presentation or the structuring of the content of fundamental science topics. Thus the new curriculum compromised on two major aspects of science: - teaching children the nature, history and philosophy of science, and innovating pedagogic methods to teach foundational concepts of science.

In what follows, I take up two aspects for further discussion: (1) ‘Everyday’ for learning disciplinary science and (2) what ‘constitutes’ context for science learning

(1) The ‘Everyday’ for learning disciplinary science.

There is a difference in approaching everyday world as a tool for learning science to integrate children to the discipline of science Vs the application of general understanding of science to everyday issues. The cognitive path and abilities required towards the learning of the discipline of science through the everyday concepts and application of science to everyday are different in nature. The former from a cognitivist’s perspective involve leading child’s thinking to the higher order thinking, structures, language and skills of the discipline of science starting from the everyday instances. The later is training children for an application oriented (STS) science learning that will train children to apply the processes skills such as observation, data collection, hypothesizing etc. and general understanding of science for everyday life socio-scientific, environmental and technological issues. This latter approach of the curriculum can be considered as an objective towards preparing a citizenry who are scientifically literate and supporting children who desire to choose a vocational stream of further science learning.

The main concerns of a state policy while imparting science education in schools must be preparing children to pursue higher learning in the discipline of science and supporting children to acquire a meaningful understanding of scientific knowledge, thinking and skills even if they are not opting for higher studies in
science. This necessitates us to ask the question as to what are the abilities required for the learning of science and what is the role of ‘everyday’ in the learning of science? How can we achieve a meaningful learning of science in the classroom? Also when a state science curriculum shows a tendency to shift to a curriculum for science and technology literacy and one that prepares children for a vocational stream of education what are the implications of it?

Chapter two of this thesis discussed the cognitive theories of science learning, according to which learning science requires reconceptualization of the ‘everyday’. To learn science and approach the world scientifically requires much more than sensory perception, than noticing and describing surface features; also more than observing, hypothesizing, collecting data, proving or disproving hypothesis etc. Scientific thinking involves a complex set of cognitive, meta-cognitive skills and process skills. Instilling these abilities in a child requires a considerable amount of instructional interventions and structuring school science classrooms, teaching-learning aids and inquiry process similar to that of an authentic scientific inquiry.

Science learning in a classroom should enable children’s ability to perceive the world using the categories offered by the discipline of science and extending the perception of a phenomenon or event beyond the everyday conceptions. When observations are disconnected from disciplinary contexts, we see but we do not observe. Without sufficient understanding of the underlying theoretical concepts, students fail to learn authentic scientific inquiry.

_You can know the name of a bird in all the languages of the world, but when you’re finished, you’ll know absolutely nothing whatever about the bird... So let’s look at the bird and see what it’s doing — that’s what counts. I learned very early the difference between knowing the name of something and knowing something._

- Richard Feynman (1969)

Approaching the everyday world from a scientific point of view requires coordination of disciplinary knowledge, theory, skills and practice. Teaching of science through activities and experiments is not only about simply instructing children to acquire categories/concepts, principles, or laws, or certain methods but also about modifying children’s everyday notions about empirical phenomenon. Science teaching and learning must initiate them to think in terms of the vocabulary offered by science, and engage in problems solving employing the tools, skills, reasoning, and thinking provided by the discipline of science.
This should also equip the child to acquire the competence needed to engage and approach a new problem situation using the skills and disciplinary concepts acquired. Children must be able to see new problem situation, raise questions, explore and find the answers using the methods and concepts of science they acquired from the science classroom. This necessitates converting a science classroom to a ‘community of science learners and practitioners’.

What we noticed in the present case of children’s conceptions of matter was that their conceptions had more characteristic of everyday observation. Children explanations and conceptions of matter were not integrated with their understanding to the disciplinary concepts offered by science classroom and without associating their perceptual observations with scientific reasoning and explanations. To categorize matter into solid, liquid and gas children’s everyday observations need to go hand in hand with disciplinary knowledge, theory, and practice. Even the high school children failed invoke the reasoning/theory offered by science classroom (or particulate theory of matter) to have categorized and explained matter in terms of the scientific vocabulary and theory. Similar was the case of children’s substance conceptions. Children found it difficult to explain a real world instance employing the vocabulary/category of ‘substance’ acquired from the science classroom and also their substance conception was not integrated to the chemical idea of substance. There was a sharp disjunction noticed in children’s conception of matter in terms of their difficulty to connect their two worlds—everyday world and scientific world. This does not imply children were faring poor in their science classroom evaluation. Children exhibited a fair understanding of the concepts involved in the units on matter when these concepts were examined during their classroom evaluation and term-end exams. So when the method of probing children resembled the classroom evaluation methods, for examples when asked “what are the states of matter?” “Explain Substance/pure substance/molecules”, children were able to reproduce what was given in the textbook in a fair manner. But when the probing method deviated from that which was familiar to them in the science classroom or examination, children showed lack of a meaningful understanding of these concepts. This was in spite of the Kerala’s science curriculum’s attempt to shift away from the traditional pedagogic method, teacher’s and science classroom’s attempt to teach children through activities and experiments and new mode of continuous evaluation.

This sheds light on the fact that the science classroom was invoked by the children for the need of schooling, science classroom and its demands, not for
the demands of every day world. Science learning in school must enhance children’s ability to achieve the higher order thinking of the discipline and ability to see the world using the categories, vocabulary, skills and tools acquired from the science classroom. But in the case of concept of matter, what we saw was their inability to invoke their science learning to the everyday world materials.

The manner of teaching application oriented science to engage with environmental and societal issues invoking a basic understanding of science will not equip the child with the powerful tools to engage with the world in a disciplinary empowered way. The cognitive view of bringing everyday world of the child towards contextual learning of science and the manner in which everyday is being approached by the Kerala science textbooks and classroom towards teaching-learning of an applied science are different in nature and both approaches serve different purposes. Scientific activity is a complex process that requires the acquisition and coordination of disciplinary knowledge, theory, and skills and the cognitivist’s idea of everyday proposes methods to integrate children to the disciplinary knowledge of science. The Kerala science curriculum gives a framework for achieving the objective of scientific literacy and application of science to societal and environmental issues and solving day to day life problems.

Acquiring skills of scientific inquiry, problem solving, concepts, reasoning and thinking, is a complex and challenging enterprise, to enter into it children need to have the knowledge, tools, and experience to support their understanding of the disciplinary framework of science. According to the cognitivist’s idea of ‘everyday for contextual learning’ scientific understanding must get enhanced through everyday and context must be employed for the purpose of integrating children to the discipline of science and theorizing and practice of science. Learning science requires replacement of everyday concepts and the one that is provided by the senses. It requires integration of everyday understanding with a more sophisticated understanding of science. Children need to see the world in terms of the new categories given by science classroom. Such a disciplinary engagement with the world will enable children to become problem solvers and while engaging in the problem solving task their understanding of the discipline is deepened. Through this, scientific concepts replace children’s everyday concepts and they can begin to work within the more formal and generalized conceptual frameworks associated with schooling and science classroom. Science curriculum, textbook, and classroom process must be structured in a manner that helps students acquire scientific concepts, thinking, reasoning and authentic inquiry practices that reveal science as a distinct way of approaching and understanding natural phenomena.
(2) What ‘constitutes’ context in science learning?

In this case of a Kerala Science Classroom, the context of the science curriculum, classroom, textbook and pedagogic processes mainly constituted the ‘context’ of science learning for the children. The context of everyday entered to the science learning experiences in terms of the content of the textbook, pedagogic strategies such as learning through activities, project and seminars which was found to be present in the topics related to applied science or STS. The everyday entered in the basic science chapter in the form of examples, phenomena or everyday processes used to introduce the fundamental science concepts. But this form of contextualization of fundamental science concepts into everyday instances did not convert to a meaningful integration of everyday and scientific concepts in the minds of children’s science learning. Children continued to conceptualize and understand science concepts through these concrete instances—for e.g. the substance conception was cognized through concrete examples such as sugar, lemon juice whereas solid was cognized through the example of stone, similarly water for liquid, and vapor for gas; even an abstract concept like element was cognized through concrete familiar examples such as copper, gold, iron, silver etc. which they failed to extend and understand to other elements that don’t have an immediate or concrete counterpart. Children’s understanding of the above science concepts didn’t extend beyond explaining through these instance and children found it difficult conceptualize them using the categories provided by science classroom.

The teacher and pedagogic processes brought in the local recourses and knowledge to the classroom but within the limits of the curriculum guidelines, scripts of the teacher handbook and content of the science textbook. What we saw in terms of the larger context of the learning was that the geographical, physical, socio-cultural, economic and intellectual context of the present schooling and science learning was rich in terms of its access to the sites of knowledge, local resources, biodiversity, availability of books, materials, libraries, internet services, facility for schooling and several other informal factors that can contribute towards the learning of science. But the classroom and teachers had limitations to be able to capitalize on these important factors of learning due the strict time tabling of school days and also due to the less autonomy of the teacher over the selection of content and choice of pedagogic processes.

This put forth the question of the ‘agency’ of the teacher in the teaching-learning process of science. The teacher serves an important role to transact the
social milieu of the child, local context and its resources to the classroom and teaching learning process. This role cannot be reduced to the mere transaction of an innovative curriculum according to the guidelines and scripts written by curriculum developers. Teachers role in the classroom must be determined by his/her professional competence (disciplinary skill and knowledge and pedagogic content knowledge), ability to choose the content of science learning, deciding and autonomy over the processes of learning and structuring the learning experience, and control over/availability of time so that the local and the everyday context of the child can be integrated to the classroom processes in a meaningful manner. What we also saw in the classroom processes was that the pedagogic processes had limitations in accommodating the experiences, conceptions and knowledge that the child brings into the science classroom.

The present science curriculum, textbook and classroom processes invoked context towards application of science to the daily life applications rather than deepening children’s understanding of the discipline of science. To introduce a discipline oriented science teaching-learning in schools that gives primacy to the foundational concepts of science and contextualizing its teaching-learning process in the everyday world requires ample resources, professional competence of the teacher, infrastructure and resource facilities in the school and science classroom; more importantly support of a state policy, funds and resource allocation that support and emphasize on a science education for the meaningful teaching and learning of the discipline of science.

8.3 Future Research Directions and Conclusion

This study has thrown insights into the Kerala science curriculum, textbook, classroom processes and children’s understanding of scientific concepts in the backdrop of the ‘context’ of science learning. This was one of the few studies undertaken after introduction of the reform processes of DPEP and SSA in Kerala, to make a systematic study of the science curriculum, textbook, science classroom, teaching learning process and bring this to bear on questions relating to children’s understanding of science. Understanding children’s mind or understanding a learner, their conceptions and facilitating learning process is a prerequisite towards any improvement in pedagogy.

Several reports have been published in connection with the DPEP and new mode pedagogy in Kerala. However the need for research on content and content
evaluation of the science textbook is felt to be essential for the meaningful introduction and teaching-learning of fundamental concepts of science. The aim of science learning stated in the curriculum and policy documents can not be simply achieved by choosing environmental related, or application related topics. Research has to take place regarding the choice and organization of content, both of fundamental science related topics and environment related topic while taking account of the characteristics of the learner and socio-cultural context (both of the schooling and larger society) of learning. There was no systematic research on content and pedagogy happening in the case of Kerala. Even though the constructivist framework is spoken about, in practice the content that was found in the textbook has been developed from the notions of a popular science movement or science and technology literacy for all. The innovation has not affected the content and teaching of the fundamental concepts of science.

Here what we saw was a state board science curriculum exhibiting a tendency to shift its focus towards training and preparing children for an application oriented science that will equip them to pursue vocational streams as future courses. We can see a curriculum diversification that is brought into the system by the state i.e. state board school supporting science and technology literacy curriculum, whereas children who want to pursue higher learning of the discipline study in private schools under central boards that offer a different science education and teaching learning process. The trend in Kerala is that children from lower income groups attend the state board syllabus offered through the government schools or government aided schools and children from higher income groups attend private English medium schools. One of the important aspects that were noted in Chapter 4 in the case of Kerala schools is the fact there is a reduction in the number of children attending the state board government schools, whereas the enrolment rate is increasing in the private English medium schools. The trend of mushrooming of CBSE and ICSE board school can be observed even in rural areas of Kerala where the well off prefer to sent their children. Children who get access to these schools are equipped and better prepared for the competitive exams that determine access to the higher learning centers for pursuing science as a discipline. Thus the students who are securing an upward mobility towards higher learning of science are the ones who attend the private aided schools that follow a different curriculum that equipe them to secure admissions to higher learning centers.

One of the aspects that need to be researched is examining whether the curriculum diversification happening in Kerala that leads to a situation where
the State board is preparing children for the world of manual labor, and English medium schools are offering a disciplinary science for children who want to pursue science as a discipline. It may be asked whether such a curriculum diversification is one of the reasons for reduction in number of children attending state board schools and private schools that follow central board syllabus.

In the examination of the children’s conceptions and science learning there was not much difference observed in the science learning ability of children of different gender. But the popular notion is that boys fare well in science and maths. What this study proposes is that, in the school boys and girls perform equally well, in majority of the grades it was the girls who excelled. A systematic study has to be undertaken to understand whether there is any difference in the cognitive ability of the learning science for boys and girls and where lies the reason for the difference in participation of men and women in the science related careers in India.

What was felt to be essential and important is a systematic rigorous research on the curriculum and content of the science textbooks. One of the aspects that have been observed was a significant overlap of present science textbooks topics with the science textbooks that were in use during the 1960’s and 70’s. An evaluation of the science textbook from a historical perspective might throw important insights into the evolution of the present science curriculum and textbook, and also how history and a colonial past are still strongly present and cast their influence in the present science education scenario. It is not only that the curriculum and content have to be examined from a historical point of view, but also the significance of the topics chosen for the science textbooks needs to be evaluated from a cognitive and sociological point of view to understand how content is appropriate for a learner located in the context of Kerala. Research has to be undertaken towards designing and structuring learning sequence, content and pedagogic process towards the introduction of the fundamental and abstract topics of science according to a constructivist and inquiry mode of pedagogy, which was felt to be essential especially for the high school grades in the case of Kerala. It is also essential to research on how to structure a school day, organize a science classroom and design teaching learning resources and pedagogic strategies that are appropriate for the teaching learning of science according to the constructivist principle or inquiry mode of learning, one that is suited for the social milieu of the child and content of learning.

What is essential and fundamental is that original research and thinking has to emerge in the context of Kerala and India regarding the kind of science
education and scientific knowledge that needs to be instilled in school children—
one that is relevant for the Indian child taking into account the everyday world
realities, knowledge systems and socio-cultural milieu of the child. A new
discipline of science education has to emerge in India that will determine the
learning theories, science learning processes and science education that is
appropriate for the children belonging to this country, and who brings in a
diverse and rich socio-cultural tradition, knowledge and background to the
science classrooms.