
One never notices what has been done; one can only see what remains to be done.

Marie Curie (1867 - 1934)
- From ‘Letter to her Brother’

This chapter begins with an introduction to the terms related to Alternative Frameworks such as mistakes, errors, misunderstandings, misinterpretations, naïve theories and naïve conceptions. Some concept specific researches in the area of alternative framework have been discussed. The nature of science and some learning theories have been explored keeping in mind the focus on Alternative frameworks in the third subsection. Subsequently, the reasons for the formation of Alternative Framework and the issues in addressing them have been explored. Conclusions have been drawn for the study in the last section of this chapter.

2.1 Alternative Framework and Related Terms

There are many terms that have been used in literature to connote a meaning similar to Alternative Frameworks. Alternative framework is differentiated from other similar terms using the notion that those persons who use Alternative Frameworks have developed autonomous frameworks for conceptualising their experiences of reality. Different researches attribute different reasons for the formation of Alternative Frameworks. Also, there are different ways of addressing Alternative Frameworks.

In chapter 1, it emerged that learners’ non-scientific understandings about science concepts have been called with several interchangeable terms like, naïve beliefs, preconceptions, Alternative Frameworks, children’s science, naïve theories, naïve conceptions, anchoring conceptions, intuitive beliefs, intuitive science, learners’ science, and misconceptions. In this section, the similarities and differences
between these terms that are being used in the literature to denote divergence for the scientifically accepted conceptions, will be explicated and clarified. This analysis reveals that these terms have changed along with the progressive outlook towards non-scientific understanding.

2.1.1 Misconceptions, Mistakes, Misunderstandings, Misinterpretations, and Errors.

The origin of term ‘misconception’ can be located in the notions where scientific communities found that the learners’ ideas are not synchronous with the scientifically acceptable. “Learners’ conceptions change progressively as they are exposed to additional relevant information in higher grades” (Lee, 2007). We also note that there are still great differences between what teachers teach and what learners learn.

(Hancock, 1940) defined a "misconception" as "any unfounded belief that does not embody the element of fear, good luck, faith, or supernatural intervention" (p. 208). This author’s postulation was that misconceptions arise from faulty reasoning. Contemporary science education researchers do not agree with this postulation.

The faulty reasoning-based definition of misconception is based on the suffix ‘mis’. (Barrass, 1984) wrote of “‘mistakes’ or errors, ‘misconceptions’ or misleading ideas, and "misunderstandings" or misinterpretations of facts, saying that teachers and brighter learners can correct errors. But what attention is paid to misconceptions and misunderstandings that are perpetuated by teachers and textbook researchers?”

Again, in all these terms 'mis' /faulty/ error based assumptions to identify this divergence is evident. This divergence is not just a fact incorrectly memorized, faulty reasoning or an inaccurate/inadequate mental structure but relates to one’s thinking or construction of a concept or a group of related concepts. There is definitely a need to identify this divergence with a less negative connotation.

2.1.2 Naïve Beliefs, Naïve Theories and Naïve Conceptions

It is important to look into the different contexts in which the word naive is used in our daily lives:
“extremely simple and trusting: having or showing an excessively simple and trusting view of the world and human nature, often as a result of youth and inexperience

not shrewd or sophisticated: showing a lack of sophistication and subtlety or of critical judgment and analysis

artless: admirably straightforward and uncomplicated or refreshingly innocent and unaffected

ARTS rejecting sophisticated techniques in art: not using the conventional styles and techniques of trained artists, e.g. in the treatment of perspective or light and shade

SCIENCE not previously experimented on: not previously used in any scientific tests or experiments or not having previously used a particular drug” (Manager, 2009).

Thus in terms of a child’s understanding of science, ‘naive belief’ would mean an excessively simple, straightforward, and uncomplicated belief about the worldview which is unaffected by the critical judgment and analysis-laden view of the world constructed by the scientific community. Similarly naive theories and naive conceptions can be understood in analogous manner. We can see that in these terms the negative connotation of mis/ faulty/ error is absent. Here the connotation is related to the conceptions being unsophisticated uncomplicated or simple to the extent that they are distant from being identified as an acceptable representation of scientific conception. There can be terms that are more expansive in connotation to represent the observations related to the divergence from scientifically accepted conceptions.

2.1.3 Preconceptions and Anchoring Conceptions

The term preconception has a connotation of pre-instructional conception developed by the science learner. “Teachers and researchers generally refer to pre-instructional knowledge as preconceptions. Before beginning instruction on any new topic, teachers need to know their learners’ preconceptions because learning, and therefore instruction itself, varies depending on whether learners’ preconceptions agree with the concepts being taught or contradict those concepts” (Lucariello, 2012).

Anchoring Conception is a term that had been seen in relation to the term
preconception. When the preconceptions discussed above happens to be synchronous with the concepts in the designated curriculum, the preconceptions are called ‘anchoring conceptions’. In other words the preconceptions that are in line with curricular goals are termed as anchoring conceptions. It is obvious that the presence of anchoring concepts will support learning of the scientific concepts. Though, with the presence of anchoring conceptions, learning is just a process of enrichment and conceptual growth, but they still need to be differentiated from the incongruent preconceptions.

The preconception and anchoring conceptions move further away from the negative connotations in the term misconceptions/errors etc. A more positive outlook than ‘naive’, in terms of perspective to look at the divergence from scientific conception, is evident in preconceptions or anchoring conceptions. But these terms also fail to recognize the import of children’s/ learners’ specific learning styles, their cognitive structures, and the variables affecting their conceptual development, which can be considered as different from those of adults.

2.1.4 Children’s Science/ Learner’s Science

The terms children’s science and learners’ science had been discussed in the literature having a reference to children’s thinking about scientific conceptions involving general and specific categories of knowledge and conceptions, mental processes, learners’ frameworks of beliefs, assumption, emotions, models, values and aesthetics, and children’s contexts of meaning. “Specifically, the major concerns involve identifying (a) potential underlying beliefs that may influence the construction of concepts, (b) cognitive processes that contribute to the construction of concepts and meaning, (c) variables that affect conceptual development, and (d) variables that may influence the construction of meaning” (Bloom, 1990).

The terms children's science and learner’s science may thus be seen to connote not the wrong or misconception/ error/ naive concepts or pre concept, but take cognizance of children's thinking that involve their own processes of knowledge construction and reconstruction. This construction of knowledge identifies the role of a broad canvas that children use to paint their realities onto. However, children’s science has the adult understanding as point of reference, which might still be at odds with the scientific community, therefore, the conceptualisation of Alternative
Framework, that has the reference of scientific community, can be seen as a still broader and inclusive.

2.1.5 Alternative Conceptions and Alternative Framework

Even though sometimes learners’ conception may concur with the scientific explanations, but there still may be some difference between the learner’s understanding and the scientifically accepted understanding of nature and natural phenomenon. “The term alternative conception is used to mean learners’ ideas, manifested after exposure to formal models or theories, which are still at odds with those currently accepted by the scientific community” (Boo, 1998). There is however a clear cut difference between the terms alternative conceptions and alternative framework. This difference is related with the consistency of using an alternative conception in more than one context. “When an alternative conception is used with consistency over more than one context or event, it is referred to as an alternative framework” (Boo, 1998).

We can very clearly see that in the connotation of ‘alternative framework’, repetition of what is believed to be ‘true’ and application in more than one context is inbuilt. Thus, the term alternative framework is broader in meaning than other terms discussed including alternative conceptions and presents more positive outlook towards the divergence for scientific conceptions. This is precisely the reason for using the term ‘Alternative Framework’ in the study to denote the discussed divergence. We need to explore this divergence in different/specific scientific conceptions to understand the presence and nature of alternative frameworks.

2.2 Concept Specific Researches on Alternative Frameworks

Different researches under different headings and assumptions related to the divergence from scientific conceptions have revealed that this divergence exists among all areas of science researched. Some of these researches have been included in this section with a broad and positive framework of Alternative Frameworks.

2.2.1 Researches done Abroad

Chemical Bonding

In Taber’s (Taber, 2003a) research, high school chemistry learners tended to present four notions of bonding in metals:
• there is no bonding in metals;
• there is some form of bonding in metals, but not proper bonding;
• metals have covalent and/or ionic bonding;
• metals have metallic bonding, which is a sea of electrons

In the specific examples of explaining the structure of solid iron using chemical bonding, some learners did not consider the lattice arrangement. Some learners thought that all iron atoms are the same element, there is no need to transfer or share electrons to form any bonds. The atoms of iron are stuck together without any bonding. “They envisioned that metallic lattices contain neutral atoms. Furthermore, some learners considered that metals had bonding similar to covalent bonding like a macromolecule. Other learners believed that metals had ionic bonding because they consisted of positive cations and negative electrons” (Taber, 2003a; Taylor, 2001). (Boo, 1998) also reports that there were those who conceived of a covalent bond as the result of the sharing of ‘one electron’ between two atoms; i.e., one of the atoms donates an electron, which is then shared between the two atoms which are said to be held by the covalent bond.

Kinematics

A Taxonomy of Misconceptions excerpted from “Force Concept Inventory” (Hestenes, Wells, & Swackhamer, 1992) has been appended with this work (See Appendix D). From the taxonomy we observe that for many children velocity and acceleration are indiscriminate, no motion implies no force, largest force determines motion, mass makes things stop, heavier things fall faster are some of the alternative ideas formed.

It is also reflected that commonsense beliefs tend to be metaphorical and vague with situation-dependent meanings. This is reflected in the use of language. Thus, terms like “force”, “energy” and “power” are often used interchangeably, as are the terms “velocity” and “acceleration.” In the world of common sense, obstacles like chairs and walls do not exert forces, “they just get in the way.” Mass is regarded as a kind of resistance, because it “resists” the efforts of an active agent. Motion occurs only when the active force “overcomes” the resistance (note the metaphor), and it ceases when the force becomes “too weak.”
Light and optical phenomena

(Blizak, F. Chafiqi, 2009) found that there is no change in learners’ misconceptions after 20 years of research concerning light and optical phenomena. They also noted that the misconceptions, which have been found in earlier studies, also exist in the understanding of present day learners. They found some new misconceptions like ‘light propagates in the horizontal direction when the air doesn’t exist’.

Weiler (1998) compiled the list of Alternative Frameworks for American Institute of Physics (Appendix E). Some examples from the lists are being represented under the following headings. In these discussions, children’s ideas do not mean that every child has these alternative ideas. In the following discussions, various areas of science titled from Astronomy to Work and Power, have been adapted from above mentioned compiled list.

Astronomy

Children think stars and constellations appear in the same place in the sky every night; the earth is at the centre of the solar system. (The planets, sun and moon revolve around the earth.) And that the moon can only be seen during the night. About one of the observations that most of us have and are fascinated by it is related to observation related to the phases of moon. They think that the phases of the moon are caused by the shadow of the earth on the moon. About stars and their positions children are of the view that the solar system contains only the sun, planets and the moon; all the stars are at the same distance from earth and that all stars are the same size. The cluster of stars or the constellations for them form patterns clearly resembling people, animals or objects. On the question of how seasons change they have an alternative framework which explains that we experience seasons because of the earth's changing distance from the sun- closer in the summer, farther in the winter.

Atmosphere

Rain, thunder, clouds etc have been fascinating not just children but adults also in different ways. A number of Alternative Frameworks have been identified which include - rain comes from holes in clouds; God and angels cause thunder and
lightning; clouds move because we move; empty clouds are filled by the sea and that the sun boils the sea to create water vapour.

**Biosphere**

About existence of Dinosaurs, a mystery animal that attracts the attention of many of us, children believe that Dinosaurs and cavemen lived at the same time and humans are responsible for the extinction of the dinosaurs. In the context of evolution children have a conception that some human races have not evolved as much as others. Also some of them opine that evolutionary changes are driven by need and acquired characteristics can be inherited.

**Colour and Vision**

When explored about children’s ideas about vision and related concepts many alternative ideas emerged. Some of them are - The eye is only organ for sight and brain is only for thinking; the pupil of the eye is a black object or spot on the surface of the eye; the eye receives upright images; the lens is the only part of the eye responsible for focusing light. Similarly sunlight and colour related concept explored throws light on many of children’s ideas some of which are - sunlight is different from other sources of light because it contains no colour; the rules for mixing colour paints and crayons are the same as the rules for mixing coloured lights; the primary colours used by artists (red, yellow and blue) are the same as the primary colours for all colours mixing etc.

**Electricity**

Positively charged objects have gained protons, rather than being deficient in electrons; electrons which are lost by an object are really lost (no conservation of charge); Gravitational forces are stronger than electrostatic forces and batteries have electricity inside them are some of the interesting ideas that were found related to electricity.

**Energy**

For many children the terms "energy" and "force" are interchangeable. From the non-scientific point of view, "work" has been found to be synonymous with "labour". It is hard to convince someone that more work is probably being done
playing football for one hour than studying an hour for a quiz. For children an object at rest has no energy and also energy can be changed completely from one form to another (no energy losses).

**Forces and Motion**

Children see motion everywhere around them and develop many ideas related to the connected notions when they study them along with the ideas related to forces. If an object is at rest, no forces are acting on the object; the motion of an object is always in the direction of the net force applied to the object; large objects exert a greater force than small objects; only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting upon it; velocity is another word for speed. An object's speed and velocity are always the same; acceleration always means that an object is speeding up; acceleration is always in a straight line; acceleration always occurs in the same direction as an object is moving; if an object has a speed of zero (even instantaneously), it has no acceleration are some.

Regarding hindrance in motion they think that friction always hinders motion. Thus, you always want to eliminate friction and frictional forces are due to irregularities in surfaces moving past each other; frictional forces are due to irregularities in surfaces moving past each other. They have been found to have the idea that a rigid solid cannot be compressed or stretched. For many of them the terms distance and displacement is synonymous and may be used interchangeably. Thus, the distance an object travels and its displacement are always the same.

**Forces and Fluids**

In the previous part forces in relation to solids were discussed. When children’s ideas related to forces in relation to fluids were explored the list lists many like objects float in water because they are lighter than water; objects sink in water because they are heavier than water. By many children mass/ volume/ weight/ heaviness/ size/ density may be perceived as equivalent and pressure and force may be synonymous; wood floats and metal sinks.

**Heat and Temperature**
For many children Heat is a substance; heat and cold are different, rather than being opposite ends of a continuum and heat only travels upward. The bubbles in boiling water contain "air", "oxygen" or "nothing", rather than water vapour. Also, when temperature at boiling remains constant, something is "wrong" when it comes to idea of coldness many think that ice cannot change temperature.

**Light**

In this heading some of the learners’ alternative ideas related to light and its properties, image formation using mirrors and lenses had been cited; Light is associated only with either a source or its effects; Light is not considered to exist independently in space; and hence, light is not conceived of as "travelling"; The effects of light are instantaneous; Light does not travel with a finite speed. Gamma rays, x-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves are all very different entities; Colours appearing in soap films are the same colours that appear in a rainbow.

For an observer to see the mirror image of an object, either the object must be directly in front of the mirror, or if not directly in front, then the object must be along the observer's line of sight to the mirror; The position of the observer is not important in determining whether the mirror image can be seen; The mirror image of an object is located on the surface of the mirror; The image is often thought of as a picture on a flat surface; Curved mirrors make everything distorted.

When an object is viewed through a transparent solid or liquid material the object is seen exactly where it is located; When sketching a diagram to show how a lens forms an image of an object, only those light rays are drawn which leave the object in straight parallel lines; Blocking part of the lens surface would block the corresponding part of the image; An image is always formed at the focal point of the lens; The size of the image depends on the size (diameter) of the lens.

**Lithosphere**

Lithosphere related concepts from children’s ideas about the real world have also been explored in the list. Some of them are rocks must be heavy; mountains are created rapidly; earth is molten, except for its crust; earth's gravitational attraction is
drastically reduced on mountaintops; continents do not move; boiling or burning radioactive material can reduce radiation; All radioactivity is man-made.

**Magnets and Magnetism**

For many children the magnetic and geographic poles of the earth are located at the same place; the magnetic pole of the earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole; larger magnets are stronger than smaller magnets; all metals are attracted to a magnet; all magnets are made of iron.

**Properties of Matter**

Matter is present everywhere around children and adults alike and children don’t wait for Science to tell them what matter is and what its properties are. Some of them think that gases are not matter because most are invisible; particles possess the same properties as the materials they compose. For example, atoms of copper are "orange and shiny", gas molecules are transparent, and solid molecules are hard; a "thick" liquid has a higher density than water. The scientific concepts studied by them have their own versions e.g. Air and oxygen are the same gas, absence of conservation of particles during a chemical change, chemical changes perceived as additive, rather than interactive.

**Measurement**

Measurement seems a very simple area which when explored in terms of children’s idea gives us a diverse understanding about them. Some of them are - any quantity can be measured as accurately as you want; You should start at the end of the measuring device when measuring distance; You can only measure to the smallest unit shown on the measuring device; The only way to measure time is with a clock or watch; time has an absolute beginning; the metric system is more accurate than the other measurement systems. For many children the five senses are infallible.

**Sound**

Loudness and pitch of sounds are confused with each other; you can see and hear a distant event at the same moment; hitting an object harder changes its pitch; in a telephone, actual sounds are carried through the wire rather than electrical pulses.
For many children, sound moves faster in air than in solids (air is "thinner" and forms less of a barrier); sound moves between particles of matter (in empty space) rather than matter; as waves move, matter moves along with them. In wind instruments, many children think, the instrument itself vibrates not the internal air column.

**Space**

Children have been found to believe that there is a definite up and down in space. Many have been found to have developed the idea that the sun disappears at night and will never burn out; the sun is not a star. They have found to have related planets’ positions with destiny and think astrology is able to predict the future.

**Work and Power**

Following are some of the problems listed related to the concept of work and power that children face-failing to be able to identify the direction in which a force is acting; believing that any force times any distance is work; believing that machines put out more work than we put in; not realizing that machines simply change the form of the work we do (i.e. trade off force for distance or distance for force).

**2.2.2 In the Indian Context**

**Pressure, Heat and Temperature**

(S. P. & H. C. Pradhan, 2009) presented a study on misconceptions that arise in introductory thermodynamics. They have focussed their attention on three basic concepts 1) Heat, 2) Temperature and 3) Pressure and found that a large number of experiences in daily life related to these concepts. They identified one possible process of development of misconceptions further elaborating that use of words that mean one thing in everyday life and another in a scientific context (e.g. pressure) and by the learner’s inability to overcome non-scientific belief.

A science pedagogy jargon's link with daily life experience to be contributing to these alternative conceptions has been identified. Learners have been found to relate their daily experiences rather than scientific information to categorise the materials as suitable for adiabatic and diathermic walls. Learners do not believe that objects kept in a constant temperature enclosure for a sufficiently long time will tend towards thermal equilibrium and reach the same temperature as the enclosure, but
rather relate it to the size and material of the object under consideration (Pathare S.R. & R.D., 2009). Theoretically this particular problem may be seen to have linkages with the problem of making abstract models by learners. But this also challenges the science pedagogy jargon of relating scientific conceptions with daily life experiences.

**DNA structure**

(A. Srivastava, 2011) identified the 2D-3D representation problem as per the findings. All the learners interpret their familiar textbook diagrams as a 2-dimensional structure rather than a 2-d representation of the 3-d structures. Using multiple models to develop their understanding, linking together multiple external representations into an integrated internal representation, and hence bringing about mental visualization of the 3-d structure has been reported to be successful.

**Human physiology**

In a survey, it is observed that high school learners displayed an anthropocentric view about biological concepts (Narendra D. Deshmukh & Deshmukh, 2009). A general tendency among the learners was to explain the physiological terms such as respiration, excretion, photosynthesis, fertilization etc. exclusively with reference to humans or animals. Research shows that misconceptions about processes of respiration, photosynthesis, circulation persist across grade levels claim (Narendra D. Deshmukh & Deshmukh, 2009).

The alternative frameworks have been reported among not just learners in science but among science teachers as well. For example, even teachers considered purification as the main function of the heart. (N.D. Deshmukh, 2009) suggest that, since, scientifically heart is just a pumping organ and is not concerned at all with blood purification, filtration, and formation, such terms ‘purification’, ‘pure blood’, ‘impure blood’ ‘oxygen rich’, ‘carbon dioxide rich’, and ‘emotions’ should not be used by teachers and textbook researchers. The pictures and figures should be correct.

**Galilean relativity: frames of reference**

In the research cited above, titled ‘human physiology’, anthropocentric view about the biological concepts is located. Similarly an anthropomorphic viewing is evident in the work done by (Panse, Ramadas, & Kumar, 1994). The analysis
indicates that learners implicitly associate frames of reference with concrete objects, localized and bounded by the latter's extension; regard particular phenomena as belonging to particular frames; allow value judgement on real and apparent [ness] of motion to coexist with their (learnt) knowledge about relativity of motion; and equate physical description to anthropomorphic viewing. They also claim that their data show unmistakably, the more prevalent alternative conceptions are also the ones which are held with greater conviction.

Thermal Equilibrium

The two pivotal ideas in thermodynamics are heat and temperature. These however are interdependent and their definition draws upon a third concept, namely thermal equilibrium. We report our work on learners’ understanding of thermal equilibrium. We found that many learners do not understand concepts such as thermodynamic variable and adiabatically necessary for discussing thermal equilibrium. They establish a strong dependence of thermal equilibrium on the size and material of the objects under study (S. R. P. and H. C. Pradhan, 2009).

Resume: While reviewing the researches on the specific areas of science, in special context of development of alternative frameworks, the following are the two key questions that express our concerns in relation to the effective teaching-learning processes in science. First, ‘Where are the possibilities of formation of Alternative Frameworks’ and, second, ‘How do we address the alternative frameworks?’ that develop in the process of making meaning out of diverse experiences in the physical and natural world? These questions have been explored in the sections 2.4 and 2.5 respectively, in detail. It seems important to the researcher to explore if there is any theoretical position in learning theories and models that can supply some arguments, models, or insights on the formation of alternative frameworks. Also, addressing alternative frameworks essentially mean moving towards scientific conceptions, in more generalised perspective, scientific knowledge.

2.3 Possible Sites of Alternative Frameworks

These two aspects viz. “implications of nature of science” and “implications of learning theories” will build our theoretical position. This can be supplemented by
research results from examination of curriculum materials, problem of learning by rote etc.

For exploring second or both theoretical positions available and specific field researches can lead us to some more insight to address these Alternative Frameworks.

(Meichtry, 1999) explains that authentic inquiry in a classroom requires the teacher to understand how science operates as a discipline. If the teacher does not understand how knowledge is obtained and verified as scientific knowledge, then inquiry in the classroom is limited to teaching process skills rather than knowledge about science.

2.3.1 Understanding Nature of Science

Nature of science has its implications on what is acceptable as scientific knowledge, how do we think we develop our own scientific knowledge, understanding about what is true and real, notion of permanence/tentativeness of reasons drawn in science, classroom processes (through the issue of emulation of culture of science as practice) etc. These implications need to be identified and explored.

Nature of Science and Scientific Knowledge

(Meichtry, 1999) depicts the nature of science as a human activity, a process used to investigate natural phenomena, a process used to add to an existing knowledge base, and a social enterprise. On the other hand, scientific knowledge is presented as a product of the human process of science and its social context.

In simple terms, nature of science is related primarily with the content and processes specific to science. Scientific knowledge can be seen as a product generated out of these contents and processes interacting with the social context specific to the scientific community. The culture of science can be understood here as this social context in which the scientific community deliberates professionally. (Lederman, 1999) elucidates that scientists have inherent, agreed upon processes and assumptions. These processes and assumptions help them to construct meaningful knowledge. The culture of science will include these inherent, agreed upon, processes and assumptions. In science classrooms, the practice of this culture of science can prepare the science learners for participation in the generation of scientific knowledge.

“Inquiry that teaches process skills without teaching why these skills are important to
the construction of scientific knowledge, offers only a surface understanding of the culture of science” (E. Peters & Kitsantas, 2010).

**Tentative and Revisionary Nature of Science**

“If I have seen further it is by standing on the shoulders of giants”

- Isaac Newton (1642 - 1727)

“I am enough of an artist to draw freely upon my imagination. Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world”

- Albert Einstein (1879 - 1955)

Some contemporary explorers of the process of generation of knowledge (termed scientific) have worked individually and institutionally to explore conclusiveness in the process of generation of scientific knowledge using the terms "tentative" and "revisionary". The tentative component of this notion emphasizes the inconclusiveness of scientific knowledge. The revisionary component stresses on the alteration of existing scientific knowledge in response to altered theoretical and experimental positions.

This tentative and revisionary nature of science is an important constituent of science education because of its implications on the teaching learning process in science. In the context of developing scientific knowledge, the culture of science also imbibes this tentative and revisionary nature of science when the scientific community is practising this culture. This culture also contradicts a perception that science is a collection of unalterable facts. Altering the accepted scientific conception also comprises of a metacognitive process of thinking about a scientist’s own process of thinking.

**Metacognition and Nature of Science**

Metacognition is the ability to think about and evaluate your own thinking processes (Brown, 1987) and is a part of being a self-regulated learner (Zimmerman, 1998). Taking into account the culture of science that can be practised in science classrooms, learners can perform an inquiry and think about why they are conducting certain processes and evaluate their thinking in terms of the way a scientist might think about the processes and outcomes.
A typical learner is not exposed to the culture of science, so the teacher needs to provide the scaffolding that will illustrate how scientists think and operate. (McComas, W. F., Clough, M. P., & Almazroa, 1998) developed the argument that metacognitive prompts built from the identified aspects of the nature of science will give teachers a vehicle to scaffold scientific thinking to learners who are underexposed to this type of thinking.

Metacognition and the culture of science can be seen to be closely associated as thinking and reflecting becomes an integral part of the development of scientific knowledge. (E. E. Peters & Kitsantas, 2009) contends that the culture of science is passed down from generation to generation through science classes. If each generation receives the idea that science is a body of knowledge and has no access to the nature of science, knowledge about how science generates and verifies knowledge will no longer be part of the public’s understanding of science. Education has a responsibility to teach learners how to think like a scientist in order to continue to be progressive, critical thinkers in our technological future. The idea of being a critical thinker in the progressive future is not a utilitarian one, but is integrated with the development of the human being while culture of science is being practiced.

**Classroom Practices and Nature of Sciences**

In contrast with the argument that had built up in the earlier section, science text materials contribute to the development of learners’ views that scientific knowledge is an array of unconnected facts and concepts. Rather than helping learners to develop meaningful understandings about scientific knowledge and the conditions by which it develops, this text subject learners to an inconceivable stream of technical jargon. (Meichtry, 1999) explains that the pace makes difficult, if not impossible, for the development of any sense of how concepts and theories originate, how they come to be validated and accepted, and how they connect with experience and reveal relations among seemingly disparate phenomena. If a teacher understands the nature of science, he or she is better able to pose questions to learners about why they are doing process skills as well as establishing an environment that allows learners to construct meaningful scientific knowledge.

Teaching the nature of science out of the context of scientific knowledge and inquiry does not give learners access to the important connection between scientific
knowledge and knowledge about science (Akerson & Abd-El-Khalick, 2004). Metacognition is one of the mechanisms that can be used by the teachers so that learners develop the habit to think deeply in consonance with nature of science.

An important deduction from the discussion of nature of science is that with the "tentative" and "revisionary" nature of scientific theories the notion of Alternative Frameworks are very good blend. This blend effectively contradicts the notion of "misconceptions" with a negative inbuilt connotation. The nature of science as a social enterprise demands the science classrooms, to be designed in a collaborative fashion so as to encourage sharing, argumentative thinking and revisiting what is learnt.

Discussion

Following are the key questions which can help to summarize the importance and implications of this probe: What is acceptable as scientific knowledge and how is it generated? Are there any right or wrong concepts in science? How to look at the conceptions other than the ones that are dominantly accepted by the scientific community? What is so specific in science that the divergence from scientific conceptions matters so much to the scientific community? Can we actually think about our own thinking on the subject of construction of scientific knowledge? How do learning science in classrooms interplays with the nature of science? Therefore before going to these subsections viz. 2.4 and 2.5, a review of different theoretical positions augmented by research findings, has been taken up to understand possible sites of alternative frameworks in terms of nature of science and learning theories.

The first question is “What is acceptable as scientific knowledge and how is it generated?” It follows from the understanding developed that the scientific knowledge is a product of deliberations within the scientific community practising the culture of science which includes inherent, agreed upon, processes and assumptions. Thus a product of this practice will be acceptable as scientific knowledge. On the question, “Are there any right or wrong concepts in science”, it follows that the question of a conception being right or wrong is understood in terms of inconclusiveness of scientific knowledge. This means, a conception is ‘the best one till the better one replaces the present one’. Or in simple words, no concept is considered as the right
concept. This understanding about the nature of science also supports the nomenclature ‘Alternative Framework’.

Next question viz. “How to look at the conceptions other than the ones that are dominantly accepted by the scientific community?” is understood as follows. The practice of culture of science is more important than the product of this practice. An opportunity to revisit one’s own conception through metacognitive and critical thinking is a part of the revisionary nature of science. Revisiting Alternative Frameworks through metacognitive practices become part of science learning if culture of science is practised in science classrooms. Inherent, agreed upon, processes and assumptions are the part of knowledge about how science generates and verifies knowledge. Thus, the conceptions other than those accepted by the scientific community are to be revisited through metacognitive practices.

A reflection on the question “What is so specific in science that the divergence from scientific conceptions matters so much to the scientific community?” presents us an understanding that the Divergence under discussion means, there can be gaps in the processes and assumptions in generating scientific knowledge in the classrooms, something that needs to be strengthened. A related question “Can we actually think about our own thinking on the subject of construction of scientific knowledge?” leads us to an understanding that metacognitive ability and self regulation are parts of culture of science learning and knowledge generation, therefore thinking about one’s own thinking related to construction of scientific knowledge is an inherent part of scientific knowledge construction.

A question about “How do learning science in classrooms interplay with the nature of science?” that has a direct bearing on science learning in classroom settings, is an important one. Learning in science classrooms seems to be in contrast with the nature of science where the concepts and theories do not originate. They are not validated and accepted but are influentially agreed as the pace makes it difficult for learner to pose questions and construct them meaningfully.

A reflection on the above questions develops an understanding that the Alternative Frameworks are possibly formed when the culture of science discussed above is not practised in science classrooms leaving some gaps. Addressing of the
alternative frameworks will involve filling these gaps using appropriate methodologies and strategies.

2.3.2 Drawing Implications from Learning Theories

A review of research related to the alternative framework cannot be justified without an outline of various learning theories and models that are available to us as the context of the learner has an inherent centrality to the framework of the present study. In order to develop this framework related to the understanding of the possible sites of formation of Alternative Frameworks, we need to first understand what are conceptions, concepts and psychological frameworks in which learning is understood to take place. An overview of learning theories, models and perspectives can help us in this regard. This section attempts to review some of those theories and models in the context of the study. Some parts of this subsection have been adapted from researcher’s work titled, “Development of Alternative Frameworks among Learners in Science: A Reflection on the Learning Theories and Models” (Kumar, 2011).

Major Learning Theories

The major categories or models under which we can understand the learning theories can be grouped under behaviouristic model, cognitivist model, constructivist’s model, humanistic perspective, descriptive & prescriptive models and identity theories etc. While we can extrapolate almost all of them to understand the development of Alternative Frameworks, some of them are more useful than others with special focus on their development among learners in science. The terms like pedagogy, cognition and learning, leading to terms such as miscognition or alternate cognition have different foci. Thus, it gives different ideas about the process of development of Alternative Frameworks. In all the discussions related to the issue of addressing these Alternative Frameworks one thing is very clear that alternate framework addressing inherently puts a focus on a particular framework as acceptable in a situation and others need to move towards that particular framework. With special reference to science this would mean the conceptual framework and understanding that scientific community in the contemporary world accepts to be the best model to explain a particular part of reality is the one that is intended from science education.

Associative Learning
Supportive learning environments have been a concern that has been shown by the science educations practitioners in schools. This concern has been shared by the science teachers with the researcher also. One can argue that “associative learning” in the behaviouristic theories also gives centrality to learning environments. But there is a fundamental difference in “where does the actor exist”. In behaviouristic theories people are considered to be no different from programmed animals that just respond to environmental stimulus. In cognitivist framework people are rational beings whose actions are consequence of their thinking and in constructivist framework people construct reality by interpreting those contextualized learning environments.

Extending this discussion to the process of generation of Alternative Frameworks would mean that in behaviouristic model, environmental stimulus will be the seat of alternative framework; in cognitivist framework it will be a person’s thought; in constructivists framework it will be the way reality is being interpreted and in Bandura’s Social Learning Theory it will be a continuous relationship between cognitive, behavioural and environmental influences. With more exploration about different learning theories and models, complexity of decision making of finding out the possible sites of Alternative Frameworks becomes more difficult. Consequently understanding the process of generation or formation of Alternative Frameworks is an even more complex issue. As the focus of this work is on the efficacy of Computer Assisted Learning in addressing Alternative Frameworks among learners in science, this issue can take a backseat. But the possibility of their formation with respect to school setting can be an important aspect to reflect on.

**Physical Environment: School or Outside?**

In the physical environment we can separate the possibilities of formation of Alternative Frameworks into two categories namely school setting and outside it. Ausubel’s Subsumption Theory is useful to us in understanding learning in school settings. Which of these two categories is to be considered as more important, may be a matter of debate but the responsibility to effectively address the Alternative Frameworks and create the settings to minimize their formation/development lies within school settings. Thus the school settings need more rigorous analysis and reflection. Ausubel believed that instructional materials used in the school settings should be appropriate for the child (Driscoll & Needham, 1994), but unlike Bruner, he
defined the appropriateness in terms of the child's prior knowledge. Bruner considered the child’s dominant mode of thinking as the basis for appropriateness thereby emphasizing the cognitive structures.

**Problems during Discovery Learning**

David Ausubel was the first educational psychologist to make a distinction between rote learning and meaningful learning. When meaningful learning occurs, there is a greater in-depth understanding of the concept and the pupil is able to link the new area of knowledge with existing knowledge. (Ausubel, 1968) also made the distinction between the passive learning and learning by discovery. Attempts at planning based on discovery approach were tried out in the period 1960-70 but they largely failed.

Ausubel’s meaningful, reception learning theory proposed two differentiations in the typical learning that goes in the classrooms. Firstly, he distinguished reception from discovery learning. Secondly, distinction was made between rote and meaningful learning. Alternatively discovery learning involves rearranging and re-organizing/transforming the given array of information and finding missing links (Driscoll & Needham, 1994). Although discovery learning is highly advocated in science,Ausubel believed that such methods are rarely efficient in transmitting the content of an academic discipline. Bruner’s Discovery Learning has also met with criticisms regarding it as being potential sources of development of Alternative Frameworks.

**Resultant of Disequilibrium**

According to this research the way to prevent or resolve Alternative Frameworks is to have the learner confront the Alternative Frameworks directly with an experience that causes disequilibrium followed by sound accommodation (Maier, 2004).

A combination of cognitivist and constructivist perspective, Piaget's work is one of the most extensively used frameworks in education. The four development stages and three developmental processes used by Piaget have been countered in terms of his claims about reasoning and also stages. Much of Piaget's work and also work of others about his theory is concentrated around logical-mathematical knowledge; he has presented three forms of knowledge namely physical knowledge, logical-
mathematical knowledge and social knowledge. Considering our focus on possible sites of formation of Alternative Frameworks, Piaget's formal operational period (11 years onward) becomes significant. The lack of achievement of formal operational development may be seen as one of the reasons for the development of Alternative Frameworks among learners of science. Also, assimilating new information to inappropriate sites of concepts can be another reason of formation of Alternative Frameworks. Ineffective accommodation may also be seen as the reason for development of Alternative Frameworks according to Piaget’s work.

When reflecting on the process of equilibration, one can deliberate that a form of state of disequilibrium can help the children in identifying the inadequacies in their own thinking and coming out with more logically sound structures. For identification of the nature of conflict and for the challenges to be posed to the child in order to create that sort of disequilibrium, a good understanding of the framework of child is needed. And this is how conceptual change is envisioned in Piaget's work. Just like Piaget, the Information Processing theorists also believe in the need for conceptual change, but unlike Piaget, Information Processing theorists explain conceptual change in terms of mental models and domain specific learning. An overview of Piaget's work and the works of other cognitive development researchers suggest that Piaget's theory can be taken as a starting point of the notion of child as ‘active self directing human being’. This notion of child in Piaget's work is in consonance with constructivist’s notions of knowledge.

**Role of Social Learning**

Vygotsky's Social Development Theory is also one of the works that has seeds of constructivists' notions of knowledge. But unlike Piaget, Vygotsky believed that social learning precedes development. Vygotsky's Social Development Theory advocates the teacher's role as a collaborator and facilitator in social learning environments. With a special focus on science learning, problem-based environments are very much advocated. In these problem-based learning environments, learning is driven by open-ended questions, the teacher having a role of facilitator. As, ready-made solutions are not given by the teacher in this environment, there seems increased probability of development of Alternative Frameworks if teacher is not able to meet
the challenge of considering the prior experiences of the learner properly in facilitation of problem-solving.

Ill-structured problems/unstructured problems are encouraged to be investigated and meaning making solutions arrived at. In the process of arriving at meaningful solutions - the process of meaning making, drawing of own conclusions, planning own investigations etc may leave the scope for development of Alternative Frameworks. When we interpret these problem-based learning environments in the light of Vygotsky's social learning environments, we can see the continuity of learners’ experiences inside and outside the classroom. In most of the theoretical discourses this continuity is valued and the teacher is encouraged to incorporate this continuity in designing the learning environments.

Network of Actors

Most concept development theories and cognition theories and ideas believed in the existence of concepts or knowledge and cognition inside the mind of an individual. Distributed cognition theory given by Hutchins expands this notion. Accordingly cognition is distributed not solely within one's head but across objects, individuals, artefacts and tools in the environment. Thus an activity or cognitive processes described in terms of not just internal representations and the dynamism but physical manipulations of objects and creation or exchange of external representations (Learning Theories Knowledgebase, 2012a). Hutchin’s ideas are seen as breaking internal-external boundaries of focus and providing a more continuous and integrated framework. In this framework, the technological design of mediating representational media has an access to a more effected model. This continuity and interconnectedness of the existence of cognitive structures has been propounded in the work of Lator and Callon in the form of Actor Network Theory.

The Actor Network Theory incorporates a ‘principle of generated symmetry’ integrating both human and nonhuman into the same conceptual framework. So there is a network of a number of factors together (Learning Theories Knowledgebase, 2012b). In the light of the above, we can say that the possible sites of formation of Alternative Frameworks will distribute in both human and nonhuman factors constituting a continuous and integrated framework of cognitive structures.

Learning Styles
The same non-centrality of one particular aspect in terms of having an impact on learning can be seen in the Experiential Learning Theory given by Kolb. Kolb envisioned the process of learning as essentially cyclic. This cyclic process has four aspects namely Doing, Reflecting, Conceptualizing and Planning. Thus according to Kolb, the concrete experiences lead to the formation of abstract concepts but are to be mediated by observations and reflections by the learner. These conceptualizations further lead to planning of new experiences.

(Kolb, 1984) also identified four learning styles based on these stages. These learning styles highlight conditions under which learners learn better. These are Assimilators, Convergers, Accommodators and Divergers. While assimilators learn better when provided with sound logical theories, Convergers learn better when provided with practical applications of theories and concepts. Accommodators need more hands-on experiences and Divergers need to collect a lot of data and information with their own observations for effective learning. From these learning styles we can extrapolate that when a diverger is provided with sound logical theories or an Assimilator is provided with a lot of data and information to be collected, there is more probability of development of Alternative Frameworks among learners in science specifically.

**Conclusion from review of Learning Theories**

A review of learning theories makes an essential case for learning of science continuum, having inseparability of content and pedagogy, product and process, environment within and without an individual, life inside and outside the school, objective, subjective forms of reality and formal and informal environment. Thus both the issues undertaken namely possible sites of Alternative Frameworks and addressing them need to looked in the perspective of this continuum.

**2.4 Reasons for Development of Alternative Frameworks**

For addressing alternative frameworks the identification of their potential sites and possible reasons can be the most important first step in addressing them. Deep probing, challenging the existing model and presenting the plausible model in the child’s own context are the keys to address these Alternative Frameworks. The reasons for the formation of Alternative Frameworks cannot be classified as, present in the classroom settings or outside it. That is to say both formal and informal
environments of the learners' expeditions to understand reality are the potential sources.

2.4.1 Researches done Abroad

On the basis of Research, examination of curriculum materials, and observations of learners and teachers, Missouri Department of Elementary and Secondary Education pointed out some of the identified reasons for learner confusion and Alternative Frameworks (Stepans, 1994). The following box provides the details of the reasons.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Details</th>
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<tbody>
<tr>
<td>1. Learners’ ideas do not always evolve as quickly as the rate of concept presentation in most textbooks and in many teacher-designed units of instruction.</td>
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<tr>
<td>2. Language used by teachers and textbooks may confuse some learners.</td>
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<td>3. There is often unexplored conflict between learners’ everyday experiences and the classroom or textbook presentation.</td>
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<tr>
<td>4. Immediate introduction of scientific definitions and formulas (many of which are abstract) are not necessarily convincing or meaningful to learners if they haven’t had sufficient experience with the ideas first. Traditionally, many learners engage in activities after presentation and discussion about the concept. These activities tend to be verification rather than inquiry-based where learners construct an understanding based on observations and evidence they gather.</td>
<td></td>
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<tr>
<td>5. Understanding is often expected before learners have a chance to adequately explore and convince themselves of what they have been told. Ideas are often imposed on learners, rather than allowing them to have the opportunity to make sense of something by exploring and developing ideas/models over time. “Covering” the curriculum without devoting enough time for building true understanding is counterproductive.</td>
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<td>6. Beliefs resulting from personal experience, intuition, and “common sense” lead learners to form their own ideas and models, often well before formal instruction. These experiences and feelings seem to contradict what learners read in their textbooks and/or are told by their teacher. Even with instruction, it is often difficult for learners to give up these ideas, or they may revert back to them later even though it appears they may have “learned” the correct ideas in class.</td>
<td></td>
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<tr>
<td>7. Instruction which fails to identify what learners’ initial ideas can leave learners’ erroneous ideas unchanged. It’s similar to a doctor diagnosing an illness. You wouldn’t prescribe a course of treatment without examining the symptoms first.</td>
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<tr>
<td>8. Teachers and schools (even tests!) often erroneously assume that learners understand a concept based on the words learners use when describing something (e.g.: evaporation). Scientific terminology is not sufficient evidence of learning unless you can ensure that learners use the terms with meaning.</td>
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<tr>
<td>9. Demonstrations used by teachers are often passive where learners sit back and observe without manipulating materials or experiencing the phenomenon individually or in small groups.</td>
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<tr>
<td>10. Pictures, diagrams, and 2-dimensional models in textbooks and other instructional materials can be misleading, and result in Alternative Frameworks.</td>
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<tr>
<td>11. Some common analogies used to explain ideas can cause difficulty because the similarity is not complete.</td>
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<tr>
<td>12. Everyday use of certain terms, often used in non-scientific contexts, contributes to learners’ confusion. Some words have many different connotations in the English language and the “scientific word” can easily be confused with a common use (e.g.: heat rises).</td>
<td></td>
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<tr>
<td>13. Some ideas are just too abstract and difficult for many learners who are still at a concrete learning stage (empty space between atoms and molecules).</td>
<td></td>
</tr>
<tr>
<td>14. Memorization of ideas can cause more difficulty, particularly for academically good learners.</td>
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</tbody>
</table>

Source: (Stepans, 1994)
Alternative frameworks are not a resultant of just personal meaning making or conflicting viewpoints. They may be a consequence of a difference between learners' pace of learning and the pace with which learner is presented with the information to be interpreted. The passive teaching learning environments, issues of abstraction and concretisation, un-engaging and non-thought provoking learning environments, use of inappropriate common analogies, pictures and diagrams in 2-D representing 3-D visualisations and age/stage specific learning difficulties have been identified in these researches.

2.4.2 In the Indian Context

Inquiry-based learning is an approach by which science teaching can be improved by engaging learners in authentic investigations. (Kubicek, 2005) emphasizes that the inquiry approach, while lauded by educators, is still not prevalent in the classroom, and is often misused. This may be the result of multiple factors, such as amount of classroom time, lack of effective means for learners to conduct independent investigations, the difficulty of incorporating abstract concepts with inquiry, and lack of teacher expertise and experience.

Absence of the inquiry based learning has been located in Indian contexts. (Educational Initiatives, 2009) conducted a national level research study over 32,000 learners from 142 leading schools of five metros - Mumbai, Kolkata, Chennai, Delhi and Bangalore. The findings of the study indicate that learners across classes answer rote-based or procedural questions relatively well. They seem to rely on memory or learnt procedures to answer almost all questions, rather than trying to think through and solve the unfamiliar ones. So when they come across a question similar to one they have ‘learnt’, they ‘jump’ to the most familiar answer they find. Learning had been observed to be compartmentalised, i.e. they may be aware of two pieces of information, but often not know how they are related or how that relation works in a real life situation.

Overall recommendations by the study are multi dimensional. For example, when updating textbooks and during teacher training programmes, such findings should be taken into account; The nature of questions in the Board Exams should change with more questions that test learning with understanding; Teacher education should also be understanding focus rather than rote-focused; Boards should start
awarding learners a percentile score in every paper; India should participate in international benchmarking assessments like the TIMSS which test learners on how well they can apply the learnt competencies/concepts.

The issue related to textbook raised by Educational Initiatives above is an important one as the textbook is usually regarded by educators throughout the world as a good source of information for teaching. (Abimbola & Baba, 1996) stated that American biology teachers rely solely on textbooks for use in their instruction. According to them, “Nearly 90% of teachers use a textbook 90% of the time”. In India too, science teachers seem to rely solely on textbooks for the appropriate content materials that satisfy the requirements of the science syllabi and the national curricula in the different science subjects. Infrastructural constraints indicate that textbooks are perhaps the only learning materials available and used in most Indian schools.

The issue of textbooks in the context of present study becomes more relevant when we look at the findings of (Narendra D. Deshmukh & Deshmukh, 2009). Findings indicate that many learners and textbook writers have Alternative Frameworks about various biological concepts. These Alternative Frameworks have been found to be generally based on social practices and school experiences but also may have come from the textbooks. The study contents that the illustrations given in the textbook can play a significant role in the learning process as they can facilitate the understanding of the scientific content. Therefore, they should be carefully chosen in order to facilitate learners’ learning and to prevent their alternative conceptions from being reinforced and/or induced by them. Also, it has been contented that many science textbook researchers, teachers and learners, are unaware of many of the Alternative Frameworks in science textbooks and the dangers such Alternative Frameworks pose to a thorough understanding of biology concepts. A point that can be highlighted from this study is that textbooks are human enterprises and should not be expected to be perfect materials.

The highlights from the study done abroad and from the Indian contexts raised issues about how and where Alternative Frameworks can develop among learners of science. Addressing them is a challenge in front of science educators.
2.5  Addressing Alternative Frameworks

Addressing Alternative Frameworks can be understood as moving from one conceptual framework to the other. This movement inherently means learning a new concept. This learning of new concept has been found to be directly affected by prior learning in the earlier sections. A brief outline of what is a concept, how it is learnt and the impact of prior learning is therefore part of our understanding of addressing Alternative Frameworks.

What is a Concept?

(Zirbel, 2006) articulates concepts as mental representations that, in their simplest form, can be expressed by a single word, such as plant or animal, alive or dead, table or chair, apple or orange. Concepts may also represent a set of ideas that can be described by a few words. More complex concepts can describe a whole idea, like for example "the theory of natural selection or the big bang model of the universe". In other words, within a particular representational structure, concepts help us make deductions and explain even more complex ideas. Concept can thus act like building blocks of more complex or even abstract representations.

Concept Learning

In objectivist epistemology (Rand, 1990), concept learning refers to a learning task in which a human or machine learner is trained to classify objects by being shown a set of example objects along with their class labels. The learner will simplify what has been observed in an example. This simplified version of what has been learned will then be applied to future examples. For instance, in learning the concept of “length", if a child considers a match, a pencil and a stick, he observes that length is the attribute they have in common, but their specific lengths differ. The difference is one of measurement. In order to form the concept "length," the child's mind retains the attribute and omits its particular measurements.

(Rand, 1990) identified the multiple roles of measurements in the process of concept-formation; two essential parts: differentiation and integration has been identified as the concepts that cannot be formed at random. All concepts are formed by first differentiating two or more existents from other existents.

According to (Blundon, 2009), Concepts arise as solutions to problems. This has been explained in terms of the concept being formed with the emergence of a
need that can be satisfied in the concept. What is central to this process is the functional use of the sign or word as the means through which the child masters and subordinates his own mental operations.

**Role of Preconceptions\ Prior Learning\ Naive Ideas**

A significant role of preconceptions in science learning is that they could channel the interpretation of subsequent teaching and affect learners’ developing conceptions. Particularly, an alternative conceptual framework often acts as an impediment to effective learning of scientific conceptions (Taber, 2003a). Therefore, the most important pedagogical knowledge a successful teacher should have is what misconception learners usually tend to have before and after teaching (Taber, 2000). Once we build the knowledge and skills, we can plan more effective lessons that help learners develop scientific ideas.

**Alternative Frameworks – A challenge**

(Fensham, 1994) highlighted one of the most important difficulties in addressing Alternative Frameworks. “It is not easy to change learners' schemes of understanding. Research in the learning of science for example has shown that many pupils resist changing their everyday and naive views on how the natural world works, despite being able to play back the ‘correct’ science explanations in formal tests” (Fensham, 1994). In order that these are addressed, many strategies and approaches have been suggested.

Learners’ Alternative Frameworks do not fall down unless science teaching permits constructions of reasonable and accessible other ideas. This cannot happen by means of a single operation: Learners must be conscious of their misconceptions, ideas must be confronted, learners must take on new models accessible to their minds (Strike, 1982); and finally, learners must learn to distinguish the context (macroscopic vs. microscopic) in which different conceptual schemes can be applied (diSessa, 1993).

(Omar, 2010) suggests, “Misconceptions can be displaced and learners will accept a scientific conception if:

- The learner understands the meaning of the scientific conception.
- The scientific conception is believable (this means that it must be compatible with the learner's other conceptions.)
The scientific conception is found to be useful to the learner in interpreting, explaining or predicting phenomena that cannot be satisfactorily accounted for by the formerly held misconceptions (i.e. the scientific concept must be seen to be better than the learner's prior belief).

The learner progressively gains expertise in using the new scientific concepts (a slow process requiring a long time period and gradual building of knowledge through experience)” (Omar, 2010).

(Duschl, Schweingruber, & Shouse, 2003) linked mediating conceptual change with what scientists do. “Certain interventions, in particular those involving an explanation of what scientists expected to happen and why, were very effective in mediating conceptual change when encountering counterintuitive evidence. With particular scaffolds, children made observations independent of theory, and they changed their beliefs based on observed evidence” (Duschl et al., 2003). This also support the experiencing of science has discussed in earlier sections. (Taber, 2003b) reviewed many researches to support the role of metacognition of addressing alternative frameworks metaphors are needed to be specifically built for the teachers so that these are not formed. “Given time and suitable instruction, learners can often manage to develop and improve their mental models so that they bring them closer to the curriculum targets. However, this can be a slow process” (Taber, 2003b).

Metaphors for addressing alternative frameworks can be built up. But teachers need to be specifically cautious in using these metaphors so that the formation of alternative frameworks is avoided to the maximum extent possible. “The main reason for this is that microscopic world of chemistry is difficult for them to experience, and thus chemistry teachers use a lot of analogies and metaphors to explain chemistry concepts. Therefore, it is particularly important for chemistry teachers to know how to avoid our teaching from being misinterpreted and leading to common misconceptions” (Posoda, 1997; Taber, 2001).

2.6 Implications for the Study

From the analysis of concept specific researches it has emerged that the formation of abstract models is a key factor in the formation of Alternative Frameworks. In this context, the language used by the teacher, providing space for
multiple interpretations by the learners, engaging learners in a metacognitive manner to reflect on their own learning, encouraging learners to generate, explain and put forth their arguments and models become important considerations. These aspects also play an important role while addressing the Alternative Frameworks.

The teacher plays an important role in addressing these Alternative Frameworks. For this, the teacher should be able to locate the Alternative Frameworks amongst learners, focus on individual explorations by them and try to analyze learner’s reactions and responses. A classroom environment for addressing the Alternative Frameworks will constitute the need to test the concepts of the learners, modify the language as per learners’ needs and contextualising the teaching-learning process and the pedagogical environment as per their needs.

The systemic pressure of reproducing the expected answers forces the learner into rote memorisation. Language used to explain scientific concepts is an effective tool in the reproduction of the bookish explanations and examples of these concepts. In order to locate the possible sites of Alternative Frameworks amongst learners we need to find ways so that the memorised responses may be avoided and a free and open ended option to express the understanding is available to the learner. One such possibility is to analyze the pictures and diagrams made by them openly along with the keywords that they associate with those diagrams and pictures related to a science concept.

Another way of locating the probable sites of Alternative Frameworks can be guided by understanding the questions that come to the mind of the learner. The resources that a learner uses for finding some solution to their problems may be a reason for possible sites of formation of Alternative Frameworks. Therefore we need to explore the ways in which a teacher addresses the above-mentioned key issues in the classroom and the questions, pictures, diagrams, terms and keywords that the learner associates with the science concepts. Resources that a learner prefers to use or is compelled to use in the absence of reliable resources also need to be explored.

The chapter reviewed various dimensions of formation of Alternative Frameworks including similar terms. The review brings forth the issue that despite there being
differences in the way science education researchers connote Alternative Frameworks and similar terms, there is a common understanding about the existence of gaps between the ‘scientific concepts’ and ‘other’ concepts that children have (hence forth denoted by Alternative Frameworks to include and accept broadest possible connotation). Also, science education aims to develop these scientific conceptions in our learners. Some concept specific researches bring forth as examples some of the vast possibilities of these Alternative Frameworks in both contexts: Indian contexts and in international perspective. Challenges like moving away from daily life experiences for scientific concept modelling, problem of 3-D representation, constraints of being a teacher (as expected to be knowing everything perfectly), language barriers and ambiguity etc have been identified. A review of major learning theories and models brings forth the idea that no theoretical framework is able to provide reasons/solutions to this problem. Nature of science framework has been revised bringing the culture of science to be developed in science classrooms. Within the identification of constraints and challenges related to formation of Alternative Frameworks among learners in science, and the objective of exploring the efficacy of computer-aided learning in addressing them, a review of the nature of work done in areas related with computer-aided learning is needed. This has been taken up in the next chapter that is the second section of theoretical framework and review of related literature.