CHAPTER I
CONCEPTUAL FRAMEWORK

1.1 Introduction
The word Science derived from Latin word Scientia which means “to know”. In this context, science is a human enterprise through which we come to understand the biological and physical aspects of the world around us. Science is tied to nature. Explanations of nature are always open to questions. Science is built from curiosity, experience, analysis, and finally the expression of discovery. Adinarayana (1977) said science is better suited than any other subjects for acquiring the ability to develop scientific attitudes, to distinguish on the fact from opinion. It is important that science is highly creative and dynamic in nature by which man can attempt to search knowledge. Science provides opportunity for an individual to develop inquiry skills, critical thinking, creativity, problem solving, decision making skills etc. National Research Council (NRC, 1996) rightly stated that Science is a Human endeavour that relies on reasoning, insight, energy, skill, and creativity. Science not only inculcates knowledge and skills to the human, it also promotes universal values to people for the betterment of society (Patel, 1997).

It was stated by NRC (1996) and American Association and Advancement of Science (AAAS, 1989; 2000) that scientific literacy is one of the foremost goals of science education. Nation vision and expectation is that everyone to become scientifically literate citizens. Considering this view, educationist, policy makers and stakeholders realised that schools have prime responsibilities to prepare the children with scientifically literate citizen. It was recommended by Secondary Education Commission (1952) that the common need of middle school students in the area of science can be met best by formulating “general courses”. At the High school stage, there will be a specialised reorientation of the science courses and Physics, Chemistry and Biology will be taught as independent subjects. The outcome of science teaching in schools should be make the students to understand the basic scientific concepts, facts and principles, process skills/methods, to develop scientific attitude, and apply the basic scientific concepts and skills in their daily life. UNESCO (1992) formally expressed the objectives for learning science as concepts, process skills and attitudes. Till
1960s, science teaching in schools was dominated by facts, principles, laws, theories and concepts. Much importance was given to products of science rather than process of science. After realising the importance of process of science, it was included in the school science curriculum. NCERT identified the process approach as one of the core elements of the science while planning the integrated curriculum for middle schools students. It emphasised that science curriculum must stress more on the processes than the products. UNESCO (1978) stated that understanding of processes of science as one of the most important objectives of the integrated science programme followed in the middle classes (Sixth to Eighth) of the Indian schools. According to Brown (1968) a study of the list of science teaching objectives in India reveals that the widespread concern of science educators with student development of an adequate understanding of the processes of science if reflected in all the science education programmes. By considering the importance of process aspects of science, almost all national level documents (Kothari Commission, 1964-66; NPE, 1986; NCF, 2000, 2005) recommended that process skills in science is an integral part of science education, and developing process skill is one of the objectives of science teaching.

1.1.1 Definitions of Science

Science is a term that encompasses many field or disciplines. The nature, structure and functions of science have been differently described by various scientists and philosophers. It is not easy to give precise definition on what is science. However many scientist, researchers, and philosophers made attempts to define science. According to Frederick Fitzpatrick (1959) “Science is a cumulative and endless series empirical observations which results in the formation of concepts and theories, which both concepts and theories being subject to modification in the light of further empirical observations. Science is both body of knowledge and the process of acquiring knowledge. According to the Columbia encyclopaedia “Science is an accumulated and systematised learning in general usage restricted to natural phenomenon. The progress of science is marked not only an accumulation of fact but by the emergence of scientific method and of scientific attitude”. By analysing the different definitions of science, following inferences are derived
Science is a systematic way of acquiring knowledge. It is dynamic, tentative and no absolute knowledge.

Science is a process as well as product. The process of science is a set of skills followed by scientist or students while discovering or verifying theories. Products of science includes facts, theory, law, principle and generalisation etc are the outcome of process.

Science is an endless process of search of truth. Human mind is always busy in pursuit of exploring the unknown.

The process of science is given more preference than the product of science.

### 1.1.2 Domains of Science

Science curriculum in school covers following domains such as cognitive affective and psychomotor. All the three domains develop students’ higher order thinking skills. Teachers should not focus only on cognitive domain; it is important that teaching of science should develop other domains of science such as affective and psychomotor. All the domains of science should not be learned in a fragmented manner, it should be learned through integrated way. The method of teaching science and science learning should develop knowledge and skills, and attitudes which comes under the different domains of science. Enger and Yager (2001) stated that learning science promotes scientific literacy and it organised around six domains

(i) **The Concept Domain:** it includes facts, laws or principles, theories, and the internalised knowledge held by students fall under the umbrella of the concept domain (Yager and McCormack, 1989).

(ii) **The Process Domain:** it includes the 13 processes identified by the AAAS (1968) in the development of science: A Process Approach is generally accepted sets of processes that scientist use as they accomplish their work.

(iii) **Application Domain:** it is the extent to which students can transfer and effectively apply what they have seemingly learned into a new situation, especially one in their own daily lives (Gronlund, 1988). It is important because students use concepts and processes.

(iv) **Attitude Domain:** It includes development of positive attitude towards oneself and development of more positive attitude towards science in general. Gardner (1975) explained two distinguishable general categories of attitudes (i) attitude towards science (i.e., interest in science, attitude towards scientist, and attitudes towards responsibility in science) and (ii) Scientific
attitude (i.e., open mindedness, honesty, or scepticism). (v) Creativity Domain: Creativity is integral to science and scientific process. Creativity promotes divergent thinking, alternative viewpoints, novelty, solving problems and puzzles. Creativity plays an important role in many of the processes of science and in doing science. (vi) Nature of Science Domain: The nature of science is about how the ideas are generated and how these ideas are developed through particular ways of observation, experimentation, and inferences. The nature of science also talks about the way of knowing science. The outline of six domains of science shown in the Figure_1.1.

Figure_1.1: Domains of Science

1. Concepts
   (Content, accumulated science Knowledge)

2. Processes
   (Scientific skills or method)

3. Application
   (ability to apply scientific knowledge)

4. Attitudes
   (perception of science, scientist, science teachers, scientific knowledge)

5. Creativity
   (thought patterns representing divergence or synergy)

6. Nature of Science
   (What science is, who does it, why it is done)

1.1.3 Nature of Science (NoS)
Science is always search of truth, scientific concepts are uncertain and it is subjected to modify the existing laws, theories, and generalisation. Scientific knowledge, skills, attitudes are important for all citizens and it comes under the Nature of science (NoS). National Science Teachers Association (NSTA, 1982) stated that understanding the nature of science is one of the prime responsible for scientific literate person. Process and products are one of the important aspects of NoS. Process leads to the development of products, and the products can be verified through process. Science teaching needs to address the processes and
products of science but too often that present science teaching in schools teach science as a subject with very little/no connection to the real world therefore students fail to connect between what they learnt in science class and how to apply in natural world. Lederman (1999) stated that teaching NoS science can increase student interest in science and can enhance their content knowledge and increase the student achievement. It is quite abstract to define NoS. However it mainly stress the way of knowing science, methods/process of science, and epistemology of science. By observing of meaning of NoS stated by various researchers the following tenets have been identified, they are

- Scientific knowledge is tentative and it is subjected to change if new information is acquired.
- All Scientific knowledge is partly based on empirical evidence. Empirical evidence which is any evidence is measurable or observable. Any other way of knowing things that lacks empirical evidence is not connected as scientific knowledge.
- Scientific knowledge is created by scientists based on observation and inference.
- Dual nature of science is product and product.
- NoS develop one’s attitude towards science and science learning.
- Imagination and creative thinking are the integral part of science.
- Scientific knowledge is socially culturally embedded.
- NoS include sociology philosophy and epistemology of science.

1.2 Science in Post Independence India

In the beginning of twentieth century science was not a school subject. Science existed only in the universities. India Science Congress also did not help in noticeable contribution towards teaching of science in schools in the early part of twentieth century (Das, 2005). After independence the development of science education greatly accelerated by recommendation of Commission, Committees, Policies. By looking at the scenario of science education, University Education Commission (1948) remarked that “our Secondary Education remains the weakest link in our educational machinery, it needs urgent reforms”. Similarly, Secondary Education Commission (1952) made following recommendations:

- It is desirable to formulate “general Science” courses for the middle stage.
Teaching of general science as a compulsory subject in the secondary and higher secondary schools.

There is a need of different approaches.

Need of curriculum reformation with logical and scientific demands of the subjects than the needs.

Memorisation should be de-emphasis.

In 1956, All India seminar on the teaching of science in Secondary Schools was the first effort concerning to school science education in terms of teaching, equipments, examination, study materials etc. It suggested that uniform systems of Science teaching for the entire country situated to its needs and resources. Tara Devi report (1956) advised that teaching of science should develop the abilities to solve problems, and inspire towards scientist and new inventions. In 1957, National Science Policy Resolution (NSPR) focused to encourage and initiate with all possible speed to fulfil the country needs of science education. Kothari Commission (1964-66) advocated that science is an important element in the school curriculum, further recommended that science should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling and recommendation were implemented in 1975 when Science for All (SFA) was introduced as a part of general education during the first ten years of schooling with this 10+2+3 education schemes started with an additional year of schooling in the country. In 1977 Ishwarbhai Patel Committee submitted its report on curriculum for ten year school. NPE (1986) recommended to accelerate the national growth and Science Education should be given high priority. The Programme of Action (PoA, 1992) recommended innovative ideas like open book examinations, diagnostic evaluation, and training and orientation for teachers. In 1996, Public Report on Basic Education (PROBE, 1996) conducted a survey in rural areas of northern state. The findings of the report brought out some suggestive measures to improve classroom environments, utilisation and maintenance of resources, pupil teacher ratio.

Science Education was flourished by National and International bodies such as UNESCO, UNICEF and NCERT, and has taken laudable efforts to improve the Science Education at School level by providing training to science teachers, supplying science kits, materials etc. Apart from that there are some macro level programmes and interventions for example, DPEP which has since been extended
into SSA and it is being sustained over several years, now upgraded into RMSA. Under this programme science kits, equipments, modules were supplied, and training programme for teachers were provided. Micro level interventions programmes like Homi Bhabha Centre for Science Education (HBCSE) of the Tata Institute of Fundamental Research popularised the science and talent searching programme, also the centre developed and supplied study materials. Hoshagabad Science Teaching Programme another example of micro level intervention for developing Science Education by preparing materials, kits, training modules, textbooks. Other small scale programme like “Prashika” “Lok Jumbish Parishad” also involved in fostering Science education in terms of pedagogy, learning materials, and science awareness. Some of the states established centres for science. For example, State like Gujarat established Community Science Centre in each district to develop scientific temper and to create awareness about science among students and society.

Technology cannot be isolated from science. The basic principle behind the products of technology is “science”. Science leads to invent technology, through technology scientific knowledge can be further expanded. Considering the need and worth of Science and Technology (S&T) in the school education, NCF (2000) suggested that “learning of science in general education up to secondary stage needs to be replaced by learning of science and technology in view of the strong organic linkage between the two. In 2004, NCAER first time brought out a report called “India Science Report”. It shows the students and parents’ interest towards learning science. Subsequently, NCF position paper on Science teaching (2006) recommended constructive method of science teaching. Based on the recommendation, NCERT department of science and mathematics revised the syllabi in 2006 and developed new textbook during 2006-08 curricular material related with laboratory manuals are being used by the teachers and students.

The above observations reveals that laudable effort and initiation taken by national level and district level programmes, results considerable progress observed in science education for example, Nation incorporated science as a compulsory subject upto X standards in all schools; students’ shows interest towards science (India Science Report, 2004). On the other side, by and large many problems persist in general, particularly in teaching learning. It was stated by NCF (2005) that most students’ quality unacceptably poor, for majority of the
students science is just another demanding and difficult subject to be learnt by rote, and small minority of students come out of the system with outstanding competence in science comparable to international standards. In most of the schools, objectives of science teaching was not achieved, particularly laboratory facility, teachers’ availability, overcrowded classroom, overloaded curriculum, lecture method of teaching are serious concern in school education. It is therefore require several reforms to accomplish the objectives.

1.2.1 Objectives of Teaching Science at Upper Primary Level

The upper primary children getting first exposed to study science as a separate subject. This is the stage wherein students can construct basic scientific concepts, acquire skills, and develop attitudes. According to Piaget, upper primary stage students are in formal operation stage (age of 11 to 14). Children at this stage very much interested to operate science equipments and experience the process of science. It is therefore the objectives of teaching science should fulfil the needs and interest of learner. The objectives of science teaching stated by Commissions and committees including Secondary Education Commission (1952), Kothari Commission (1964-66), NCERT (1990), National Curriculum Framework (2000 and 2005) are as follows

- Teaching of science should lead to development of certain values, and it should link scientific principles with daily life experiences of the learners.
- Acquisition of skills for planning and executing socially useful productive work with a view of making education work based.
- Science teaching should be placed in the wider context of children’s environment to equip them with requisite knowledge and skills to enter the world of work.
- Instead of loading the students with scientific information, efforts should be made to help them to learn key concepts which cut across all the discipline of science for developing curiosity and to create awareness and understanding.
- Science teaching should engage the learners in acquiring methods and processes that will nurture their curiosity and creativity particularly in relation to the environment.
At this stage emphasizes should be given on acquisition of knowledge and many skills, ability to think logically, to draw conclusion and to make decisions at a higher level.

Science teaching at this stage should initiate the student into the use and appreciation of the scientific method by which facts are discovered, relationship established, and sound conclusion reached.

Teaching and learning of science needs to be characterised by emphasis on processes i.e. experimentation, taking observation, collection of data, classification, making hypothesis, and drawing inferences.

Acquisition of knowledge through observation study and experimentation in the area of social and natural science.

Exposing the children to the process of science, teaching of science should stress more on the processes than the product.

Teaching of science should develop scientific attitude and scientific temper.

Developing measurement and manipulative skills and to encourage the use of locally available resources.

The emphasis on the process skills of science, and it continue through the upper primary stage to enable children learn how to learn themselves.

Learning should be made active through experiential mode.

In a nut shell, from the above objectives it can be observed that more emphasis was paid to process of science. In contradiction to the above objectives, status of science teaching in schools revealed the dismal picture.

1.2.2 Status of Science Teaching in India

Looking at the contemporary scenario of science education in schools, the issues and challenges are more with regard to instructional method, laboratory and equipments facilities, curriculum materials, and evaluation system. Of the above issues and challenges, instructional method plays a significant role in science education at any stage. Science teaching largely follows lecture method; occasionally demonstration was conducted in the classroom or laboratory. Science teaching was not emphasising the process aspects. Science teaching was dominated by facts, concepts, principles, and generalisation; teachers very rigidly following the experiments and investigations. It was recommended by Kothari Commission (1966) that there is a need of drastic change in teaching methods.
Successively, Secondary Schools Science Teaching Projects (1969) conducted by NCERT collaboration with UNESCO pointed out that science education is not seen sufficiently as a whole either from developing attitude, acquiring skills as well as gaining knowledge, and the topics studied and the methods employed are not sufficiently related to children natural interest, traditional attitudes towards learning science found in Indian Schools, investigatory method are not encouraged, rote learning is all common too. Nation struggling to achieve universalisation of elementary education this is because one of the factors may be that low attract school for enrolment and drop out at the elementary stage due to lack of infrastructure facilities, untrained teachers in teaching (UNESCO, 1984). A survey report by Indian Journal of Public Administration (1986) stated that most of the schools basic facilities for teaching learning process far from satisfactory level. 70 % middle schools had no laboratory facilities, and 41.5% had no blackboards.

NPE (1986) also stated that the Present curriculum narrowly conceived, learning has become a rather mechanical process of acquiring skills and teaching has been largely a process of coaching for examinations and testing the memory, present syllabus emphasising more on memorisation and recall of information little or no progress was made in training the pupils in practical side of science. Research findings (Veerappa, Ganguli and Vashista, 1991) revealed that the position of science teaching which was characterized by the “Herbatian” plane, lecture, lecture cum demonstration method and essay type examination (Fifth Educational Survey, 1988-92). Report of the National Advisory Committee on learning without burden (1992-93) pointed out that transaction of information rather than experimentation, exploration or observation characterizes the teaching learning process in most classrooms. Teaching is too mechanical very little or no active involvement by students in the process of learning; students are trained to blindly memorise the content without thorough understanding of concepts. A survey conducted by PROBE on elementary education in the year 1996, findings reported that the following facilities such as blackboard, playground, drinking water, library, teaching kit are unavailable or available but not functional, similarly poor enrolment, inadequate teachers, lecture dominated teaching and rote learning, many of the classroom are not conducive for learning.
Malhotra (1998) and Umasree (1999) study findings reveal that teachers often provide lecture and students are rarely given opportunity to do things or take initiatives largely, and students observe the teacher rather than actively participating in the classroom. Thirty years Hoshangabad Science Teaching Programme (1972-2002) stated that “the dismal picture of science teaching is nothing new; it is mainly emphasis of textbook based rote learning, no scope for experimentation, exploration”. Teachers are not only transmitter of knowledge of science but also to engender in students a passion for science. Teachers of science have the challenging task of involving the students in scientific enterprises through science teaching. India Science Report (2004) pointed that Student’s science learning is low, because inadequate time to complete syllabus, lack of scientific equipment, inadequate physical infrastructure and lack of good teachers. Interest in science as well as satisfaction with the quality of science teaching declined as the age increased, all these issues may fail to express excitement towards science education. Aravind kumar the Director of Homi Bhabha Centre for Science Education stated that “it is unfortunate that the majority of the school across the country teach science in a boring and mechanical style allowing little room for original thinking and investigation. Most of the time, students spent on searching for correct answer; this is false interpretation of science teaching. Science is all about doing and learning even through mistakes (HBCSE, 2004).

The above observations are the evidence for poor transactional method employed by science teachers in most of the schools. Science is only subject having more scope to do experiment, investigation, demonstration, activity and discovery and so on but it is unfortunate that there is no innovation in teaching and assessment. Teachers are not providing opportunity for the students to do hands on-minds on experiences. Most of the time Teaching was going on in classroom; development of scientific skills, interests, attitudes, creative thinking, problem solving skills are remaining in an utter state of neglect. Constructivist approach of learning science emphasis that learners are prime concern in learning process, learners have self autonomy to learn knowledge and skills, active involvement by the student are the major focus; teacher not to dictate the information and learners are constructor of knowledge and skills (NCF, 2000 and NCF 2005). Looking at the dull picture of science teaching, policies and commissions made recommendation to improve the method of teaching since 1966 but the status of science teaching was unsatisfactory. PROBE revisited in the year of 2006 in the same northern states, the survey reports that there has been major progress in the PROBE states
in schooling facilities and enrolment rates. At the same time, fundamental problems remain prevail that the children who are enrolled are not necessarily in school, and mere attendance does not guarantee learning, many children who attend school are in classes where there little teaching activity. Teaching activity, where it does not exist, often translates to mindless rote learning, quality remains a serious concern, with low levels of teaching activity observed. Schooling situation in India remains dismal in international perspective. Enormous challenges that lie ahead in the area of upper primary schooling. Physical infrastructure is far from sufficient, numbers of teachers are not adequate, low levels of teaching activity observed in the 2006 survey. Indian Institute of science Bangalore, and NKC (2008) stated that teaching science through experiments is largely missing in most schools. Even where the laboratory is available, they are not upgraded. The students suffer due to lack of science material; laboratory equipments deteriorate due to lack of maintenance, overcrowded classroom, and chalk and talk method of teaching.

It is necessary to strengthen the quality of science teaching, rote memorisation should be de-emphasised. There should be active involvement from student side, innovation and creativity to be promoted. Need a paradigm shift from “listening science” to “doing science”. 96th Indian science congress also suggested that teaching of science needs to be refined substantially it must help the students to develop skills of procuring information and its analytical examination. Opportunity should be given for the students to carry out experimentation and investigation. Process skills should be nurtured in students. National Curriculum Framework (2000, 2005) advocated that teaching and learning of science needs to be characterised by focussed emphasis on processes of science. There is a need of alternative textbook which includes activities and experimentation for observation because scientific concepts are to be arrived at mainly from activities and experiments. National Knowledge Commission (2006-09) recommended that all school children should be encouraged to involve in some practical activities that require working with hands. Teachers of science should not strictly follow only textbook and train the students to memorise the concepts by ignoring the process skills. Content transmission is not the goal of science teaching. Basic content of science is important but those contents should be learned through process of science. Process aspect of science is more important than the product. Process skills are fundamental for formulating scientific concepts; rediscover the new knowledge, to develop scientific attitudes, to promote logical and creative thinking, and curiosity.
1.3 Product and Process of Science

1.3.1 Product of Science

It is stated in the NoS that the dual nature of science is process and product. Products are the outcome of process. Systematic observations and experimentation leads to the formulation of theories and generalisations. Empiricism generally encompasses systematic study of facts, theories and generalisation. Enger and Yager (2001) opined that central focus of science instruction is to understand the concepts. Concepts are always tentative; all propositions are subject to being revised or falsifiable. Hurd (1971) opined that significance of concepts and facts are constantly shifting within the scientific discipline and new ideas and theories leads to change present knowledge.

NCF (2005) suggested content validity is one of the basic criteria for science curriculum and it demands that science curriculum must convey significant and scientifically correct content. The content presented in the curriculum is not just for memorisation, it is for comprehension. Students should not come out of science class with a memorised set of definitions without understanding the contents. Students must know the reason behind the concepts for example why warm air rises up, what is essential to support combustion, how sound travels in a medium. Practical learning should be promoted and rote learning should be discouraged. Such learning becomes more permanent, meaningful and concrete. The purpose of learning science at early stage is not behave like scientist, rather the purpose is to develop process skills, concepts and attitudes towards science which will enable them to cope up effectively for their further education. The science process skills such as observation, classification, communication, measurement, prediction and inference and so on can be translated into immediate behaviour by the child as he attempts to understand the phenomena of science encountered in his environment. Pritam Singh (1971) says that pupil should observe, measure, classify, use numbers, see relationship, make hypothesis, devise experiments, interpret evidence, draw conclusions and verify the findings. It refers that, systematic way of knowing science.
1.3.2 Process of Science

Science is both thought and action. Thought is nothing but the ideas, conception, and beliefs about the natural phenomenon wherein the action is methods and procedures or processes followed by scientist or students. The process includes certain set of skills and abilities such as observation, measurement, communication, testing hypothesis, design experiment, changing variable etc. These skills are commonly called scientific method. These skills are the foundation for formulation of theories, generalisation, principle, and laws. It encourages the spirit of inquiry through laboratory experiments. Menon (1986) stated that the processes of scientific inquiry represent the spirit of science as an activity and its essence that it distinguishes science from other discipline. Hands-on minds-on experiments and activities provide rich learning experiences for the students to acquire science process skills. These are chiefly mental skills, but also associated with physical skills.

1.4 Concept and Genesis of Science Process Skills

Science process skills are commonly used the term now, but one point of time synonymously it was termed as scientific method, scientific thinking, and critical thinking and processes of science. Harlen (1992) stated that process skills include planning, following directions, observing, experimenting, measuring, predicting and inferring; these are concerned with processing evidence and ideas, and so are often called process skills. Science process skills are the set of procedures which are employed by scientist during investigation and discoveries. SAPA (Science: A Process Approach) describes that scientific process skills are defined as transferable skills that are applicable to many sciences that reflect the behaviour of scientists. By observing the above definitions it can be inferred that science process skills are the set of intellectual skills which are performed by our mind in association with sensory organs during the process of science.

Early to 1960 there was a proliferation of new science programmes. This was a manifestation of a shift in emphasis of teaching from content to process skills. The process of science first implied by the American Association for the Advancement of Science in their programme (AAAS) called Science: A Process Approach (SAPA), after 1960 “Content” was de-emphasised (Bhatt, 1988). Following curriculum change projects were launched and renovated to emphasis
processes of science in science teaching namely Physical Science Study Curriculum (PSSC), Science A Process Approach (SAPA), Harvard Physics Project (HPP), Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), Elementary School Science Curriculum Improvement Study (ESSP), School Science Curriculum Project (SSCP), Minnesota Mathematics and Science Teaching Project (MINNEMAST), Conceptually Oriented Programme in Elementary Science (COPES), Chemical Education Material Study (CHEMSTUDY), Chemical Bond Approach (CBA), Science in Process, Warwick Process Science (WPS), Nuffield courses in the UK (Figure_1.2). These curriculum reforms and projects stresses on process skills through different approaches such as inquiry approach, investigatory approach, and discovery approach of teaching science. All the Curriculum reforms and projects findings reveals that the process approach is more effective in increasing pupils’ science achievement and attitude compared to traditional science program (Blosser & Mayer, 1982). By realising the need and importance of science process skills, Current Science Education Standards such as Science for All Americans (SAA, 1990), the Benchmarks for Scientific Literacy (1993), National Research Council (NRC, 1996), and National Science Teachers Association (NSTA, 2002) advocated the Science Process Skills among the school students. By considering the importance of process aspects of science, much earlier Secondary Education Commission (1952) recommended that science curriculum should provide opportunity to carry on practical activities and laboratory work. Subsequently, all commissions and policies continuously emphasises development of process skills. At present, there is a shift in the Science curriculum to emphasise from content of science to process of science. It was stated in the NCF (2005) that development of process skills upto standard X is one of the objectives of teaching of science.
1.5 Classification of Science Process Skills

The American Association for the Advancement of Science (AAAS), UNESCO (1992) identified thirteen process skills under two major classification namely Basic and integrated. Basic Science Process Skills (BSPS) are Observing, Classifying, Communicating, Measuring, Predicting and Inferring. These basic process skills are foundation for acquiring the integrated process skills. Integrated Science Process Skills (ISPS) are identifying and defining variables, describing the relationship between variables, formulating and testing hypothesis, collection of data, designing investigation and experimentation, manipulating the variables, identifying the cause and effects, acquiring organising and displaying the data with charts, graphs, tables. All these process skills are interrelated; there is no sequence or particular order of these skills. Any skill can begins first, all other skills follows later. But most of the time observation skill starts first, rest of the skills follows later.
1.5.1 Basic Science Process Skills (BSPS)

1.5.1.1 Observation

Observation is the fundamental science process skill among all other process skills. The process of observing is taking in information through sense perceptions. It is the most basic and broadest skill through which all other skills are refine it. Good observations lead to the development of other science process skills such as communicating, predicting, measuring, classifying and inferring. Observation begins from every activity of science. It is more than just ‘seeing’ and it is associated with collecting data using all the senses such as eyes nose ears tongue and skin as well as instruments that extend beyond the reach of our senses. Seeing allows the students to notice such properties as sizes, shapes, colour of objects or organisms, it is also to gather fine details. Hearing makes knowable properties of sounds such as loudness pitch and rhythm. Touching is to know the texture hardness roughness softness powdered crystalline in nature hotness and coldness. Tasting is to feel how some properties of substances are bitter sweet sour and salty. Smelling is to recognise the odour of particular chemical substances, and food items based on the commonalities and differences.

There are two aspects in development of the observation skill: attention to detail and ability to distinguish what is relevant to a particular investigation. UNESCO (1992) said that what children say, draw or write about what they see smell hear or taste or feel with their fingers is an important source of evidence of their observation. During observation one can use hand lens and microscope for observing the minute detail about the particular events or occurrences. Observation should be till the end of event or completion of experiments not just only in the beginning. Deep observation can provide more accurate information.

The observation can be classified both qualitative and quantitative. Qualitative observations are qualitative in nature that is descriptive terms such as colour, smell, texture, properties and characteristics’ of object or things or organisms. Quantitative observation refers to notice the numbers in terms of object or things or organisms. Quantitative observations usually are more precise than qualitative observations. For example: observing the number of legs in centipede millipede or number of segments in earthworm or number of tentacles or antenna in some insects or if a student reports that a lemon has six seeds it is likely that other children observing the same piece of fruit would make the same quantitative observations. Observations using comparisons such as “an arm’s length” or “as big as my fist” are considered quantitative.
1.5.1.2 Classification

Classification is the process of sorting, grouping, ordering or arranging objects on the basis of similarities and differences, larger or smaller and other common characteristics. Most intuitive thinkers can select and group the objects by some common property such as colour, shape and size. The classification can be qualitative as well as quantitative. Qualitative classification based on size, shape, colour, habit and habitat and the nature of substances such as smoothness, roughness, hardness, softness, opaqueness, transparent, solids, liquids, gases etc. Quantitative classification is based on number for example: age, number of leaf or petals in a flower. The classification can be binary or multistage. In binary classification system a set of objects or things are classified into two subsets for example (i) living being is classified into plants and animals (ii) animals are classified into vertebrates and invertebrates. Binary classification is the most basic form of classification. In multi-stage classification each subsets follows consecutive binary classification or succession of binary classification for example, subset animals further classified into mammals, birds, lizards, reptiles and so on. Classifications of things or objects or substances are not only unidirectional, it can be multidirectional also i.e. grouping or arranging them into more than one category based on presence and absence of certain attributes. For example: a group of living organisms are classified into birds, reptiles, insects, unicellular, multicellular, herbivores, carnivores, omnivores, terrestrial and aquatic animals, vertebrates, and invertebrates, mammals etc.

Objects, things, substances and organisms can be classified in different ways but before going for classification one has to think whether the particular property is being present or not. Thorough observation is needed before arranging or ordering the things. Classification skill helps to understand and conceptualise the scientific ideas in a systematic manner. Classification helps the students’ to retrieve information from a conceptual scheme. Classification skills develop creativity and also develop divergent thinking. Classification skill helps to relate the objects having similar attributes through which concepts can be constructed.
1.5.1.3 Communication

Communication skill refers to convey of information from one person to another by verbal or nonverbal means. Verbal communication conveys the information orally using scientific terminologies clearly. Nonverbal forms of communication are through charts, graphs, maps, and drawings, symbols, pie chart, tables, chemical formulas of particular element or compound, symbols of electric component, flow chart. Harlen (1992) argues that both written and oral recording communication are integral parts of the activity because making records helpful for further discussion and display through adequate communication way for easy understanding. Making record is the part of communication which helps for future verification. It was stated by AAAS (1965) that Observation and communication are two process skills which are absolutely essential for an individual to relate to the physical world. Scientists use to communicate with another person about what they observed or discovered. They makes model, draw able graph or histogram symbols to convey the information. NCS (2002) stated that communication skill helps the learners to reflect on their own learning and to build confidence as a person.

1.5.1.4 Measurement

Measurement is the act of using numbers to describe objects or events. Measurement is a process wherein measure the attributes that are measurable such as temperature, length, breadth, height, area, mass, and volume. Measurement is a process which involves comparison of an entity with standard measurement. Measurement skill follows calculation, after completion of every measurement it should be written with proper measurement unit for example: Units like centimetre or millimetre Kilogram length breadth temperature weight mass area volume etc. Prior to measure the objects or liquids one has to choose appropriate measuring instruments such scale, ruler, meter stick, yardstick, balance, clock, thermometer, graduated cylinder or containers, protractor, screw gauge, vernier calliper, and tape. Also it is very essential to ensure that the selected measurement device is standardised or not, capacity (range), increment values, and calibration or adjustment to ensure the proper use of the instrument, whether the device is numbered or unnumbered, and ensure the accuracy of instrument.
1.5.1.5 Prediction

Predictions are the statements about what might happen or could be expected to happen in the future. It is based on some relevant prior knowledge in a form which can be investigated. Prediction is the act of predicting the forecasting events based on a previously developed model or experience. A model is a visual or cognitive representation that relates various aspects to one another, a well developed model allows one to be more confident in making predictions related to a situation, for example: meteorological model that allows forecasters to make accurate predictions of future weather conditions in a locale (Bentley, 2007). Prediction can be based on the use of available evidence or past experiences but there should be proper justification for the prediction (UNESCO, 1992). For example, based on observation of simple pendulum experiment one can predict what would happen if length of the pendulum increased? Predictions, unlike inferences, are verifiable. A prediction is not a wild guess; a guess has no rational foundation. Predictions are kinds of thinking that require learners’ best guesses based on the information available to them. It involves the learners in using knowledge to decide what will happen if something is changed in a situation. Prediction can develop one’s deep thinking and logical analysis and interpretation. Before conducting an experiment or activity one can predict ‘what will happen? Later, prediction should be verified. Prediction also can be based on inferences.

1.5.1.6 Inference

Inference is the act of making statements based on observations. Inference is a process of making suggestions, conclusions, assumptions or explanations about a specific event based on observation. Inference is different from observations, there can be a misconception that observations are inference but both are different conceptions. Observation is the use of one’s senses to perceive objects and events and their properties. Inferences are making statements or conclusions after a deep observation and understanding of a phenomenon, therefore observations are the base for any inference. For example a student observing a plant and reported that “two leaves are dying”. In this, student made inference based on the observations of colour difference of the leaves (two leaves colour is yellow or brown and other leaves are green). Sometimes more than one inference can be made based on a list of observations. Inference skill encourages metacognition process and it stimulates higher order thinking skills, problem solving skills and decision making skills. Inference helps to identify the Cause and effect relationship.
1.5.2 Integrated Science Process Skills (ISPS)

**Formulation of Hypothesis:** Formulating the tentative statements or expected outcome for experiments. These statements must be testable.

**Identification of Variables:** Stating the factors or variables which affect the experiment. It is important to manipulate the variables being tested and keep all other variable constant. The one being manipulated is the independent variable. The one being measured is the dependent variable.

**Defining Variable Operationally:** Operationally describe the variables of an experiment.

**Describing Relationship between Variable:** Describe the relationship between variables in an experiment such as independent and dependent variables.

**Designing Investigation:** Design an experiment in a systematic way to test a hypothesis.

**Experimenting:** Carry out an experiment carefully by following correct procedure so that results can be verified by repeating the procedure several times.

**Collection of data:** Collect qualitative and quantitative data during experiments through observations, measurements and any other means. Employ sensory organs to collect information.

**Recording the Data:** record the quantitative and qualitative data for further use.

**Analysing Investigations:** Interpreting data statistically, identifying human mistakes and experimental error, evaluating the hypothesis, deriving inferences, and design further investigation if necessary.

**Identifying the Cause and Effect Relationship:** Identify the factor or variable which affect the experiment.

During the process of doing science, scientist and students employ both basic and integrated science process skills. By employing the process skills one can acquire the procedural of doing science and conceptual clarity.

1.6 Nature of Science Process Skills

Process skill domain has its own values and identity in science. It is the most important domain wherein all other domains of science can be developed. Process skills are inventive and exciting activity to search the knowledge. These skills must be nurtured among the students in a systematic manner so that they become scientifically literate in their life. The nature of science process skills describes the systematic method of knowing science. The nature of science process skills have certain characteristics, they are

- It leads to the development of scientific concepts.
Agreement and disagreements are the important features of process skills through which inference can be derived.

Productive thinking can be encouraged in relation to the processes of science.

Process skills follow empiricism many empiricists or scientists such as Fleming, Einstein, Newton, Galileo, and early Greek scientist Aristotle and Archimedes are used these skills during their inventions.

Verification and generation of new concepts is one of the important natures of process skills.

During Process skill sensory organs associated with cognitive operation therefore it sharpens the thinking skills and these thinking skills are developmental in nature.

Process skills develop scientific attitude, scientific temper and values.

It helps to find out the relationship between cause and effect about a particular phenomenon.

Intellectual abilities such as curiosity, creativity, problems solving, decision making are intertwined with nature of Process skills.

Process skills connect with the persons to the physical and biological world.

Process skills helps the learner to learn any complex concepts in science, also it facilitate the learner to learn other subjects.

Accuracy and truthfulness.

Abilities to formulate new ideas, concepts by their own.

It removes misconception in science and it freedom from superstitious believe.

1.7 Purpose of Developing Science Process Skills at Upper Primary Students

According to Jean Piaget theory of cognitive development, science instruction at upper primary stage plays pivotal role in developing process skills. At this stage, children can think and able to reason out with symbols, ideas, abstractions and generalisations. They are in a position to proficient in basic science process skills. NCF position paper on Science teaching (2006) suggested that process skills of science should continue throughout upper primary stage to enable children learn how to learn for themselves so that they carry on learning to even beyond school.
Several projects such as SAPA, ESS, SSCP, SCIS, MINNEMAST, and ESSP were conducted at elementary level students to enhance the process skills. Vaidya (2003) opined that unconsciously upper primary children use simple process skills during their exploration of the world but often teachers are not providing opportunity to refine or enhance the basic skills because of conventional instructional strategy followed in the classroom, results students unable to perform complex skills in their later education. Upper primary stage is a crucial for acquiring basic concepts and skills, the students who are proficient in process skills can become scientifically literate and they can improve the standards of their lives by using these skills. Initially children’s process skills are limited and unsystematic; teachers of science need to give adequate inputs about process skills at very early stage so that when they grow, pupils use these skills proficiently. If process skills are not developed among the students of upper primary stage, then the teacher cannot expect them to develop higher order skills in their later stage. It is therefore, this is the crucial stage for developing science process skills.

1.8 Approaches and Methods for Developing Science Process Skills
Learning science is different from learning other subjects; science can be best learned through various learning experiences such as demonstration, field trips, investigation, discovery and experimentation etc. Teaching of science is not just delivering of scientific knowledge and expecting the students to memorise. Harlen (1992) stated that teacher should have the different view of learning, where the learner is active in understanding and using process skills to test and modify ideas rather than describing for rote learning. Effective teaching is always pupil centred so that students learn easily and effectively. According to Doraiswami (1970) the purpose of the syllabus is to make the child participate actively in the learning experiences in the classroom, there should be a greater emphasis on the ‘processes of science rather than Products of Science. Process of Science cannot learn effectively through “Chalk and Talk Method”. There should be an active involvement by the learner; teachers must engage the learner in “doing science” and “experience the science” such learning become concrete, meaningful and experiential.
There are different methods of learning such as active learning, activity based learning, cooperative learning, discovery learning and so on. Whatever may be the methods but method of learning should provide opportunity to the learners to receive hands-on and minds-on experiences. That can facilitate the learner to develop the concept and skills. The principle of constructivism is learners’ experiences. Piaget (1977) opined that as a learner strives to organise personal experiences in terms of pre-existing mental schemes, knowledge is constructed. He further stated that the meaningful learning takes place within the children if the learning environment is appropriate and experiential. Experiential learning is one such a learner centred method that facilitates the learners’ individuality. Experiential learning engages the students in the learning process individually and in groups because process and learners direct purposeful experiences are the main core of experiential learning. Harlen (1992) recommend that the experience provided will enable pupils actively to seek evidence through their own senses to test their ideas. Children can best learn science when they exposed in “hands on meaningful and relevant activities”. In experiential learning, teaching is less and learning will be more. It stresses more on process approach. By considering the educational value of experiential learning it was recommended by national and state level educational policies such as NCF (2005), National Curriculum Framework for Teacher Education (2009), Gujarat State Board Curriculum for Science (2006), Tamilnadu State Board curriculum for Science (2009) and Common School Curriculum Bihar (2007) that the learning should be experiential. John Dewey stressed the concept of experiential learning much earlier, in the light of John Dewey philosophy, almost all the documents emphasising to incorporate experiential learning.

1.9 Historical Underpinnings of Experiential Learning

Learning is the key to personal development and experience is the key for meaningful learning. According to David Kolb (1984) experiential learning theorist; learning is the process whereby knowledge is created through transformation of experience. The simplest form of experiential learning (EL) means learning from experience or “learning by doing” (Croom, Lee, Talbert, and Vaughn, 2007 cited in Parker, 2011). The idea of experiential learning is not new in the field of education (Wulff- Risner& Steward, 1997). Learning through experience has been valued in all educational settings. Experiential learning in
general has a long history rooted in the early work of John Dewey (1938). He is the one who attributed experiential learning movement in his educational philosophy (Hickcox, 1990), later there was a boom evolved in the 60’s and 70’s by the work of psychologist, sociologist, and educationist such as Piaget (1950), Kurt Lewin (1957), Paulo Freire (1970), Vygotsky (1978) and David Kolb (1984). The eminent Philosopher John Dewey written a book “Experience and Education” offering a justification for learning by doing. John Dewey in the mid 1930s used experiential education in multiple disciplines including sociology, anthropology, science and research due to its interdisciplinary nature (Carver, 1996 cited in Mughal and Zafar, 2011). Dewey work stressed the importance of students’ engagement in real life experience in the development of a cognitive construct. In his view, the end goal of learning is not to get the right answers but rather to understand and use the experience (Warren, & Hunt, 1995). Kurt Lewin social psychologist who notably said “there is nothing so practical as a good theory”. Piaget’s theory of cognitive development describes how intelligence is shaped by experience. Piaget view on philosophy of learning is assimilation and accommodation; assimilation being the process of incorporating new experiences with prior knowledge already exists in mind, and accommodation is the process of prior knowledge being altered by new experience. According to Carl Rogers (1983) Humanistic Psychologist “experience is the highest authority, and the touchstone of validity is my own experience” Rogers distinguished two types of learning: cognitive (meaningless) and experiential (significant). The former corresponds to academic knowledge such as learning vocabulary or multiplication tables and the latter refers to applied knowledge such as learning about engines in order to repair a car. Paulo Freire (1970) stated that the goal of education is to raise the critical consciousness of learners by means of experiential encounters with the realities of their culture. Kolb (1984) believed that theory and practice should be integrated together. Modern theorist David Kolb works on experiential learning based on the educational philosophy of Dewey Kurt Lewin and Piaget, and he developed learning style inventory and experiential learning cycle. According to Kolb (1984) knowledge is results from the combination of grasping experience and transforming it. Over the past fifty years, theorist and practitioners has made a significant contribution to our understanding and acceptance of experiential learning. From the foundation they have laid, new experiential approaches continued to evolve all over the world. In India, experiential learning is mushrooming in all
educational system, the institute of experiential learning was established in Bangalore in the year 2011 by the experiential learning foundation trust and it supports education, research and developments (source: www.inexel.org). Indian Council for Agricultural Research also developing course structure, operational modalities and evaluation procedure for the experiential learning course which will be common to all discipline such as horticulture, forestry, dairy, technology, fisheries and home science (Source: www.icar.org.in/node).

Most of the documents and reports on school education also recommended to incorporate experiential approaches in teaching learning process. Apart from these, there are 2453 research studies also conducted on experiential learning all over the world from school education to higher education covering all the discipline such as mathematics science agriculture tourism education psychology medicine nursing computer to develop knowledge and skills (Kolb and Kolb, 2008). Research Studies suggested that learning through experience is essential for individual and organizational effectiveness (Argyris and Schon, 1974; 1978). Experiential learning philosophy continues to gain recognition among the learner, teacher, and educator. This movement needs to be widened in all facets of educational systems to bridge the gap between the learner and the learning process, theory and the practice.

1.9.1 Experiential Learning and Experiential Education

Experiential learning should not be mistakenly used to interchange with experiential education. Various researchers understandably conceptualised the experiential learning and experiential education. Some of the definitions are as follows. Craig (1997) stated that Experiential learning is "knowledge, skills, and/or abilities attained through observation, simulation, and/or participation that provide depth and meaning to learning by engaging the mind and/or body through activity, reflection, and application". According to Colin and Beard (2007) Experiential learning as the sense making process of active engagement between the inner world of the person and the outer world of the environment. Whereas, Association for Experiential Education (AEE) defined experiential education as “a philosophy and methodology in which educators purposefully engage with learners in direct experience and focus reflection in order to increase knowledge, develop skills, and clarify values” (AEE, 2002).
1.9.2 Principles of Experiential Learning

In traditional classroom situation the instruction is highly rigid and authoritative, whereas in experiential learning students learn from one’s own experience. The instruction is designed to engage the learners in direct hands on experiences for gaining knowledge and skills. Effective instructional methods have certain principles; accordingly Association for Experiential Education (2011) listed some of the experiential learning principles which are as follows

- Experiential learning occurs when carefully chosen experience are supported by reflection, critical analysis and synthesis.
- Experiences are structured to require the students to take initiatives, make decision and be accountable for results. Throughout the experiential learning process, the students is actively engaged in posing questions, investigating, experimenting being curious, solving problems, assuming responsibility, being creative and constructing meaning.
- Students are engaged in intellectually, emotionally, socially, soulfully and/ or physically. The involvement produces a perception that the learning task is authentic.
- The results of the learning are personal and form the basis for future experience and learning.
- Relationships are developed and nurtured: student to self, student to others and student to the world at large.
- The instructor and student may experience success, failure, adventure, risk-taking and uncertainty, because the outcomes of the experience cannot totally predicted.
- Opportunity is nurtured for students and instructor to explore and examine their own values.
- The instructor’s primary roles include for setting suitable experiences, posing problems, setting boundaries, supporting students, insuring physical and emotional safety, and facilitating the learning process.
- The instructor recognises and encourages spontaneous opportunity for learning.
- Instructor strive to be aware of their biases, judgement and preconception, and how these influence the student.
- The design of the learning experience includes the possibility to learn from natural consequences, mistakes and successes.
1.9.3 Characteristics of Experiential Learning

While developing a learning activity it is good to understand what characteristics make the activity an experiential learning event. Burnard (1989) describes several underlining attributes that define an experiential learning activity (Beaudin, 1995).

- **Action**: the learner is not a passive receptacle but an active participant; and there is physical movement, not just sitting.

- **Reflection**: learning only occurs after the action is reflected upon.

- **Phenomenological**: objects or situations are described without assigning values, meanings or interpretations; the learner must ascribe meaning to what is going on; and the facilitator's meaning must not be automatically forced upon the student.

- **Subjective human experience**: a view of the world that is the learner’s not the facilitator's.

- **Human experience as a source of learning**: "experiential learning then is an attempt to make use of human experience as part of the learning process". According to Joplin (1981), experiential programs consist of several overarching characteristics:
  
  - **Student-based rather than teacher-based**: the learning encounter starts with the students’ ideas and concepts rather than the teacher’s or the books.
  
  - **Personal not impersonal nature**: personal experiences and personal growth are valued in the classroom.

  - **Process and product orientation**: emphasis is placed as much on learning as it is on the “right” answer.

  - **Holistic understanding and component analysis**: students are urged to fully understand the content through the analysis of primary sources of the material and/or experiences with the material.

  - **Organized around experience**: the students’ previous experiences are taken into account when creating the curriculum, as well as the new experiences that will be provided in the classroom, lab, or field trip.

  - **Perception-based rather than theory-based**: “experiential learning emphasizes a student’s ability to justify or explain a subject rather than recite an expert’s testimony
Individual based rather than group based: group identity and socialization skills are stressed; however, emphasis is placed on the individual learning within the group rather than on the group as a whole; criterion-referenced rather than norm-referenced.

1.9.4 Experiential Learning Environments

It is not easy to identify the place where the learning takes place effectively. Learning can occur anywhere, anytime, and by anybody but it is depends upon cognitive level, readiness of the learner and learning environments where he or she experience the learning process. Optimal learning can be influenced by the learning environments and learning experience. It was stated by Beard and Colin (2007) there are diverse range of places or spaces for experiencing the learning. It can be outdoor and indoor learning, real or virtual, natural or artificial learning, private or public, formal or informal those are used to facilitate the learning. Typically indoor learning environments have been strongly associated with lecture theatre, hall, classroom, multimedia theatre, and laboratory. Outdoor learning environment can be playground, zoo, museum, jungles, desert, mountains, gardens, parks etc. Artificial environment is a man made structure, device, or environment that stimulate a natural setting which can be used for teaching. Beard and Colin (2007) stated that the use of artificial spaces for experiential learning is of greater significance for knowledge creation.

1.9.5 Experiential Learning Activities

There are range of experiential activities and technique available for facilitators to help pupil to learn through experience. In experiential learning, fundamental activities and method is “experience” Educationist Beard and Colin (2007) listed some of the experiential learning activities such as projects, experiments, sensory simulation, problem solving, the use objects for variety of purposes, training kits, outdoor recreation, cartoon production, theatre, drama, art, storytelling and writing and reading, role play, simulations. Creating a variety of opportunity is the essence of experiential learning activities. Researchers used different experiential learning activities and techniques for developing knowledge and skills. Beasley (2010) used three experiential learning methods in secondary education such as experiments/lab activities; service learning projects, and field trips. Thomas (2012) selected the following experiential learning activities and
methods such as role play, video clips, laboratory activities and storytelling to develop spiritual intelligence and emotional intelligence, findings revealed that the selected activities and methods significantly influence for the development of spiritual and emotional intelligence among the teacher educators. Taylor (2004); Horwath, (2004); Miller et al, (2005); Askeland (2003); Cummins (2006); Cummins Sevel and Pedrick (2006) also used diagrams, individual and network activities, reality play approach, multimedia learning environment, and use of reading and writing are the experiential activities (Wong, 2007). Sheetal (2010) used situational discussion, role lay, brain storming, group activities, group discussion under the experiential learning methods and techniques.

In 1969, Edgar Dale suggested various learning experiences in his cone of experience (Molenda, 2003). According to Edgar Dale cone of experience, learners retain more information and skills, and gain concrete learning experiences when they engaged in “doing” purposeful activities. Reading and listening are the least experience. The Edgar Dale (1969) cone of experience is shown in the Picture_1.1.

**Picture_1.1: Edgar Dale’s Cone of Experience**

1.9.6 Experiential Learning Theory (ELT)

Experiential learning Theory (ELT) was built upon the work of learning, and development theorists John Dewey, Kurt Lewin, Jean Piaget, Carl Jung, Paulo Freire, Carl Rogers (Kolb and Kolb, 2005). All of those believed that experience plays central role in learning and they laid foundation to evolve experiential learning theory. Dewey (1938) opined that “there is an intimate relation between the processes of actual experience and education”. It refers that learning must be based on real experience. Social Psychologist Kurt Lewin’s (1952) theory of action learning proposes that experiential learning occurs through a four stage cycle that involve engaging in two dimensions of naturally opposing activities: experience versus abstraction, and action versus reflection. Piaget's theory of cognitive development describes how intelligence is shaped by experience. Piaget (1970) suggested that individual can develop abilities by engaging activities according to sequential stages of cognitive development. He made a clear distinction between the two dimensions of learning: Experience and abstraction are the ways of assimilating new experiences into existing concepts, while action and reflection are the ways of accommodating existing concepts into new experiences (Kemp, 2007). Piaget’s last two stages are concrete and formal operations where knowledge is represented in symbolic terms. Symbols are capable of being manipulated internally with complete independence from the experiential reality (Kolb, 1984; Hickcox, 1990). Carl Rogers Stated that cognitive learning is meaningless and experiential learning is meaningful. He further opined that learning as a cycle that begins with experience, continues with reflection and later leads to action, which itself becomes a concrete experience for reflection (Rogers, 1996). Considering the ideas of theorist philosophers and Psychologist John Dewey, Piaget and Kurt Lewin and Carl Rogers, an American educational theorist David Kolb developed experiential learning theory or cycle (Figure_1.3). According to him experience as the source of learning (Kolb, 1984). He stated that ELT is the process whereby knowledge is created through transformation of experience. The theory provides a framework for understanding both cyclic nature of experiential leaning and individual learning tendencies (Yaganeh, 2006).
Figure 1.3: Kolb’s Experiential Learning Cycle

The cornerstone of Kolb’s model has four stages of learning. The first stage is Concrete Experience (CE): In this stage, students involve themselves fully openly without any bias. The second stage is Reflective Observation (RO): during this stage student reflects on and observes their experience from different perspectives. Third stage is Abstract Conceptualisation (AC): here the students create abstract concepts based on their observation. The final stage is Active Experimentation (AE): where the students apply or verify their theory through experimentation (Myers 2004; Yaganeh 2006). The descriptions of each stage of Kolb’s experiential learning are as follows:

**Concrete Experience (feeling)**
- Learners directly involve in the action process for understanding
- Learners feel the experience rather than listen teachers voice
- Learners use their previous experience
- Learners are self directed.

**Reflective Observation (watching)**
- Learners viewing the situations in multiple perspectives
- Learners apply their senses and gather informations
- Learners exercising the skills and observe the things reflectively, critically by action

**Abstract Conceptualisation (thinking)**
- Learners use their intellectual by thinking about the events
- Learners formulate theories from observations and experiences
- Learners develop explanations and hypothesis
- Learners make conclusion
Active Experimentation (Doing)

- Learners very actively experimenting with influencing or changing situations
- Learners have a practical approach and opposed to watching situations
- Learners verifying the concepts by their own

The four stages of experiential learning such as concrete experience, reflective observation, abstract concepts, and active experimentation constitute an experiential learning cycle or theory. These are interrelated in the holistic adaptive process of learning. ELT describes four developmental dimensions: affective, perceptual, symbolic and behavioural complexities (Hickcox, 1990). ELT exclusively provides the groundwork for learning that takes place in and out-of-classroom where learners advance by acting on their environment and experiencing the consequence of that action (Coleman, 1977).

1.10 Constructive Based Experiential Learning and Science Process Skills

Concepts and skills can be effectively constructed when the students engaged in science. Students interestingly perform experiments. Knowledge of science is hollow if concepts are not properly understood and skills are not acquired by the learner. Scientific knowledge should be self discovered by the students through process of science. There is a strong relationship between process skills and concepts. Process of science is not a part of science; rather science itself is a process. It cannot be learned best through “cookbook” method, Paulo Freire what he called “Banking Concept” where the children are the passive receiver and teachers continuously deposits knowledge into their mind.

Science is not to be taught by verbal method. Instead, emphasis is on first hand experimentation and observation. A shift is needed from teaching to learning. Learning should takes place on the cognitive, affective and psychomotor domains of learners. Pedagogy should follow Dewey’s philosophies, ideas and thoughts of “learning by doing” and “learning through experiences”. Dewey opined... continuity of experience motivates the learner to form an attitude and desire for continuous learning (Neil, 2003). Jean Piaget (1977) suggests that as a learner strives to organise personal experiences in terms of pre-existing mental schemes knowledge is constructed. Further he stated that cognitive development depends
upon the factor called experience. The philosophy of constructivism also argues that the learners are not empty vessel; students come to school with previous knowledge and skills gained through their personal experiences. Crowther (1997) suggests that “as we experience something new we internalise it through our past experience. There is interplay between experience and learning. Experience plays important role in learning process; action is the fundamental doctrine of experiential learning”.

The principle of constructivism is personal experience, student autonomy, active involvement, exploring the concepts, exchanging information using cognitive terminology, employing the process skills, raising questions and arriving conclusions etc. Experiential learning provides such type of climate to the learner to experience process of science. Amin (2012) stated that experiential learning is one of the constructive approaches. Accordingly, students must experience the science by doing hands on science experiments like handling the microscope to observe fine details (ex: Human Blood Cells, algae, fungi), observing the smell, texture, colour and smell of chemicals; noticing the similarities and differences between pictures or objects; observe the preserved plants and animals specimens; observe science experiments; using magnifying lens during observations; operating the science equipments. Such experiences can develop skill of observation. Children observe many things around them. After observation of things, materials and organisms, that is to be classified based on the similarities and differences. Experiential learning activities and environments provide such opportunity to classify the materials’ or substances. Science is not only observable it is also measurable using standard measuring unit. Experiential learning facilitates the students to develop measurement skill by measuring the length mass weight temperature volume etc. While employing the skills such as observation, classification and measurement, students tend to discuss, share their observations and findings with other students through both verbal and non verbal method of communication such as tables’ charts graphs symbols diagram etc. While involving in experiential learning activities such as hands on experience, field visit, role play, demonstration, multimedia presentation, simulation they can able to predict the future event and derive inferences by their own based on observations.
In a nut shell, by observing the research findings and committee’s reports on science teaching it can be inferred that science teaching in schools are unsatisfactory, teachers often follows lecture method, students acts as passive listeners. Hands on learning experiences rarely or not provided to the students, results students were not in a position to expert in basic science process skills. John Dewey an educationist advocated that the learning should be experiential, he said that one can learn best by doing, accordingly learning should go beyond traditional lecture method; there should be rich learning experience wherein students actively participate in the learning process. Constructive based experiential learning provides such rich learning experiences for the students though which students can acquire knowledge and process skills.

1.11 Rationale
Science is universal and knows no boundaries, no absolute. It is future oriented and a disciplined way of seeking new knowledge for deeper understanding. Science is a part of school education and it act as a starting point for children intellectual and personal development results individual can prepare better life. School science prepares the children to understand basic scientific concepts and process skills and its application. It develop attitudes and values, also prepares the children to study science in higher education. It was stated by reports and documents that one of the main objectives of science teaching is development of process skills. Process and products are interrelated. Process approach leads to development of products. Harlen (1999) stated that the process skills and content of science are inseparable, “Process skills must be taught in relation to some type of content”. Curriculum for science education (NCERT, 1990; NCF, 2000; NCF, 2005) also emphasising the process skills. Process validity is an important criterion since it helps in ‘learning to learn’ science. UNESCO (1992) report on “Developing New Teacher Competencies” also emphasised the process skills in many learning areas of the curriculum in all countries including India. UNESCO (2009) recommended that, to achieve MDG “Science in schools should provide concepts, skills, and processes.

Process skills are the foundation for constructing scientific concepts, scientific attitude, understanding the nature of science, science interest, curiosity towards science, problem solving, creativity. Rehorek (2004); Germann & Aram (1996) opined that development of science process skills enables students to construct and solve problems, critical thinking, deciding and finding answers to their
curiosity rather than having the students to memorize the concepts. By employing these process skills students can clarify their doubt, modify their ideas, construct and reconstruct the concepts. If these process skills are not carried out in a rigorous and scientific manner then the emerging ideas will not necessarily fit the evidence; ideas may be accepted which ought to have been rejected, and vice versa (Harlen, 1995). There is a strong belief that children who are properly introduced to science through process skills will find the skills useful throughout life. It is possible to easily forget science content learnt but process skills tend to remain with many individuals for a relatively longer period, use of science process skills can increases the permanence of learning.

Science teaching plays a prominent role in knowledge construction and process skill acquisition. Conventional lecture method has no scope to develop process skills. Unfortunately, present science teaching in Indian schools is examination oriented, over domination of rote memorisation, teachers’ centeredness, process aspects of science is largely ignoring, and students were not allowed to do practical part of science. Science teaching was not allowing the students to creativity and inventiveness (Umasree, 2003; Vaidya, 2003; NCF, 2005; CABE committee, 2005; NKC, 2006-2009). Findings of HSTP (1970-2002) a massive Science teaching programme revealed that “Science teaching is mainly textbook-based rote learning with little emphasis on understanding of concepts or the process of science, students are unfamiliar and far behind in basic process skill”.

In many classrooms today “teaching” means talking, and Learning means “listening”.

Science teaching needs to be revised from teacher centeredness to student centred. Approach of teaching science to be broadened and it should facilitate the learner to be an active participant not a passive listener. Science Teaching should move away from rote learning. Teachers of science need to give ample scope for the students to expose themselves into hands on minds on experiences so that children can involve physically and intellectually in the learning process and acquire concepts and skills for their personal long term academic and personal success. Learning through one’s own experience is more realistic, personal and meaningful. Experiential learning is one such a method facilitates the students to participate actively in the learning process for acquiring knowledge and skills. In this method learning takes place through experiential mode, teachers’ role is to provide facilitation.
20th century Philosopher John Dewey (1938) who elaborated on the philosophy of learning from experience. He opined that “an experience exist because of the interaction between student and his/her experience”. He attributed experiential learning movement in his educational philosophy. Carl Rogers (1961) said that “Experience is for me is the highest authority and the touchstone of validity is my own experience”. Further he stated that Cognitive learning is meaningless and experiential learning is meaningful. According to Thorndike a behavioural psychologist “The behaviourist approach defines that learning as a relatively permanent change in behaviour that results from experience”. David Kolb (1984) an educationist opined that experience as the source of learning and development. Eminent Educational theorist and psychologist Dewey, Lewin and Piaget emphasised the importance of experience in learning process and they laid down the intellectual foundation of experiential learning in all educational systems. National level and State level documents, Curriculum Frameworks for School Education, Teacher Education (eg. Report of the CABE Committee, 2005; Report of the Common School System Commission, 2007; Tamilnadu Common School Education Curriculum, 2009; School Education in Gujarat, 2006; NCF-2005 and NFCTE, 2009) also recommended experiential learning method. Research findings revealed that experiential learning is an effective and long-lasting form of learning where the learner involves by creating a meaningful learning experience (Beard, 2007). Hence, experiential learning method was adopted in this study for developing process skills. The present study carried out among upper primary students of standard eight in the state of Tamil Nadu. The period of upper primary is one of the tremendous cognitive development, shaping reason, intellect and social skills, as well as the skills and attitudes necessary for entering into the work place. At this stage children are getting first exposure to learn ‘science’ as a separate subject; this is the stage to bring right perspective of what it means to “do science”. Eighth standard is the threshold and it is a transition phase between primary and secondary education. It is a crucial stage wherein students receive higher level scientific inputs, and very significance in terms of promoting interest and attitude. At this stage Children willing to do experiments enthusiastically, critically observe, manipulate the variable, logically analyse and construct the scientific
concepts and skills. According to Piaget eighth standard children are in formal operation stage (Twelve Years above) beginning of adolescence, students thinking is hypothetical, deductive and logical reasoning, ability to think abstractly, they argue, debate, ability to combine, classify items in a more sophisticated way, raise questions, observing the number of specific events and inferring an abstract, analysing the cause and effect (e.g. changing the length of string and weight of the pendulum) (Morgan et al, 1993). In this stage, emphasis on the process skills in science should continue to enable children learn how to learn for themselves, so that they could carry on learning to even beyond school (NCF, 2005). Objective of science teaching at this stage should stress more on the processes of science than the product so that they can generate and validate the scientific knowledge. If the students proficient in basic process skills, certainly helpful for developing higher level integrated process skills in their later stage of education. Thus, present study taken up in the students of standard eight.

Present study undertaken in the state of Tamilnadu. The state has achieved near universal access at both primary and upper primary levels. The GER and NER for Primary are 101.5 and 99.4 and for Upper Primary are 103.8 and 98.6 (World Bank Report, 2008). To improve the quality of school education state has taken enough measures in various curricular areas. One such measure is revitalisation of curriculum. Tamilnadu School Education System implemented new syllabus named as “Common Curriculum” (Samacheerkalvi) from the academic year 2011 from sixth to tenth standard. Also, under the direction of SSA across the State schools adopted has Activity Based Learning (ABL) transaction method of teaching for standard one to four and Active Learning Methodology (ALM) for standard sixth to tenth. By realising the importance of Experiential learning, Tamilnadu Common School Education Curriculum (2009) also recommended that learning should be experiential and need a shift to remove rote learning from text book. Keeping all these in mind, researcher carried out a study on science process skills in students of standard VIII with the following research questions.

1.1.1 Research Questions
1. To what extent science process skills have been developed among students?
2. How effectively science process skills can be developed among students?
3. How far it is feasible to assess the developed science process skills?
1.11.2 Statement of the Problem
Acquisition of Science Process Skills through Experiential Learning in Students of Standard VIII

1.11.3 Objectives of the Study
1. To Study the Existing Status of Science Process Skills among the Students of Standard VIII.
2. To develop an Intervention Programme based on Experiential Learning to enhance Science Process Skills.
3. To Implement the Intervention Programme among the Students of Standard VIII to enhance Science Process Skills.
4. To assess the acquisition of Science Process Skills after the Intervention Programme.

1.11.4 Hypotheses
1. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of observation skill in Students of standard VIII.
2. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of classification skill in Students of standard VIII.
3. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of communication skill in Students of standard VIII.
4. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of measurement skill in Students of standard VIII.
5. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of prediction skill in Students of standard VIII.
6. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of inference skill in Students of standard VIII.
7. There will be no significant difference in the mean scores of pre test and post test with regard to achievement on basic science process skills in Students of standard VIII.
1.11.5 Explanation of the Terms

**Science Process Skills:** Science Process Skills are broadly described as a set of transferable abilities or skills which are employing by scientist and students during science experiments, investigation and activities. These skills are classified into two types – basic and integrated. Basic Science process skills are observation, classification, communication, measurement, prediction and inference. Integrated Science process skills are formulation and testing of hypothesis, manipulating variables, defining variables operationally, designing and experimenting, identifying the cause and effect. For the present study researcher selected only Basic Science Process Skills (BSPS).

**Experiential Learning:** For the present study, it refers that the students construct the scientific knowledge and skills by engaging cognitively, affectively, and behaviourally in direct hands on learning experiences individually or in group. The direct hands on learning experience can be inside or outside the classroom.

**Intervention Programme:** For the present study, it is a scheduled programme developed by researcher by taking the contents of Tamilnadu State board science textbook of Standard VIIIth for developing BSPS in Students of Standard eight. The programme included various learning experiences such as Hands on Experiences, Role Play, Demonstration, Field visit, Multimedia presentation (Virtual Class Experience), and Simulations which follows Kolb’s Experiential Learning Cycle. Students engaged in these learning experiences individually or in group in one academic year for acquiring BSPS.

1.11.6 Delimitations of the Study

- The present study was delimited to Gudalur Government Higher Secondary School situated in Gudalur Taluk, Nilgiri District, Tamilnadu.
- The study was delimited to English medium students studying during the academic year 2011-12.
- Present study was delimited only to basic science process skills.

This chapter presents the conceptual clarity on Science process skills and Experiential Learning. Also rationale, objectives, hypotheses, explanation of the terms, and delimitation of the study were included. The subsequent chapter depict the scenario of research studies in the area of science process skills and Experiential Learning.