CHAPTER II
CHAPTER II
CONCEPTUAL FRAME WORK

2.1 INDIA'S CONTRIBUTION TO SCIENCE EDUCATION

India is considered to be one of the leading countries in the world as far as availability of trained manpower in science and technology is concerned. The same, however, cannot be claimed with regard to the status of research at the frontiers of science. India has a long tradition of practicing science, astronomy, mathematics especially arithmetic and medicine. Situated geographically in the centre of the old world, India has been destined to play an important role in the transmission and diffusion of scientific ideas. Mathematics is not an exception in this process of diffusion. Science has been known and nurtured in India since ancient times. It is evident from the perusal of available literature that original works in science, astronomy and medicine has by no means been lacking in any period of history.

Several hundred years before the birth of Christ, Aryabhata, a great Indian astronomer carefully observed and studied the motion of the heavenly bodies and prepared almanacs that were found accurate for many centuries after him. Aryabhata also suggested that the apparent daily motion of fixed stars is due to the rotation of the earth, a fact that was realized much later by the western astronomers. Prior to Aryabhata, Varahamihira and many others have laid the foundations of the source materials for both astronomy and mathematics. It may not be out of place to mention that according to Varahamihira, in the context of lunar eclipse, the Rahu and Ketu meant ascending and the descending node respectively of the moon. The eclipses are caused by the shadow of moon was later suggested by Aryabhata. Interestingly, the opinion of the ancient Indian astronomers about the planetary motion is very close to the presently accepted theories. Bhaskara I, one of the greatest exponents of Aryabhata’s system of astronomy, lived between 550 and 628 A.D. One of his works is an elaborate
exposition of the chapters written on astronomy by Aryabhata. The tradition was maintained during the medieval period also. Jantar Mantars, the astronomical observatories, constructed by Maharaja Jai Singh II, born in 1686, in four cities of India are a testimony to this. The fascination of Indians for astronomical studies continues even today. The contribution of S. Chandrasekhar in the understanding of the life cycle of stars is well known.

The development of scientific thought in India is inseparable from the growth of religion and philosophy on the Indian soil. The spirit of enquiry and skepticism, which characterized the growth of Buddhism, favored the development of science in India. Agriculture was well developed and an honored occupation. There are references to abundance of crops and absence of famine indicating availability of stored rain water for irrigation and proper water management.

One of the important practices and alchemy in ancient India was the art of making different kind of pottery. Indians knew the technology of making painted grey ware from early times. This ceramic is a thin grey ware that was wheel made, well burnt, glossy and beautifully painted. The innovation in making different forms of pottery continues in India even today.

The ethos of scientific development continued unabated in India all through although its pace kept on changing with social, cultural, political and economic milieu in different periods of history. The renaissance in Indian science during the British rule could be attributed to the founding of the Indian relationship for the cultivation of science in Calcutta (now Kolkata) in 1876. In the last 125 years many Indian scientists have made significant contributions in different areas of science. Some of the notable scientists and mathematicians of the pre-independence period in India have been Sir C.V. Raman, S. Ramanujan, S.N. Bose, Meghnad Saha, K.S. Krishnan, S.K. Mitra, P.C. Ray and J.C. Bose. Raman was the first Indian scientist to receive the Noble prize in Physics. In recognition of his work many Indian scientists were made fellows of the Royal Society, London. This brought great fame and name to our country, India.
2.2 INDIA’S CONTRIBUTION TO SCIENCE EDUCATION IN POST-INDEPENDENCE

The post-independence era continues to carry forward the legacy of scientific enterprise in India. The Scientific Policy Resolution (SPR) adopted by the government of India in 1958 clearly reflected the faith of the government and the people of India in the development and the use of science and technology for the well being of the society. The focus of scientific research and development in this period shifted to the application of science and technology to improve upon the quality of life of the people. The research and development efforts in the field of agriculture saw the country to emerge from a food deficit state to self-sufficiency. The development of atomic energy programme fifty years ago in 1954, under the leadership of late H.J. Bhabha laid the foundation for the applications of nuclear energy for a variety of purposes such as power production, medicine and irradiation of food for its preservation. India seized the opportunity in the field of electronics and space science research from the beginning of their emergence. This paved the way for the revolution in the field of communication and provided the base for entering the information age in India. The importances of developing integrated and self-reliant capabilities in India have led to many accomplishments in the field of defence research and space science and technology. India at present is one of the six countries that have acquired the capability for the fabrication and launching of space satellites for communication as well as remote sensing. Indian scientists among the world are leading scientists in some of the emerging areas of science such as biotechnology, ocean development, environment and information technology. Some of the scientists and technologists who have made significant contributions in these areas are M. Visvesvaraya, Meghand Saha, M.S. Swaminathan, Homi J. Bhabha, Vikram A. Sarabhai, P. Maheswari, Varghese Kurien, M.G.K. Menon, Salin Ali, Sam Pitroda, S.Z. Quasim, C.N.R Rao, P.M. Bhargava, Lalji Singh and A.P.J Abdul Kalam. Many scientists and technologists of Indian origin have also earned laurels for their
work while in other countries. Notable among them are Hargobind Khorana, Yellpragada Subba Row and S. Chandrasekhar.

The National Council for Educational Research and Training (NCERT), the apex body in the country in the area of school education, had recognized as early as the sixties of the last century, the need and importance of exposing school children to India’s contribution to the field of science, mathematics, astronomy and medicine and the life and work of the people who made significant contributions in these areas at different periods of time. However, the NCERT was faced with the dilemma about the manner in which this could be accomplished without burdening the school curriculum and disturbing the logical continuity in the presentation of the contents in science and mathematics. The first choice was obviously to make this information available through the textbooks published by the NCERT even though they provided a limited scope for doing so. The textbooks of science for the middle schools published in the 1970s included biographies of some of the eminent Indian scientists. References to the work of some of the ancient scientists, astronomers and physicians like Kanada, Susruta and Aryabhata on the one hand and some modern scientists and mathematicians like S.Ramanujan, Sir. C.V. Raman and S. Chandrasekhar were given in the textbooks wherever required.

The NCERT’s efforts to popularise science and mathematics amongst masses, especially children, continues even today. A number of titles, both in Hindi and English, has been brought out the highlights of the contributions made by scientists and technologists in the research and development in various areas of science during the 15 years or so under the series titled, ‘Reading to Learn’. ‘Prachin Bharatiya Ganit Ki Aitihasik’ and ‘Sanskritik Jhalakiyan’ are the two titles under this series that give a glimpse of mathematics including its application in astronomy during the ancient and the medieval periods. Another title in the same series, ‘Some Eminent Scientists and Technologists’ has been published in May 2001. The textbooks in science and technology for the upper primary and secondary stages published during 2002-04 include some aspects of the life and
work of Indian scientists, astronomers and mathematicians from different periods of history.

The NCERT has always conscious of the need to acquaint the school children with India’s contribution to science and mathematics. In its endeavour to provide the teaching-learning materials to accomplish this objective, the NCERT has brought out a large number of publications that has been prepared by keeping the school children in mind. The benefits of this endeavour can accrue only if these efforts are complimented and supplemented by the teachers, parents and above all by the children themselves.

2.3 FEATURES OF SCIENCE EDUCATION

The role of science and technology in the rapid progress of a country like ours (India) is bound to be of the utmost significance. People in many lands, including our own country (India), have contributed to the advance of science and its sustained progress. A fundamental example that immediately come to one’s mind is that all elementary particles in nature-be these electrons, protons or what not-are either fermions or bosons, these being named after the great Enrico Fermi and our great Physicist Professor Satyen Bose of the University of Calcutta, who first studied the relevant quantum statistics about 1924. Science is a collective activity of mankind, and it is this which has led to its extraordinarily rapid, almost exponential growth. Scientific knowledge is doubling itself in some 15 years; and this means that a “normal individual” or must necessarily soon get out-of-data in fact, far too much out-of-data-in relation to his awareness of the fast changing world around him. We cannot help this; but what we must ensure is that the new generation studying in the schools, colleges and the universities is taught what is obsolete. There is no time to pause to consider why in a relatively short period of time progress in science has been so much, and so rapid, as compared to other fields of human endeavour. The basic reason, of course, is that in the field of science-within the confines of the laboratory -the pursuit of excellence, objectivity and integrity, and rejection of narrow selfishness are much easier to cultivate than
in other fields, e.g., politics. Science encourages co-operation rather than competition, and its roots lie deep in man's highest aspirations and in his noblest motivations, more spiritual than material.

The prosperity and strength of a country these days are directly dependent on the level of scientific and technical knowledge cultivated in the country and on its capacity to make use of that knowledge to serve practical ends. Let us note in passing that in the contemporary industrial and political climate, it is not too difficult for a newly developing country to build (with the assistance of industrially advanced countries) new fertilizer factories, steel plants and so on and these take only a couple of years or so to install. But to manage and run the plants efficiently and to maintain them properly, it requires a large number of competent technical men. It takes several years to train such men, and it is no easy task by any means. It demands a massive and reasonably sound educational system in the country. A very important part of the system and specially so in relation to industrial development is that of secondary education. As Sir Charles G. Robertson has observed in his inimitable book (The British Universities, P. 281, Benn's Sixpenny Library, London, 1930): "... if the nineteenth century was prove up to the hilt one salutary truth it was that without an efficient and progressive system of secondary education, efficient and progressive universities were impossible."

2.4 SPECIALIZATION IN SCIENCE EDUCATION

At the stage of school education specialization should be avoided as far as possible. The bulk of the course should be common to all students. One of the serious defects of the present higher secondary school system in our country is that it requires a student hardly 13 years of age, to decide about the subjects the students would later take up at the university. In other words the choice of occupation has to be made when a student has hardly the ability or is in a position to make the choice. It is now widely recognized that school education should be wide in character and avoid specialization.
2.5 THE MODERNIZATION OF THE SCHOOL CURRICULUM

The matter which should receive earnest consideration is that of the modernization of the school curriculum. Let us take the example of Physics. In the teaching of Physics (and for that matter any science subjects) great stress has to be laid on clarity of presentation, inclusion of adequate but not more mathematics and encourage the students to think and apply the fundamental principles to concrete situations. It means that great effort and care are necessary in the selection of competent teachers and this is particularly so when dealing with those parts of the subject where emphasis is on concepts and ideas as distinct from information data and facts. Bad teaching will generate confusion and in worse cases may even distort science into superstition. The basic point is that the content of a syllabus must be directly related to the competency of the available teachers. A first-class syllabus, but without first-class text books and other essential teaching aids, would in the hands of third-rated teachers result only in chaos and confusion. In such circumstances a less ambitious, even mediocre syllabus would yield better results.

The new science syllabus should emphasize science as a major human activity-as a means for discovering truth about nature. As a human quest for truth, it (science) is much concerned with basic values and is indeed an active humanity and it follows that schools have the duty of presenting science as part of our cultural and humanistic heritage to be taught in harmony without in opposition to the various arts subjects which alone have hitherto been called humanities.

2.6 LABORATORY DEVELOPMENT IN SCIENCE EDUCATION

For the expansion of science education in our country it is very important to develop simple apparatus and equipment of good instructional value. It is an important and urgent task. Sections or even divisions for this purpose could with profit be established in some of the national laboratories and university departments.
Even higher secondary school is provided with a reasonably good workshop say carpentry tools, simple mechanics kit and possibly a manual lathe. Teachers and students should be encouraged to build simple apparatus in the school workshop. One learns a lot of good science by using a simple and inexpensive apparatus to the limit of its capability and accuracy. On the other hand, one hardly learns little of real value by using a first-rate instrument in a third-rate way as unfortunately is very often the case in our laboratories.

In the case of school buildings it should be possible to improve effectively their fundamental utility and at the same time cut down costs. Much thought has been given to this subject in recent years.

2.7 TEACHING–LEARNING OF SCIENCE AND THROUGH TECHNOLOGY

The need for radical changes in teaching techniques for keeping up with the ever increasing volume and variety of scientific knowledge is being recognized as an inevitable phenomenon in the present process of change in education. The passive modes of learning have to be replaced by methods involving active learning in order to achieve the desired goals of education. The National Policy on Education (1986) has also laid considerable emphasis on participation of students in the teaching-learning process through its following recommendation:

A child centered and activity-based process of learning should be adopted. First generation learners should be allowed to set their own pace and be given supplementary remedial instruction.

The National Curriculum Framework for School Education (NCFSE) brought out by the National Council of Educational Research and Training (NCERT) in the year 2000 has also laid considerably emphasized on the use of appropriate instructional strategies for transaction of curricular objectives. It has recommended the organization of learning activities for students. According to National Curriculum Framework for School Education (NECRT, 2000),
instructional strategies may assume a variety of modes and involve activities such as observation. Collection of materials and information, demonstration and experimentation, project assignment, field work and educational excursion and visits to museums, fairs and industrial units and places of historical importance. According to NCERT -2000, an effective learning takes place when teachers are able to involve the students in the process of learning by taking them beyond the process of listening to that of thinking, reasoning and doing.

Thus experiments are appropriate and an important mode of encouraging students to participate in the process of learning and constructing knowledge. It is an accepted fact that activity based learning, literally meaning learning by doing, enables students gain first hand knowledge and better comprehension of the subject. The activities may be performed with the involvement of students in making observations, classifying data, drawing conclusion and making generalization. It would help them to develop abilities in all the three domains-cognitive, affective and psychomotor.

Time and again the use of activities and experiments has been recommended in teaching-learning of science. Their use assumes even greater importance with the substitution of the teaching-learning of science by Science and technology as recommended in the NCFSE (National Curriculum Framework for School Education)-2000. It may be visualized, if we understand why the teaching of science is being substituted by the teaching of science and technology is to be integrated with science.

2.8 WHY SCIENCE AND TECHNOLOGY IN PLACE OF SCIENCE

Science and technology have always been important factors in shaping the human society. Technological efforts have tended to manipulate and control the physical world while scientific pursuits have primarily tried to comprehend it. The purpose behind a technological activity is to facilitate to fulfill human aspiration, to solve some practical problem, to put knowledge (science) into the service of
mankind and to extent the boundaries of existing possibilities. For example, it is
the purpose of science to explain how and how much energy is released in the
reaction of combustion of hydrocarbons [(LPG (Liquefied Petroleum Gas), Petrol,
kerosene, diesel, CNG (Compressed Natural Gas) etc.)]. But to put this reaction to
different uses bending to utilize the released energy is a technological effort. In
modern times, these separate efforts have joined into an inseparable whole and
have helped improve the economy and quality of life. These advancements of
science and technology have brought benefits to common public only if the
common man can comprehend and keep pace with the changes being made. The
overall improvement in the quality of life means adoption of new technology,
economic growth, socio-cultural upliftment and modification or changes in the
value systems. This goal may be achieved by providing scientific and
technological literacy to the future generation of this country. It entails providing
them with avenues by which they can become scientifically and technologically
literate, self-reliant, self-sufficient and responsible as members of the society.
Scientifically literate means that people understand the basic scientific principles
governing the world around them that they are open minded about ideas and
experiences and that they are critical minded in securing or dealing with
information. Further they should be able to use simple scientific process, for
example practical skills, problem solving and decision-making in dealing with
phenomena occurring in everyday life. They should have a better understanding of
science and technology together with proper scientific attitudes and technological
skills, which may be used in their day today activities.

These objectives may be effectively achieved by presenting in the
curriculum the scientific principles with their ramifications to technology

(i) Along with appropriate activities and experiments and laying emphasis
on innovations involving design and improvisation of apparatus and
procedure.

(ii) Involving students in model building, incorporating technological
application with relevant science concepts.
(iii) Providing the linkages of science with industries, agriculture, population, pollution, energy, materials, and conservation of natural resources.

(iv) Linkage of science and technology with society.

The inclusion of activities and experiments in science and technology curriculum is of utmost importance, as it will help in achieving the goal of developing the desired scientific and technological attitudes and skills in children. A number of studies also advocated the use of experiments and participation of students in the learning process. Jean S. Piaget, a renowned educational psychologist, has emphasized on experience and social interaction in the learning process. Piaget's terms of experience and social interaction may be interpreted as involving students' in formulating and verifying hypothesis, formulating and applying theories, and solving problems rather than sitting passively in the class rooms and listening to explanations. Unfortunately, the predominant means of teaching science, the lecture encourages the latter (passive) type of student's experience.

2.9 EMINENT LEADERSHIP IN THE SCIENCE CURRICULUM

There is a great need for talented leadership in the science curriculum. A nation depends upon scientists to come up with theories and practices which improve society. Continual improvements need to be made in health care, job opportunities and satisfaction, a clean environment conducive to healthful living, technology to build safer and more utilitarian buildings, develop computerized automobiles possessing features which maximize safety as well as do not pollute and are cost effective, as well as increase agricultural yields which produce healthful food products for human consumption. Science learning for students needs to be salient in the curriculum and for life in society.
2.10 UPDATING THE SCIENCE CURRICULUM

How might the leader in science keep the curriculum relevant? First, quality ideas in teaching science need to be discussed with other professionals in the school setting. The ideas may be presented orally in an informal setting. Sent by e-mail to other teachers, or discussed in a more formal setting. What is important assists teachers to stay abreast of good, current teaching suggestions. Teachers may report back at a suitable time if these ideas worked effectively. The point is to get teachers to talk about and improve in the teaching of science.

Second, the science supervisor needs to assist in developing quality in science education programmes. The programmes need to be important. However, the science supervisor also needs to encourage teachers in thinking about and accepting innovative methods of instruction. Accessibility to carefully evaluated new instructional ideas in teaching is important. The following methods of faculty involvement in science education are important.

1. Workshops involving a general session to determine problem areas in science teaching. All faculty members in a school should be actively involved in identifying these problem areas.
2. Committee or small group work for participants to solve identified problems. Adequate resources should be available here for participant use. Committee progress should be reported at suitable times to the entire faculty.
3. Individual study in which a teacher has a problem area to consider and work on in the teaching of science. The problem areas may involve considerable research with necessary consultant.

Faculty meetings pertaining to the teaching of science have also been very beneficial to teachers. In the faculty meeting all should have ample opportunities to participate in discussions on vital issues in science instruction. Report for the
thinking of all is important. Time may be needed to do in depth study to secure information on an issue.

Third, a professional library should be available in the school setting for teachers’ use. The professional library needs to contain monthly science journals and periodicals emphasizing science teaching. Teacher education textbooks along with video tapes, CDs and DVDs, should be accessible as data sources to improve science instruction. Comfortable spaces with tables and chairs should be available for teachers use in reading content and viewing visuals pertaining to teaching and learning situations.

Fourth, seminars in science education may be conducted to explore in teaching concept in depth. Seminar members through study and interaction become well informed on instructional methods and philosophies of science teaching. Trying out in the classroom new, innovative ideas based on sound educational thinking in science instruction might will be in the offing.

Fifth, science teachers need to be encouraged to attend professional meetings on the state and national levels. Ideally, the school district should pay expenses for attending these meetings. At the conventions, teachers may attend sessions on trends, methods and materials of instruction, hands on approaches in learning, reading in science and assessing student achievement.

Sixth, science teachers need to have opportunities to view exemplar teaching. Exemplar teaching may be seen in the local school or school districts. It also may be observed through observational visits made to other school districts. When visiting the teachers to classrooms, appropriate guidelines need to be available in order to properly assess quality teaching practices. Video tapes may to some extent, substitute for the actual observation of good teaching in science. Thus, a set of teachers may view and discuss observations made from video tapes. The advantage of the video tape presentation, as compared to the actual observation is good for teaching. The cost in traveling to another school district
and arrangements to be made for actual observations are high, whereas the video tape may be presented in classrooms settings with a minimal of effort. However, an actual classrooms setting might well present a more lift like and specific situation with all the problems involved in teaching such as disruptions by students.

Seventh, a set of science teachers may be involved in doing a research project pertaining to a vital problem of instruction. The research problem needs to be carefully delimited so that a clear statement of purpose is involved. There needs to be an experimental group with the innovation implemented and a control group who have the traditional curriculum. The students for both groups, ideally, should be random sampled so that bias is minimized in the study. If randomization is not possible, then a quasi experimental design may be used, since students are generally assigned to classrooms and randomization or quasi experimental studies are done as research, the researchers need to equate the two groups based on pre-test results so that the initial starting point and place is similar for both the experimental group and the control group.

Eighth, a plan of improvement in science teaching needs to be developed by each science teacher. The plan might then be submitted to the science supervisor for approval. Funding should be available for selected items of personal improvement in teaching which may cost considerable money. The following are recommendations for a plan of improvement in science teaching, i) Take courses at a university to improve instruction in science. ii) Do a study on selected facets of improving science teaching such as grouping for instruction. Team teaching or teaching towards students achieving mandated objectives. iii) Take part in peer teaching and evaluation involving one or more other science teachers.

Nineth, workout a series of lesson plans on the integrated science curriculum. These may be shared with the science supervisor and other teachers.
Tenth, develop and receive approval of a self appraisal device written to evaluate one's own science teaching. The instrument should be diagnostic with possibilities to remediate weaknesses in teaching science (Ediger, 1999).

2.11 PRINCIPLES OF LEARNING TO IMPROVE SCIENCE LEARNING

There are salient principles of learning which may be used to teach science effectively. The teacher needs to engage students in ongoing learning opportunities. Students need to be actively involved in learning and not be passive individuals in receiving knowledge and skills. Each student whether working by the self or with others needs to feel a sense of belonging to a group in ongoing science activities and experiences.

Learners need to develop feelings of experiencing purpose for achieving in the science curriculum. Thus, students perceive reasons for acquiring vital facts, concepts and generalizations in science. Without purpose, the student may feel the futility in putting forth effort to learn, grow and achieve.

An adequate self concept needs to be developed by students individually as well as collectively. With positive feelings toward the self, the student may progress more optimally. Self efficacy in learning provides feelings of being able to accomplish. Success in learning assists in developing self efficacy.

Meaning theory is important to emphasise in teaching students. With meaning attached to what is being learned students understand that which is being taught. If subject matter does not make sense, the chances are learners will turn off on acquiring relevant knowledge and skills. To develop background information for new concepts and generalizations to be achieved, students need to understand previous subject matter taught. With meaning attached to content acquired, students might well use the new learning. The level of application requires that a student understands the content or skills therein. If knowledge / skills cannot be used, then retention of subject matter may be lacking as time goes on.
Understanding subject matter taught means that it has a better chance of being applied in a new situation. Then too, with the level application retention may be there is a rehearsal of subject matter element when content is used (Ediger and Rao, 2003).

Learning styles theory has made selected recommendations as to how best assist student learning. Among others, the following are salient ideas from the theory of learning styles.

1. Some students learn best within committees whereas others achieve better by working individually.
2. Some prefer a small amount of constructive noise better than a quiet classroom to work in.
3. Some prefer a flexible curriculum rather than lecture methods of instruction.
4. Some prefer close student-teacher relations whereas others prefer more objectivity in human relations.
5. Some prefer holism in learning rather than a step by step approach (Searson and Dunn, 2000).

Each student needs to be provided with try and achieve optimally. Leadership in the science curriculum needs to assist teachers to guide student achievement with a variety of learning opportunities which engage and help students to appreciate science and its many contributions. The very latest in technology and inquiry methods of instruction need to be inherent in lesson plans and teaching units in science.

2.12 APPLICATIONS OF NEW APPROACHES TO SCIENCE AND TECHNOLOGY EDUCATION AT SCHOOL LEVEL

Widespread application of science and technology has led to the remarkable development in the quality of human life. It has provided the man with comfort and leisure on one hand and equipped him with the skills needed for problem
solving and decision making on the other hand. Mankind has become so much
dependent on science and technology that we have to ensure that there is sufficient
number of quantified people to address the scientific and technological needs of
the future generations. For this consistent and continuous efforts have to be made
to provide science and technology education to the coming generations.

The place of science in school education has been well established
throughout the world. In India science until now was offered as a part of general
education up to ten years of schooling. Current education reform proposals are
constantly advocating for the introduction of technology in the education of all
students. Important advocates of this proposal are the benchmarks for science
literacy (American Relationship for the Advancement of Science, 1993), the
National Science Education Standards (National Research Council, 1996) and the
standards for Technological literacy (International Technology Education
Relationship, 2000). When we consider the idea of introducing science and
technology education as part of general education at school levels, different
formats are put forward for studying these subjects at school level which can be
summarized as below:

1. Science and technology as autonomous disciplines.
2. Science based technology courses in which scientific knowledge and
   principles are applied in practical contexts.
3. Technology based science courses in which a technology context is used as
   the basis for the understanding of science concepts.
4. A strand parallel to Biology, Chemistry, Physics, Earth Science which is
   part of a coordinate science curriculum.

When we take first approach, it immediately alarms us about already loaded
curriculum of general education. If second and third approaches are followed
dominance of one subject over another takes place which in the present day is not
acceptable either to the scientists or technologies as both claim ontological and historical priority of one over another.

Fourth one is a more reliable approach which integrates technology with science curriculum. There is a justification for that. Science is related to the fundamental knowledge of the universe, world and its environment and technology to application and use of scientific material and manpower resources to satisfy human needs. Science influences technology by providing knowledge and methodology but on the other hand technology also influences science by providing equipments. Hence, both are interdependent. In view of this organic linkage of both the disciplines, it is more appropriate to have integrated science and technology curriculum. That is why NCERT (2000) has recommended science and technology as a subject at upper primary and secondary levels.

2.13 INTEGRATED TEACHING OF SCIENCE AND TECHNOLOGY

An integrated approach to learning is an important contemporary educational development which reflects the different forms of knowledge that are interrelated in real life contexts.

Integrated teaching of science and technology consists of a mode of presentation of scientific and technological knowledge which allows the expression of the fundamental unit of scientific and technological process and avoids explaining too much or too less, the differences between different areas of science and technology. This leaves the scope for correlating the knowledge of both the disciplines through coordination and sensitization as well. The organization of practical activities is the best device for integration of science and technology in teaching.

The fifth approach which includes Science-Technology and Society interactions are more appropriate. The technology is the cultural response to problems and opportunities which affect the way we work and live. Therefore,
social aspects also should be included in the science and technology curriculum. This approach for teaching science and technology is known as Science-Technology and Society approach (STS approach).

2.14 SCIENCE-TECHNOLOGY-SOCIETY (STS) APPROACH

This approach has been seen as the first meaningful interaction between science and technology education. It has enriched our view of science and technology in society (Speiegel-Rasing and Sulla, 1977).

In this approach, application of knowledge and process of science are recognized into a logical sequence that makes sense from a different point of view, from a technological perspective or from societal perspective. At school level the children’s world encompassed the areas such as food, health and nutrition, agriculture, energy and industry. Therefore at school level only these areas should be components of science and technology curriculum. In STS approach the scientific facts and principles are applied in technology to serve the human purpose. In the realistic socio-technological contexts the students learn science contents like mixtures, concentration, chemical reactions, electrical circuits, equilibrium and the biology or body cells and the systems. While the content is driven by the socio-technological contexts, the content is still the content of academic science. For example while teaching the topic of concentrations, teachers often finds that their students achieve greater depth in their quantitative problem solving than normally expected.

In STS approach, practical activities are very important to integrate Science Technology and Society. This entails the teaching of some applications of science and technology as well as an understanding of scientific knowledge and process (Fensham, 1981) such as make observations and formulates a theory, design an experiment, conduct the experiment, analyze the results, draw some conclusions, and make a generalization look for an application. Whittle (1993) lists the
following technological process which can be developed through technological activities; identify a real problem, define the problem, consider possible solutions, carry out some initial tests, select a possible solution, design a practical device, make the device, test the device in real situation, make improvements, and test the modified device. There are many practical activities which bring into play together the process of both the disciplines; science and technology are the activities as a whole address the social needs. Thus, STS approach brings the integration of science and technology teaching.

2.15 CONSTRUCTIVISM: A NEW PERSPECTIVE IN TEACHING & LEARNING SCIENCE

Socrates tried to lead students through a series of questions in order to promote critical thinking. Today, his questioning approach is often hailed as an effective teaching technique. The needs of the emerging knowledge society necessitates the development of personal competencies such as the abilities to be self starting, quick thinking, problem solving, risk taking individuals who can operate in collaborative situations. Unfortunately it is not happening in the traditional epistemological paradigm. In last six decades pedagogy has been dominated by the behaviouristic model. In behaviouristic approach, the teachers’ task consists of providing a set of stimuli and reinforcements to emit desired responses. It is based on S-R (Stimulus-Response) theory, leading to desired and observable behaviour. If the objective is that students replicate a certain behaviour, this method works well, but if we want to develop understanding, synthesis, eventual application, and the ability to use information in new situations, a behaviourist approach is not useful. Because, there is no place in the model for understanding, Cognitive scientists support constructivist view of learning. Today’s cognitive research focuses more on students than teachers. Learning is an active process occurring within, and influenced by the learner as much as by the teacher and the social context where learning is taking place. From this perspective, learning does not depend on what the teacher presents. Rather, it is an
interactive process, how the student processes knowledge, based upon the existing personal knowledge. All learning is dependent on language and communication. It reflects an alternative theory of knowing-cognitive constructivism. Knowledge, its nature, and how we come to know, are essential considerations for constructivists.

2.16 WHAT IS CONSTRUCTIVISM?

Constructivism is a philosophy of learning, founded on the premise that by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own rules and mental models which we make from our experiences. Learning therefore, is simply the process of our mental models to accommodate new experiences. Glaserfeld (1995) describes it as a 'theory of knowledge with roots in philosophy, psychology and cybernetics'. In the constructivist perspective, knowledge is constructed by the individual through his interactions with his environment. If we believe that learners actively construct knowledge to make sense of their world, then learning will likely emphasise the development of meaning and understanding 'Constructivism is a theory that assumes knowledge cannot exist outside the bodies of cognizing beings --- knowledge is a construction of reality'.

2.17 CONSTRUCTIVISTIC VIEW IN SCIENCE EDUCATION

Duiet (2000) has very aptly mentioned that the constructivist view primarily presents a particular way of conceptualizing knowledge and knowledge acquisition that is, learning. It is a view of the nature of knowledge and its development. It is based on a certain epistemology, that is, theory of knowledge. The constructivist view comes in many variables in science education on students’ learning but it shares a common 'constructivist core'.

The common constructivist core is a view of human knowledge as a process of personal cognitive construction, undertaken by the individual who is trying, for
whatever purpose, to make sense of his/her ‘social or natural environment’. In other words, knowledge is not viewed as some sort of a true copy of features of the world outside but as construction of the individual knowledge acquisition. That is learning. It is not the transfer of knowledge to the individual but a personal construction by the individual. The learner is not seen as a passive receiver but as an active constructor of knowledge.

In science education, Glasersfeld’s radical constructivism is generally used as a reference point of the constructivist view. Radical constructivism is an epistemology, a theory of knowledge, more precisely a theory of ‘experiential’ knowledge. This knowledge is seen as tentative human construction on the basis of already existing knowledge. The tentative character of experiential knowledge reflects that there is any kind of ultimate truth for this kind of knowledge. The character concerns every kind of experimental knowledge, knowledge constructed by the individual and science knowledge as well. There are three key principles of radical constructivism (Duit, 1998).

★ The first principle is: “Knowledge is not passively received but is constructed by the cognizing subject”.
★ The second principle states that “The function of cognition is adaptive and enables the learners to construct viable explanations of experiences, knowledge of the world outside, hence, is viewed as human tentative construction”.
★ The third principle highlights that “Although individuals have to construct their own meaning of a new phenomenon on idea, the process of constructing meaning always is embedded within a social setting of which the individual is a part.

2.18 CONSTRUCTIVISTIC VIEW IN THE SCIENCE CLASSROOMS

Science teachers understand that knowledge cannot simply be transferred verbally without understanding about meaning and experiential base. Knowledge
is not acquired passively. Constructivist teachers of science promote group learning where two or three students discuss, approaches to a given problem. Science teachers consider students’ prior knowledge as the starting point, they are encouraged to reflect on their understandings in test and if necessary modify these in the light of new evidences. The classroom structure encourages the exchange of ideas. The process in each case is fundamentally social.

★ Students are encouraged to activity oriented with ideals and evidence. The student creates new understanding for himself. The teacher allows to experiment and students participate in hands-on activities.

★ Students are challenged to develop meaningful understandings.

★ In a constructivistic classroom, learning is constructed. Students come to learning situations with already formulated knowledge, ideas, and understanding. This previous knowledge is the raw material for the new knowledge they will create. Teachers allow students to reflect and to construct their own learning.

★ Students control their own learning process and they proceed by reflecting on their experiences. The teacher helps create situations, where students feel safe. The teacher should also create activities that lead the students to reflect on his prior knowledge and experiences.

★ Constructivistic view of learning is inquiry based. The main activity in the classroom is problem solving. Students use inquiry methods to ask questions, investigating a topic, and use a variety of resources to find solutions.

★ All ideas or knowledge by the individual are tentative in nature. Also science knowledge as accepted in scientific community today, in principle is tentative in nature and open for revision (Duit, 1998).

★ Science is linked with students’ likes and interests.

2.19 PRACTICES ASSOCIATED IN TEACHING SCIENCE

The philosophy of constructivism has been discussed by many philosophers and psychologists. But classroom teachers need clarification on impact of
Wheatly (1991) proposed a model of constructivist teaching using the problem centered learning approach. This approach has three components, tasks, groups and sharing. Wheatley has suggested that in preparing for a class, a teacher selects tasks which have a high probability of being problematical for students’ tasks, which may cause students to find a problem. Secondly, the students work on these tasks in small groups. During this time, the teacher attempts to convey collaborative work as a goal. Finally the class is convened as a whole for a time of sharing. Wheatley believes that each student will build his own conceptual structures. Wheatley’s problem centered approach to learning is a simple and open ended approach.

There are many variants of constructivism having earned a place in science education that has improved teaching and learning in science. The contemporary constructivism is a part of student centered pedagogy of science teaching and learning. If we are eager to prepare a responsible and reflective citizen that is a person who is able to a certain extent to understand basic features of science concepts and ideas that will deeply influence the life in the 21st century then the deep understanding of science, as underlying the constructivistic view of learning is a must so to speak. This understanding namely, includes deep and applicable knowledge of science context, insight into the role of science contents in technology and society (including issues of environmental concern) as well as comprehension of the nature of science knowledge. (Duit, 2000).

2.20 CONSTRUCTIVISM INSPIRED PEDAGOGY

The aim of constructivistic science instruction is fundamentally different than conventional approaches. Constructivist view of learning is student centered. Understanding science is a part of constructivist approach which is far beyond to memorization of science facts. It also includes application of science knowledge.
Schooling has to give every student the confidence and ability to manage their own learning as an ongoing life long activity. Schools, therefore, have to start a dynamic process through which pupils are progressively weaned from their dependence on teachers and institution.

Cognitive psychology has provided a basis for constructivistic teaching. Piaget (1971) was one of the early contributors. Piaget suggested that new experiences are received through existing knowledge, a process of assimilation and accommodation. Learners construct knowledge as they attempt to bring meaning to their experiences. Glasersfeld (1995) was another contributor of constructivistic research. Piaget explains that constructivism is a theory of rational knowing. Learners construct knowledge themselves. Sundra J. Moussiax and John T. Nonnan (1998) have observed that constructivistic teaching emphasizes thinking knowledge while it does not neglect basic skills. It is based on the idea that learners construct their own knowledge, rather than reproduce someone else’s knowledge.

In a constructivistic classroom, the teacher is no longer a transmitter of knowledge. The science teacher is a facilitator of knowledge construction. Thus, a science teacher functions as a facilitator of learning. As a facilitator he / she understand that learning is related to the learners’ previous knowledge, current interest, and level of involvement.

Tolman and Hardy (1995) have observed that constructivistic teaching is guided by five basic elements: i) activating prior knowledge, ii) acquiring knowledge, iii) understanding knowledge, iv) using knowledge, and v) reflecting on knowledge.

From a constructivistic perspective, learners construct knowledge as they attempt to bring meaning to their experiences. Glasersfeld (1995) has explained that constructivism is a theory of rational knowing. Learners construct knowledge themselves on the basis of subjective experiences. Learning takes place within the
cognitive domain of the individual. In this context, teaching is taken as a purposeful, designed intervention into the process of learning through knowledge construction.

Teaching reflects inter relationship between people. This revolves around the active construction of conceptual structures, which mediate between the learner, and his / her live experience (Glaserfeld, 1993). The teacher attempts to be a significant part of learners live experience. Constructivist science teachers are the intermediate agents between learners and curriculum. Some of the procedures used by science teachers include (Mike Watts, 1998, Yager, 1991);

★ Place the focus on learner.
★ Using student questions and ideas to guide instructional units.
★ Accepting and encouraging students initiation of ideas.
★ Interact with learner closely in order to enhance social interactions.
★ Encouraging the use of alternative sources for information both written material and experts.
★ Encouraging students to suggest causes and for events and situations.
★ Encourage students to test their own ideas.
★ Using cooperative learning strategies that emphasis collaboration with respect individually.
★ Encouraging self analysis and reformulation of ideas in the light of new experiences and evidence.
★ Take a variety of roles in order to monitor and evaluate learning.
★ Encourage a plural tentative and contingent view of scientific knowledge.

2.21 THE SCIENCE CURRICULUM

Objectives in ongoing science units of study need to be carefully chosen. These objectives are desired behaviors which teachers wish pupils to achieve.
Pupils need to become good observers of their natural environment. These observations may become a quality basis for securing scientific information. A pupil might then observe a puddle of water after a morning rainfall, and late in the afternoon notice that the water is no longer there. Curious pupils may wonder, “What happened to the water?” This provides an ideal opportunity for the pupil to obtain related information in answer to the question. Interested pupils have an inward desire to know and learn. There is much that pupils can learn in science from informal every day situations.

Equally important is that pupils observe carefully within an ongoing science experiment. Thus, when observing an aquarium with a certain water level gets to be lower in time, unless more water is added. The water level can be marked so that pupils may notice how the water line is below the marking after one or more days. Here again, pupils might wonder what happened to the water? Learners have a need to find out on their own or with teacher / parental assistance. The teacher who develops feelings of curiosity within pupils towards science phenomenon certainly has strengths which are helpful to pupils in achieving more optimally (Ediger, 1999).

Pupils need to become proficient in the identification of problem areas. Thus, the teacher needs to encourage problems may come from diverse sources such as within a science experiment. If in an experiment related to a science unit being taught pupils are to learn that air takes up space, then the following experiment may be performed.

★ Out comes of an experiment or demonstration such as what happens to selected liquids, solids and gases when heated.
★ A report on what life for dinosaurs in the natural environment during the Mesozoic era.
★ A summary of ideas gleaned from a video tape on food webs and food chairs.
★ Major ideas gleaned from an excursion to a discussion on sheet and gully erosion, strip cropping, terraces and cover crops.

Pupils need to be able to develop inferences pertaining to subject matter presented in a concise manner. If pupils, for example, are viewing data on population figures from a tabulation chart including each decade from 1950 to the present of selected nations, they need to be able to infer meaning from the mass amount of content given. Or, if pupils look at information on the distance in miles or kilometers between planets, they need to infer meaning and understanding. Reading between the lines is significant since conclusions need to be developed by the pupil involving a selected amount of information.

Pupils need to think objectively in science units of study. Ideally, subject matter in science exists independently to the observer. The learner then needs to eliminate biases and prejudices in ongoing learning opportunities.

Pupils need to be open minded to new ideas in science being presented. Closed minds will shutout new ideas in the offing. A truly scientific mind is open facts, concepts, and generalizations. That person can separate facts from opinions, fantasy from reality and accurate from inaccurate content. Openness to the new in science makes for achievement growth and accomplishment. A closed mind is unwilling to objectively assess the new in terms of being verified and substantiated. Developing within pupils the desire to learn and to achieve new subject matter in science is indeed a highly worthy objective. Learning opportunities may be devised to continually assist pupils to become lifelong learners and students of science. To be open minded is an attitude of the willingness to accept and assess what is new and revise thinking if evidence warrants.

To develop an appreciation for the methods of science, pupils need to be able to identify weaknesses in problem solving procedures and be willing to learn
from mistakes made which do need correction. How might pupils be assisted to appreciate methods of science in dealing with observable phenomena’?

★ Provide a stimulating learning environment which guides pupils to identify their very own problems instead of the text book or the teacher solely determining which problematic areas learners are to consider.

★ Guide pupils to use analytic and synthetic procedures to view scientific concrete situations in order to separate or analyse ideas into component parts as well as to synthesis or summaries ideas.

★ Have materials of instructor available in the classroom which stimulate interest in learning. An appreciation may be developed here which encourages pupil learning in science. Life-long learning and appreciation for this opportunity are must.

Pupils need to develop attitudes of wanting to learn more than formerly in ongoing lessons and units in the science curriculum. A concerted effort should be made to have pupils develop feelings of wanting to participate in ongoing activities. Learners need to be caring individuals who assist other pupils to do well in life’s endeavours. Having a good self concept aids pupils to do well. Receiving honest praise for doing better should help pupils to feel that they are being recognized for what has been accomplished.

2.22 ASSESSMENT OF ACHIEVEMENT

Assessment to ascertain what pupils have learned in any lesson or unit of study is important. Why? The assessment process assists in determining what pupils have learned. It also has a diagnosis basis in that assessment helps teachers to find out what pupils have left to learn. The scope of the assessment should include knowledge obtained by learners, skills developed, and attitudes incorporated by children. Knowledge might be classified as vital facts, concepts, and generalisations achieved by pupils. Skills involve observing, communicating, hypothesizing, measuring, classifying generalizing and predicting.
Teachers' observation may be one of the best means of assessing pupil achievement. It can be used rather continuously in ongoing science lessons. When pupils with teacher guidance are engaged in performing science experiments the teacher may observe how well pupils are identifying problem areas, gathering information in relation to the problem, developing hypothesis, testing the hypothesis and modifying / changing the hypothesis. By recording how well pupils did in problem solving, the teacher might need to adapt or modify methods of instruction.

Teachers' written tests too may be used to find out how well pupils are doing in each science unit of study. With well written multiple choice test items, the teacher receives feedback on what is left to learn test items in all cases, need to be valid and reliable and be consistent in what has been measured be it test / retest, alternative forms or split half reliability. Proper criteria need to be used when writing test items. With multiple choice test items, each of the four distracters must be reasonable not ridiculous.

True / false test items may be clearly written to measure knowledge acquired. Since guessing the correct answer is very much possible, the test taker should correct the part which is false in a true / false test. This tends to minimize guessing on a true / false test.

Matching test items might be written to ascertain pupil achievement. One of the two columns in a matching test should have more distracters than the other. This avoids using the process of elimination on the part of the test taker. Thus, the pupil may not be able to guess as well which are the remaining matching items in which the correct matching is not known. He / She may match the items known first and the rest may be matched correctly through guessing. This situation might be avoided to some extent with more distracters being in one column as compared to the next. One of the two columns should have a single word, concepts or phrases, it become too difficult to match the two columns if both have lengthy
sentences. Directions for test taking should always be meaningful. Thus, if a
distracter may be used in matching more than once, this should be stated in the
directions given for test taking.

Completion test items should have enough information given so that pupils
know what is wanted when responding to the blank spaces. Each sentence together
with the completion response should be grammatically correct. An alternative may
be a short answer test with no blank spaces but questions which require brief
responses by the learner.

The essay test may truly require higher levels of cognition. Here pupils may
answer sequential test questions requiring inquiry approaches. The pupil when
responding may stress creativity in the possible answer as long as it relates directly
to the question. Questions involving inquiry will take a longer period of time to
answer as compared multiple choice, true / false, matching, completion, and short
answer test items. In addition to subject matter, pupils may reveal writing strengths
such as using complete sentences proper capitalization and punctuation, consistent
indentation of sentences written as well as correct grammar.

Tests given to pupils should not be too lengthy whereby tiredness and
fatigue sets in. Nor should they be so short that very little is measuring during
testing time.

It is concluded that the quality of science curriculum must be developed
which has high expectations for pupils to achieve, but not too high whereby failure
is in evidence. Pupils should be held to high standards in science achievement.
Objectives need careful consideration before they are implemented. Learning
opportunities need to align with the stated ends of instruction. Each assessment
technique is valid and reliable. All test items are clearly stated. Information from
results should be used to improve instruction.
2.23 SCIENCE OF SCIENCE EDUCATION: THE PEDAGOGICAL CENTRICITY

Science is a systematic body of knowledge acquired through observation and experimentation, which is capable of verification. The main features of science are: i) Existence of systematic body of knowledge based on cause and effect relationship. ii) Use of scientific methods of observation which are objective and un-biased. iii) Development of scientific principles based upon observation and tested by repeated experimentation. iv) Universal validity of principles.

In contrast to science, art refers to the proficient application of skills and knowledge to attain desired results or outcomes through an activity. Hence, art presupposes theoretical knowledge, which is personalized through application of skills practiced at high level of proficiency infused with creativity and style. On close examination, science and art are not unusually exclusive but complementary to each other as far as their application is concerned.

2.24 SCHOOL SCIENCE EDUCATION

The goal of science is to discover, evaluate, integrate and refine concepts of science. The goal of science education in schools is to give students an understanding of some of the basic concepts. Scientific concepts are generalizations, which attempt to make sense out of the great variety of observable objects and phenomena in nature. Concepts are the man’s view of how and why nature behaves, the way it does. Some concepts are categorization of objects and events to facilitate scientific study. On the other hand, some concepts are referred to as scientific principles and deal with observed relationship between various concepts. Thus concepts condense and make subject matter meaningful and provide base for further study to help the learners to develop a rational thought process. Once learned, concepts are more readily available for use when needed than many forms upon which they are based.
2.25 SCIENCE EDUCATION: VARIOUS HUES

As far as science education up to secondary level is concerned, it is science-for-all and broad-based. The curriculum in science up to secondary level is a complete programmes in science for all students enrolled in the schools system, with sufficient alternative courses to accommodate variations among pupils. But a cursory look at the science as it is taught at the secondary stage has received little attention and innovation.

At the global level, in the last two decades, three major emphases for science teaching have emerged. The first approach based on systems analysis, stresses behavioral objectives and competition as important bases for structuring the sequences of experiences for students. In the classroom, a course designed in this way operates like a training and practice programme. Lectures and demonstrations are main media of classroom instruction. A second approach based on the theoretical structure of the particular science, emphasis concepts resulting from scientific studies. The theories of cognitive learning are applicable in this case. The third approach stresses individual and group learning through diverse activities and minimizes competition among students. There are very few schools practicing this approach.

In the secondary stage, where science laboratories exist, they are often used for demonstrations and verification type experiments. It is only in the senior secondary schools, there are separate laboratories for Physics, Chemistry and Biology where prescribed experiments are done by students. There are hardly any attempts for open-ended experiments or investigations. There are problems at the level of teachers too. Resistance to change in the science curriculum frequently comes from teachers trained along traditional lines acceptance of change by students is generally less of a problem. The professional preparation of teachers, therefore, needs to encourage positive attitudes towards accepting change.
There is a dire need to make science teaching process-based. The process/goals of science teaching emphasise the need for learners to participate actively in genuine inquiry. This implies that from the first introduction to science, children will be involved in investigating, experimenting and discovering through which they learn not only to think and to grow in intellectual self-direction but also derive joy of learning.

2.26 WHAT IS PEDAGOGY?

Pedagogy is derived from the Greek word meaning the ‘Childs’ leader’ or ‘leading a child to learning’. The other meanings attached to pedagogy are: ‘Science, and craft of teaching’ and ‘any conscious activity by one person to enhance learning in another’. According to Doyle, pedagogy is the science of viewing classroom as ‘activity system with a focus on the context of teaching’. In Bruner’s views pedagogy as a process of developing a teaching system in which children are seen as active constructors of meaning. Bruner further holds that pedagogy is to help children to construct their own experiences and help them grasp distinction between their personal knowledge and objective knowledge through inquiry ‘discussion’ collaboration and sharing of knowledge in an unthreatening social setting.

Brown and his associates advocate of centrality of pedagogy in teaching with emphasis on a learning situation which leads to co-production of knowledge both by the teacher and learners. What is learned relates strongly to the situation in which it is learned. According to Cox, pedagogy makes a pre-assumption about learning, i.e unless learners are building up their understanding of the learning situation and process; knowledge learned in one context is unlikely to pass to another.

Watkin and Associates put forth that the process of better understanding of one’s own learning is basic to pedagogy. This understanding is developed through active learning, collaborative learning, and learners’ responsibility and meta-
learning or learning about learning. With the emphasis on pedagogy, the focus shifts to the learning process in order to advance the learners' concepts of learning, improving what children and teachers both know and seeing themselves as active agents in learning.

2.27 GOOD PEDAGOGY AND BAD PEDAGOGY

A good model of pedagogy pays attention to i) Relationship between individuals and groups, ii) Has a vision of 'learning' and 'learning about learning', iii) Creation of a learning community in which knowledge is actively co-constructed by the teacher and learner, iv) Teachers' professional learning seen as a dynamic and adaptive process. The traditional teaching practice is an example of a bad model of pedagogy since children learn only from diabetic exposure i.e. children is presented with facts and rules of action. It is propagated that 'knowing' can be conveyed by 'telling' and concepts are to be remembered mechanically as facts and rules.

2.28 TOWARDS PEDAGOGY SOUND CLASSROOM AND TEACHING PRACTICE

In order to make a shift towards pedagogically sound classroom and teaching, the two things need to be practiced, i) Creation of a social and physical climate of mutuality i.e. friendly and supportive teacher-pupil relationships and display of children's work and teacher's work, ii) Emphasis on process learning with the teacher and pupils as co-learners 'i.e' facilitating thinking and understanding; providing self-learning opportunities, group-learning opportunities, allowing self-pacing, acquiring and applying processes and methods beginning from concrete experience or personal knowledge and moving towards objective knowledge. The teacher's role is to create relationships, process and systems that lead children to conceptualise reality and generate knowledge from the experience. In pedagogy, learning by human child is considered to be innate and it is to be
developed through constant learning by teachers about the social climate in the classroom and creating learning experiences or activities. The teacher would get a constant feedback through formative evaluation to keep on improving himself or herself as a creator of social climate and learning activities. The teachers' efforts must lead the child to become self-learner and constructor of knowledge.

The present day science education lays so much stress on the mugging of facts or rote learning that the real feel of the subject takes a back seat. This is brought home through the play strange place, this school which is an open satire on the present science education in schools.

2.29 CONCLUSION

Science education in daily life, especially at the school stage, is necessary for several reasons. First, the rapid growth of science and technology is influencing almost all walks of life. Second, significant portion of the students terminate their studies after primary education and therefore, there is an imperative need to provide them education, informally or non-informally, on continuing basis, about the ongoing developments in the areas of science and technology which are directly relevant to life. Third, in view of the nature of science, the scientific laws and principles being generalization of common experience, the need for relating science with life of community becomes quite obvious.

Science and technology has occupied almost all spheres of life. We are living in the society, which is completely drawn into the scientific environment. Now, we cannot think of a world without science. In the modern world of education there are a number of changes in the instructional procedure and materials used for facilitating learning. It has been established that the technology is a versatile device to interact with high quantum of information and with scientific pace of learning.

The result of this study has been presented in the subsequent chapters.