UNIT 1 SCIENCE IN SCHOOL
CURRICULUM

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1.1 INTRODUCTION

Science is the word for modern age. This word is an inseparable part of modern life. What is science? What is so special about it? Why do we teach science to our school children? What do we teach them in the name of science? These are the basic questions to which a science teacher must know the answers.

You have decided to become a science teacher, so you should know all about science. This unit will help you understand the nature of science, the purpose of teaching science and objectives of teaching science for the cognitive, affective and psychomotor development of human abilities. You will also learn about the science curriculum and its place in school education. This unit also provides for the recording of your own observations and experiences as you move along with the unit. Towards the end of each part some assignments have been framed for you to recapitulate what you have learned. The summary of each part is given at the end of each part. At the end some references are suggested for your further consultation.

1.2 OBJECTIVES

After going through this unit you should be able to:

- describe the nature of science in your own words,
- identify the components of science,
- describe various processes of science,
- establish a relationship between the type of knowledge acquired and the process used for acquiring it,
- identify the components of scientific attitude,
- classify objectives in cognitive, affective and psychomotor domain,
- write down the objectives in behavioural terms,
1.3 NATURE OF SCIENCE

1.3.1 What is Science

We will not give you any standard definition of science as given by scholars nor the definition given by scientists. Instead we will help you to define science in your own words as you develop an understanding of science.

Human beings are curious by nature. They have a highly developed mind because of which they can observe precisely, correlate observations and predict future happenings on the basis of their observations. This ability has helped human beings to adjust to nature. They explore, interpret and change the physical world according to their own need and requirement. The process of observing, describing, exploring and using the physical world is nothing but science.

Suppose Anil says “All insects have three pairs of limbs.” If this statement is Anil’s own observation then we will say that Anil is learning science.

What are the sequences after which Anil has given this statement?

Anil saw an ant moving on a wall and while observing its movement his attention was diverted to its legs. On another occasion he saw an housefly and his attention was drawn on its legs. Anil was amazed to note that it also had the same number of legs as an ant had. In this way Anil’s instances of observing insects goes on increasing and he gave the conclusion that ‘all insects have 3 pair of limbs.’

The first observation could be a chance observation but once he realised the similarities his further observations became more intentional or selected some element of curiosity was involved in Anil’s second observation onward. During the intentional observations Anil might have observed other creatures also which he kept in other categories. He could have retained his attention only on insects and that too on the part of body responsible for locomotion. Anil is learning science. Anil has not given the statement on the basis of only one observation Learning of science is a lengthy and continuous process. Let us see what is this process.

1.3.2 Science as a Process

Process and processing are the words we often use in our day-to-day conversations. In teaching profession alone, the word, ‘Process’ is extensively used, such as, admission process, teaching process, learning process, process of socialization, examination process, and evaluation process etc.

Process may involve the following activities:

- steps to accomplish a task
- ways of doing work
- planning various stage of an activity, and
- establishing systematic steps for gathering and retaining information.

In science, the way of gathering information, thinking, measuring, solving a problem or in other words the ways of learning science are called the ‘processes of science’.

Let us reconsider Anil’s observation leading to his statement ‘All insects have three pairs of limbs’. First of all, Anil:

- became aware of various insects in and around his house
- saw some ants carrying sugar cubes
- was curious about their activity.
Then, he:

- by chance observes the limbs/legs and count them
- intentionally observes housefly, mosquito and other small insects in and outside home
- observes common characteristics of insects especially limbs
- draws inferences, and
- makes a statement.

**Basic Processes or Basic Processing Skills**

Anil has employed two basic skills here:

1. Observation and
2. Inferences.

To apply processes, certain skills are required. These skills are called processing skills. These are as follows.

(i) Observation: You must be clear by now that observation is not just ‘seeing’ or ‘looking at’, or ‘glancing’ or ‘viewing’. During the time we are awake, we ‘see’ or ‘look at’ various objects and phenomenon around us. The regularity in viewing these phenomena or objects catches our attention and becomes observation.

We see birds flying, raining, cloth drying, water boiling or different varieties of plants, flowers, animals etc. The foremost process skill is observation. It is through observation only that we know our environment, physical as well as social. We observe natural phenomena, objects, plants, animals and human beings and learn about their nature and behaviour.

What do you do when you first observe a thing? You look for its characteristics and on the basis of these characteristics you classify it into a particular category.

(ii) Classification: During classification, you may group distinct objects in one group on the basis of similarities which the objects share e.g. text books, reference books, novels, story books etc. are grouped together under the category or class of books. Similarly, are the class of Insects, Flowers, Acids, Carnivorous or Intelligent People etc.

(iii) Communication: For representing a class of objects we need some name, label, sign or symbol etc. These labels and signs communicate the information about the class members. Communication is an important skill in transmitting and testing the knowledge.

For recording and communicating the information, especially in science we also need the skill of Measurement.

(iv) Measurement: Measurement is used for recording precise and accurate observations. For example ‘rise in temperature, change in dimensions, change in duration etc. For recording such observation various scales and instruments could be used. Selection of the instruments depend upon the degree of precision or exactness required in the measurement.

(v) Estimations: Sometimes we do not require such accuracy there we can use Estimations e.g. half a class of water or one fourth of a piece of bread, a bunch of flowers etc.

On the basis of the acquisition of the aforementioned skills one can peep into the future. While planning activities skill of prediction is required.

(vi) Prediction: When you observe dark clouds in the sky, what do you say about the weather? If you have to go out you may have to take an umbrella. Why? Because you have predicted the weather. Prediction is the skill which helps us to know the behaviour of any particular object or phenomenon before it happens. All our planning depends upon prediction. Prediction about eclipses, crops, weather, behaviour of substances of human beings are some instances.

If you are able to predict various phenomena on the basis of your experience and observations, you can also explain it. To explain the phenomenon you should be able to relate various facts properly. This ability of establishing relationship between various phenomena or facts is the ability of Generalization.

**Inferences**

The abilities of Prediction, Explanation and Generalization together form the process of making
Inferences.

The quality of knowledge acquired by an individual depends upon the quality of basic skills applied. Sharp observation will lead to sound and accurate knowledge.

As the mind grows with age, the complexities of the processes also increase. Several skills functions together and help the child to interact and adjust in his physical and social environment. Integration of skills help an individual to answer Why, When and How type of questions. Many skills are required to solve a problem and to carry on an experiment.

**Integrated Skills**

Various skills that are required to carry on an experiment successfully or to solve a problem are known as Integrated Skills.

When an individual is confronted with a problem, then he looks for the nature of the problem and its relationship with the whole system. Suppose you want to dissolve some solid substance into a given amount of liquid to make a solution, and you wonder as to how much solid could be dissolved in the liquid. Now the process of making the solution depends upon the nature of the solute, nature of the solvent and the temperature. These are the variables of the system. Here system can be designated as the ‘solution’. We shall discuss the skills required in the following pages.

(i) Identifying and Controlling Variables: In science we study the effect of one variable over the other. For example if you want to study the effect of ‘Praise’ on the ‘achievement’ of your students. The first variable i.e. ‘Praise’ will be called the Independent Variable and the effect of this variable on other variable i.e. “Achievement” which is called the Dependent Variable will be seen. There are other factors also which might effect the achievement but you are not studying their effect on the achievement such as age of the students, intelligence, physical comforts, fatigue etc. These variables have to be controlled or kept constant.

(ii) Defining Operationally: Whatever information individuals acquire through experiments, observations or experiences, they use it to describe in meaningful statements the phenomenon, object or event etc. For example “The solubility of a substance in a given solution increases with the increase in temperature of the solution.”

(iii) Forming Hypothesis: We have already discussed the meaning and importance of prediction. Statements of predictions are also called the Hypotheses. It denotes the conditions in which future happenings are expected. As these statements mention the conditions for prediction, they are said to be more formal and controlled scientifically. Hypothesis makes a guess about the expected outcome of an experiment.

(iv) Experimenting: Experiments are conducted to test hypothesis. Designing and conducting an experiment requires the use of many skills. During the testing of a hypothesis we study the effect of independent variable on the dependent variable keeping other variables under control.

(v) Tabulation or Graphing: During the experiment the investigator collects information in an organised way. The information can be represented clearly in the form of tables or graphs.

(vi) Interpreting Data: The information received or the knowledge gained through the study of data help the investigator to test the hypothesis or form conclusions. You can study the table and conclude that amount of solute dissolved in one litre of solution increases with rise in temperature or the volume of a gas decreases with rise in pressure.

(vii) Investigating: In order to solve a problem pupils are required to observe, collect and analyse the data in order to form meaningful conclusions. All the above mentioned processes help the learner to discover meaningful information and form/ take decisions.

The systematic and organised use of the above mentioned process skills help people understand and adjust to their physical and social environment. It is through these processes that they learn to unfold the mysteries of nature which in turn help them to use nature according to their own needs and requirements. According to Dr. D.S. Kothari — ‘to learn science is to do science, there is no other way of learning science.’ Science is a systematic process of learning.

**1.3.3 Science as a Product**

Whatever information or ideas we acquire through various processes of science form the body of knowledge we have and are referred as ‘PRODUCTS’ of science. Solution to every problem
leads to the discovery of a new problem and the cycle goes on and the result is the accumulation of knowledge.

The basic components of knowledge are Facts, Concepts, Principles and Theories.

Facts

Facts are specific verifiable, pieces of information obtained through observations and measurement. They are verifiable with reference to time and place, e.g. “15 students attended the class on 7th July’86 at 10.30 a.m.” Some facts do not require the time and place to be mentioned e.g. ‘iron is a greyish hard metal.’ Some facts are specific like ‘water boils at 100°C at 760 mm. of pressure.’

Water is a liquid, solids have definite shape and volume, birds fly etc. are facts.

Concepts

Concepts are abstract ideas that are generalised from facts or specific relevant experiences. Concepts are single ideas represented by single words e.g. Chair, book, acids, flower, honesty, democracy, student etc. According to Bruner every concept has 5 (Five) elements viz. name, example (positive and negative), attributes (characteristics), attribute value, and rule (definition).

Principles

Principles are more complex ideas based on several complex concepts. They are the rules on which the activities or behaviour of things depend. e.g. Pauli’s exclusion principles, Aufbau’s principle/rule, Hund’s rule etc.

Theory

Broadly related principles that provide an explanation for phenomena are known as Theories or Laws. These are used to explain, predict and relate various facts and phenomena. Theories confirmed by various scientific experimentations by scientists over a period of time become Laws.

The relationship between various components of the Product is shown in the following diagram.

LAW

↑

THEORY

↑

PRINCIPLES

↑

CONCEPTS

↑

FACTS

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

c) Distinguish between “seeing” and “observation”.
1.4 OBJECTIVES OF TEACHING SCIENCE

Education is a process of bringing about changes in an individual in a desired direction. It is a process of helping a child to develop his potentialities to the maximum and to bring out the best from within the child. To bring about these changes we teach them various subjects at different levels of school. Science as a subject is included in the school curriculum from the very beginning. Before taking any decision about teaching science we should pose certain questions to ourselves, such as, why do we teach them science? What are the goals and objectives of teaching science? What changes does science teaching bring about in the behaviour of the students?

Before answering these questions let us first define goals and objectives.

A goal is the ultimate target in life which an individual tries to achieve. Goals are basically long term objectives which require a long period of time to be achieved. For example, development of scientific attitude, to become a responsible citizen etc. Objectives are short term targets which are specific and could be achieved in a single day or single hour. For example, acquiring knowledge about some specific things within a prespecified time limit, would come under the purview of objectives.

Students are potential human resources required to be developed into educated, sound, skilled and efficient citizens who will fulfil the aims of social, economical, political and technological development of the society.

The aim of education is to provide opportunities for personal all-round development of individuals, to equip them with up to date and sound knowledge of science and technology and make them capable of using science and technology for the betterment of human society.

1.4.1 Goals/Aims for Science Teaching

Considering the individual teacher and his/her own reason for teaching science it would become impossible for any educational system to provide facilities for each teacher to achieve his/her goals. Therefore, goals are decided at the national level.
Various commissions and committees on education set up by Government of India after Independence emphasized the teaching of science from the primary level.

All of them emphasized the teaching of science for:

- the development of process skills like observation, classification, measurement, communication etc.
- acquisition and understanding of knowledge, development of problem solving skill, skill of investigation, ability to think logically and to draw conclusions on the basis of experiments.
- development of ability to reach generalizations and to apply them for solving every day problems.
- development of understanding of inter-relationships of science and society.
- to foster creativity in people, enabling them to carry out innovations in science.

National Science Foundation, Washington also set the following goals for science and mathematics teaching under its ‘Project-2061’ during 1988-89.

**GOALS FOR SCIENCE INSTRUCTION UNDER ‘PROJECT-2061’ (NSF, WASHINGTON)**

*Goal-I: Science must enhance each learner’s Personal Development*

This could be achieved when children will:

- understand and use new ideas and scientific information to improve their lives.
- develop skills to support scientific inquiry.
- develop problem solving skills needed to respond to a changing society and environment.
- develop a positive attitude towards science that will encourage continued interest and learning.
- develop the attitude and skills they need to become responsible consumers.

This goal focuses on ways to enhance students’ personality, their curiosity, honesty, self confidence, ability to make decisions, examine values, reason logically and practice the ethics of science.

*Goal-II: Learner must understand the inter-relationship of Science, Technology and Society*

Under this goal the learners will be able to:

- understand the interaction of science, technology and society.
- recognize that solution to one problem can create new problems and that decision must consider the possible consequences for other community members.
- recognize that data may be interpreted differently by different people depending on their values and experiences.
- recognize how the advancement of science and technology has changed the lives of people in local, national and global communities.
- possess a sense of custodianship (collective responsibility for the environment over a period of time) as the need for conservation increases.

*GOAL-III: Science must develop each learner’s Academic and Process Skills*

Science instruction should help the learners to:

- develop a knowledge and understanding of scientific principles and concepts.
- develop attitude, values, ethics of science to use as a basis for science related decisions.
- learn to think critically, creatively and rationally so that they can solve problems and promote lifelong learning.
- develop process skills so that they can think scientifically.
- develop psychomotor skills so that they can properly manipulate/handle equipment and instruments.

This goal concentrates on what children need to become scientifically literate. The curriculum must include the knowledge, concepts, principles, and ideas of science, as well as the attitudes,
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values and ethics of science, and critical thinking and problem solving skills.

**GOAL-IV: Science must help to expand each learner’s career awareness**

This goal focuses on learner’s ability to:

- realize that science and technology are relevant to all fields of employment.
- develop an awareness of occupational and professional opportunities in science for women, minorities and handicapped.
- develop an awareness of science requirements for occupations and professions.
- recognize that scientists and technicians possess a full range of personal characteristics and should not be stereotyped.
- develop effective and positive work habits related to science.
- become informed about the contribution scientists make to society.

These goals of education are intended to be achieved by the time pupils leave the school and enter the society as responsible and efficient citizens. During the school years they are in the process of developing the personal, social and intellectual aspects of the personality. However, it is necessary to see that the development is taking place in the right direction. In order to monitor the process of development, short term objectives of teaching have been framed by educationists in all societies keeping in view the requirements and nature of individuals as well as that of the discipline, towards progressive development.

The most important and widely accepted contribution in this direction is that of Bloom and his associates.

### 1.4.2 Bloom’s Taxonomy of Educational Objectives

Bloom and his associates developed a taxonomic model of educational objectives. They adopted a division corresponding to three primary aspects of pupil’s growth viz. cognitive, affective and psychomotor. Within each domain they arranged the objectives in logical and psychological order i.e. the sequence of the development of mental abilities has been maintained.

#### Cognitive Domain

The cognitive domain represents the intellectual component of mental life. It is the most important aspect with respect to education. You will appreciate the sequence in which these mental abilities are classified under this domain. These are as follows:

- Knowledge — comprehension — application — analysis — synthesis and — evaluation

#### Knowledge

Memory or remembering is the lowest level of intellectual structure model. Knowledge involves the recall or recognition of specifics, universal, pattern, structure etc. For example, recalling the names of animals, recognising them as herbivorous or carnivorous, recalling their food habit, type of food they eat and type of teeth or alimentary canal they have.

#### Comprehension

Comprehension is considered at a higher level than knowledge but is also the lowest level of understanding. An individual is expected go beyond the level of recall and recognition. Pupils should be able to understand the meaning of the concepts, because facts and concepts describe a process. For example, relating the type of food with the structure of teeth or alimentary canal of herbivorous or carnivorous animals or describing the process of ‘raining’ by relating the concept of ‘evaporation’ and ‘condensation.’

#### Application

While applying, an individual is expected to use his knowledge and understanding of the facts, concepts, principles, ideas, or procedure in a particular situation or for solving any particular/ specific problem e.g. selecting the food for their pets.

#### Analysis

It is the next higher level of cognitive ability. Here an individual is required to analyse a meaningful statement into its various components. Pupils should be able to identify the concepts and their
inter-relationship in the statement. Analysis will lead to establish the relationship between various statements in a meaningful communication.

Synthesis

It is a complex ability at a higher level of cognition. It involves the ability of an individual to put together the elements or parts in a way that a new pattern emerges out. It is an ability to give new shape or structure to statements or procedures. It has an inherent element of creativity.

Evaluation

The highest level of cognitive structure is the ability to evaluate or judge. It is also the most complex ability which involves all the other abilities. It enables a person to judge a material, product or process against a standard and to establish the worth of it.

All these abilities in the cognitive domain are in a logical order. Application of knowledge is not possible until an individual has a sound understanding about the material and the process to be used. Also, for developing this understanding, knowledge is the prerequisite.

Affective Domain

There is another important aspect of human nature which includes the interests, likes and dislikes, feelings, behaviour and attitude etc. Psychologists have tried to identify and arrange three qualities in a gradual manner like cognitive abilities. These qualities are classified under the category of Affective Domain. These are the behavioural abilities which lead towards the formation of attitude, the complex and ultimate behaviour norm. These are as follows.

Receiving

The lowest level under the affective domain towards the development of attitude is Receiving, i.e. the ability of an individual to receive information. Attention of an individual is an indication that he/she is ready to receive information. Awareness of the sources of information and willingness to receive the information are the sub-levels of this category.

Eg. Awareness of Science Centre/Information Centre Library/Video lib. etc. in the neighbourhood.

Responding

Regularity in attention and motivation leads to Responding. This ability is represented by interests. Interest is a tendency to respond to a particular object/situation.

Eg. Visits resource centres collecting/reading materials/obtaining membership of centres.

Valuing

The next level towards behaviour formation is achieved when an individual is able to internalise the sense of worth and identification with it. Individuals set guidelines for controlling their own behaviour. Acceptance of a value, preference for a value and finally the commitment to a value are the steps towards character building.

Take decision about the activities of the groups analysing and assessing the issue.

Organisation

An individual's behaviour or attitude is not ordinarily motivated by a single or isolated value. A system of values form the complex behaviour, represented by general behaviour, a code of conduct. There should be an organisation of values for a balanced conduct.

Decision about conduct in real life situations forming opinions about major issues in reality.

Characterization

It is the highest level in the character building or attitude formation of an individual. The values are imbibed and the individual has a consistent philosophy of life.

Set attitude $\rightarrow$ character building $\rightarrow$ Personality development

Whatever function an individual performs is a result of neuro-muscular coordination. As the level of coordination goes up, the action becomes more rapid, speedy and automatic. The action abilities are classified under PSYCHOMOTOR DOMAIN. Five categories have been identified under this domain.
Imitation

It is the lowest level of psycho-muscular activity. It starts as impulse and may grow into an overt act with the capacity to repeat the performance. Though this ability is found in early childhood years of individuals it is also carried over, to some extent, in the later years. This is also the first essential skill for training the students for practical and experimental exercises. They learn the skills first by observing others (teachers) performing them.

Manipulation

It is the next higher level of motor coordination. It involves selecting a certain action in preference to others, following directions and acting accordingly. Selection is important in manipulation.

Precision

Practice or repetition of performance will result in decreasing the faults in performance. Precision is related with speed and refinement giving the learner the ability to control his/her action in response to the requirement.

Articulation

On attaining the ability of articulation, individuals will be able to handle many actions in unison. This ability involves the coordination in action.

Naturalization

Perfection in performance or in any action is the final level in psychomotor domain. On attaining perfection an individual requires minimum time for completing a perfect task. His actions become mechanical and without any conscious thinking or planning.

For teaching/learning science, these abilities are very essential and need to be developed from primary stage. One can learn science only by doing it. Experimentation and measurement are the basic skills for learning science. Precision is required in measurement and observation, articulation and naturalisation are required in planning, designing and performing experiments.

Behavioural Objectives

You may realize that the description of these objectives in aforementioned three major domains does not indicate any way in which learning of the pupils could be measured. In order to measure the learning outcomes, it is necessary to write them in such a way that they describe the change in the behaviour of learner. The objectives written in such form are known as Behavioural objectives. All the general objectives have behavioural specifications. There are various action words or verbs to describe the behaviour of learner which help the teacher and the evaluator to decide whether learning has taken place or not.

It is not customary to describe the educational objectives for all subjects in all the three domains. Depending upon the nature of discipline the objectives are derived from the cognitive, affective and psychomotor domain.

1.4.3 Instructional/General Objectives for Science Teaching

The specific objectives under cognitive, affective and psychomotor domain are clubbed into three, two and one respectively for the purpose of formulating general instructional objectives for science teaching. These are as follows.

1. Knowledge
2. Understanding and
3. Application are from the cognitive domain,
4. Interest and
5. Attitude are from the affective domain and
6. Skills are from the psychomotor domain.

By now you are familiar with these terms. Let us now discuss these objectives as they are used for instruction purpose along with expected change in behaviour of learners.

Knowledge

Knowledge as you know is the lowest level of cognitive ability. Therefore, the first objective of
teaching science is related to acquisition of knowledge by the students. It states:

"Students will acquire the knowledge of facts, concepts, principles, processes and techniques etc."

The behaviour specification to demonstrate the achievement of this objective is that pupil will be able to:

- recall terms, facts, concepts, principles and processes etc.
- recognise facts, terms, concepts, principles and processes etc.

You know that words like ‘recall’ and ‘recognise’ are the action words which represent the behaviour of individuals. This overt behaviour can be observed and measured by teacher as well as by an evaluator or any observer.

Understanding

The second objective of science teaching is related to the next higher cognitive ability i.e. comprehension or understanding. It states:

"To develop the ability to understand facts, concepts, principles, theories and techniques etc."

Behaviour specification of objectives are that pupils:

- illustrate terms, facts, concepts, principles etc. by citing examples.
- express the same fact or concept in different ways by way of explanation.
- locate errors in known situation and correct them.
- compare and contrast between related terms and concepts.
- classify objects, facts or any information.
- discriminate between allied substances or concepts.
- identify relationship between various facts and concepts.
- extrapolate for known information.
- translate symbolic statement into verbal statement and vice versa.
- interpret data, charts, graphs etc.
- detect errors in faculty statements.
- verify facts.
- solve numerical problems.

Application

The essence of teaching/learning, as you know, is the application of knowledge. You perform various activities or solve many problems in your daily life. You are able to do this only because you have the knowledge and understanding of the things around yourself. The third objective aims at using knowledge in new situations. It states:

"To develop the ability to apply knowledge of concepts and principles of science in new or unfamiliar situations."

Behaviour specification of the objectives are that the pupil will:

- analyse situation or problem
- formulate hypothesis on the basis of observations
- select appropriate methods and material for testing the hypothesis
- give reasons for happenings
- draw inferences, conclusions and generalizations
- predict results or happenings on the basis of known facts

Skills

We know that ‘Science learning is science doing’, therefore, for learning science, various skills are required for performing activities and acquiring knowledge. Also, type of knowledge acquired
by an individual depends upon the processes applied for acquiring it. The fourth objective of teaching science states:

"To develop observational, experimental, manipulative and drawing skills".

To demonstrate the acquisition of skills pupil will:

- handle objects, material, instruments, specimens and apparatus properly
- clean apparatus and instruments carefully
- observe and record relevant data accurately
- measure weight, volume, temperature, pressure and other dimensions accurately
- put articles in proper order and place
- draw and label neat and appropriate diagrams
- make graphs and charts from given data
- improvise apparatus
- dissect neatly
- take precautions

Interest and Appreciation for Science

Why have you studied science? It was because you liked it, you enjoyed studying it, your curious nature got satisfied by the answers given by science. Now you want to develop the same interest and appreciation for science among your students. Pupils learn only when they enjoy the subject and appreciate the fruits of science for the development of society. So, our next objective states:

"To develop the power of appreciation of the developments in science and to create interests in learning science."

The behaviour specifications which will be demonstrated by the students on achieving the objectives are that the pupil will be able to:

- show thrill and excitement while performing science experiments.
- feel satisfaction in collecting and exhibiting the materials, objects, specimens and the pictures showing development of science.
- enjoy performing experiments in chemistry.
- read scientific literature.
- read with interest, about the achievements and sacrifices of great scientists.
- take part in scientific debates, discussions and functions.
- explain interdependence of organism and environment and of organisms themselves.
- collect materials and specimens.
- preserves materials, leaves, flowers, insects stones and minerals etc, properly.
- visit places of scientific interest on his own.
- contribute articles on topics of scientific interest.
- join scientific hobby clubs.
- improvise models and apparatus.

Scientific Attitude

We aspire for the development of scientific attitude in our students. It is the ultimate aim of science teaching. You will also agree that if we teach science properly i.e. through activities performed under the supervision of teachers or allow children to perform unsupervised activities on their own, then surely, they will adopt scientific process for learning their environment. Through guided and self learning, they will acquire the behaviour and attitude which we call as scientific attitude.

On acquiring scientific attitude pupils will demonstrate the following behaviour:—
• They will respect the teacher.
• They will have a keen desire to know hows and whys of any event or phenomenon.
• They will not ignore any detail even if it is of no direct relevance of the work in hand.
• They will record, report and interpret their observations honestly.
• They will not accept or reject any thing without valid reasons.
• They will suspend judgement till it is repeatedly confirmed.
• They are unbiased in their approach to problems.
• They are willing to consider new ideas and discoveries.
• They will admit their mistakes unhesitatingly.
• They will develop independent thinking.
• They will show a spirit of team work, self help and self reliance.
• They are prepared to face hazards in their investigation.

Check Your Progress

Notes: a) Write your answers in the space given below.
     b) Compare your answers with those given at the end of the unit.

4. a) What are the goals of science teaching framed by NSF.

b) Do you agree with them?

c) Why?

5. What are the essential characteristics of scientific attitude?
1.5 SCIENCE CURRICULUM

In the previous sections you have studied about the nature of science and objectives of teaching science. Now you are in a position to define 'Science' and also able to tell the reason as to 'why we teach science?' We have set certain objectives for teaching science in order to mould the behaviour of children in a desired direction. These objectives are classified under 'Cognitive', 'Affective' and 'Psychomotor' domains. They cover the intellectual, behavioural (social, moral, personal and physical) and manipulative (skills) aspects of human development.

Now the question arises as to what should be taught to the students and what experiences should be provided to them so that they can display the expected behaviour.

Whatever content and activities we use/apply to achieve our objectives form the part of curriculum. It includes:

- Content/subject matter given in the text books.
- Learning experiences through laboratory work.
- Learning activities performed in science clubs.
- Learning experiences due to peer and community interaction outside the classroom.
- Learning through pupil-pupil interaction.
- Learning through pupil-teacher interaction, etc.

Hence, curriculum spells out the total experience pupils should have in schools through classroom activities, laboratory work, playground experiences, interaction with teachers and peers, inter school and inter class academic and cultural activities.

We know that children are individuals with their own intellectual and biological needs, capabilities and potentialities. Every aspect of their need and development should be taken care of while framing curriculum for them. Similarly we are living in a developing nation which has its own demands for scientific and technological developments. These demands are to be fulfilled by the younger generation when they enter the society as responsible citizens. Another important aspect of curriculum is the subject matter or the medium through which these demands of the child or society are to be fulfilled.

Now the question arises as to how to plan a curriculum that caters to the needs of pupils, society as well as that of discipline/subject matter. There are some principles for constructing the curriculum. Let us examine them.

1.5.1 Principles of Curriculum Construction

(i) Principle of Child Centredness

Foremost consideration should be given to the child. We know that childrens' cognitive abilities develop with a pre-set sequence. A child is a growing person not only intellectually, but also physically, emotionally, morally and socially. It becomes obligatory on the part of curriculum planners to provide means and material to satisfy the child’s need for proper growth and development.

(ii) Principle of Community Centredness

We know that children are an asset of our society. No society can possibly be completely developed and perfect. There is growth and development in every society. For development it needs human resources as well. The requirements of society have to be fulfilled by educated citizens. Planners foresee the needs of the society in the form of teachers, doctors, engineers, skilled and trained personnel in different fields, scientists and technicians etc. as required by the society.

So the curriculum should be so planned that it could equip the children with knowledge and competencies expected for their role and place in the society. They should fulfil the needs of the society.

(iii) Principle of Integration of Science

You know that the later half of the twentieth century saw the explosion of knowledge. Knowledge
is accumulating at a much higher rate than ever before. This expansion of knowledge is there in every discipline, especially science and social science. The things which are relevant today may become obsolete tomorrow i.e. by the time children will come out of schools.

You also know that science has a distinct structure and within this framework of structure, new knowledge is accommodated.

You know that science has three main branches viz. Biology, Chemistry, and Physics and all the three are equally important for learning and exploring the environment. In actual life situation we cannot separate the three. There is a component of all the three sciences in whatever we observe e.g. food, water, air, plants, animals and other non-living things. (Imagine anything thing and think about the chemistry, physics or biology involved in it or find out the relation of at least two of them).

Take the example of ‘AIR’. The constituents of air we study in Chemistry, its pressure and movement are studied in Physics and it is also essential for life, used in respiration, therefore, we also study it in biology. Similar is the case with water and food.

So in order to highlight the integrated nature of science all the three subjects should be taken as General science, integrating the discipline, especially upto secondary stage.

(iv) Principle of Integration of the needs of Child, Society and Discipline

You may realise the difficulties faced by a curriculum planner to justify the needs of child, society and discipline, as all the three are equally important. What we can do is to integrate the requirements of the child, society and subject matter in the best synchronized form. At each level of planning we should keep in mind all the three aspects.

(v) Principle of Creativity

Have you ever seen a normal, healthy child sitting quietly and doing nothing for most of the time? Possibly not, because children by nature, are very energetic. They are always active when they are healthy. If you observe the childrens’ activities you will find out that most of them are very creative.

To keep this ability alive, there should be a conscious effort on the part of planners to make the curriculum creativity oriented. This aspect will help the child to try out new methods and techniques when he will be in actual field of work in the society. It will help him to take part in the development of society.

(vi) Principle of Activity Centredness

We know that children learn science only when they do it. Only when they are intellectually and physically in contact with scientific materials material of science, will they learn it. Simple scientific activities performed in the classroom, in laboratory, or at home enable the child to go beyond the verbal information. They will get a feel of it only when they deal with it.

This aspect of learning is being kept in mind while developing the curriculum. Curriculum should be activity based.

(vii) Principle of Flexibility

Ours is a diverse society. India is a large country, apart from human variations in terms of culture, occupation, social and economic conditions, religion, castes, rural/urban etc. We also have differences in geographical conditions. It is impossible to set a rigid national curriculum for our country. Also the knowledge is changing with such a rapid rate that every year, new discoveries are either replacing old knowledge; or improving it so it is necessary to keep the curriculum flexible in order to make it effective.

(viii) Preservation of Culture

We know that culturally, India is a very rich country and over the years, people of India have preserved it. It is through education only that our younger generation have got glimpses of an extremely varied culture.

The values, morals, attitudes and customs which are part and parcel of culture have to be preserved and concerned.

We have mentioned some major issues which have to be considered by the planners while framing the curriculum for secondary schools.
1.5.2 Science Education in India

Now let us examine some of the efforts put into shaping science education for Indian Schools.

Science as a separate subject, was included in school curriculum in the beginning of nineteenth century. It was then referred to as general science. After acquiring political independence in 1947, Indian government set up the University Education Commission under the Chairmanship of Dr. Radha Krishnan in 1948. Though the Commission was to report primarily on university education, it made valuable suggestions for secondary education. The Commission recommended inclusion of General Science as a course of study in secondary schools.

During 1947-52 the system of Basic Education, accepted as a national system of education visualized the General Science approach to teach science at elementary stage.

MUDALIAR COMMISSION — 1953

The first genuine attempt for making teaching of General Science as a compulsory subject in secondary school, was made in the recommendation of the report of Secondary Education Commission 1953 (Mudaliar Commission). The Commission suggested compulsory inclusion of General Science at middle and secondary level. It also suggested diversification of courses having science group subjects as optional channels at higher secondary level.

A thorough discussion on all aspects of science education, viz., syllabus, equipment and materials, teaching aids, text books, science clubs, museums, and methods of examinations etc. was held at All India Seminar on Teaching of Science in Secondary Schools held at Tara Devi in 1956. It had suggested a uniform system of science education for the entire country, suited to its needs and resources. It had also suggested organisation of content of science under i) environment centred topics ii) life-centred topics and iii) a combination of both to bring about integration among the various branches of science. The major and minor concepts should be related to facts and events of everyday life and include necessary practical work and out door activities.

In 1961 the Government of India established the National Council of Educational Research and Training to look after the school education. In 1961 the Indian Parliamentary and Scientific Committee was set up. The Committee took up the study of ‘Science Education in Schools’ in 1962. The Committee found a gap between what was being taught and what ought to be taught.

The Department of Education in Science and Mathematics in NCERT undertook the responsibility of development of science and mathematics curriculum at secondary level. A team of experts from UNESCO arrived in India to advice and assist restructuring science education at school level. They suggested experimentation and inquiry based teaching methods to improve science education.

KOTHARI COMMISSION — 1966

In the meantime the report of the Education Commission (1964-66) under the chairmanship of Dr. Kothari was published. The Commission recommended that science and mathematics should be taught on compulsory basis to all pupils, as a part of General education during the first 10 years of schooling.

It recommended that:

- At lower primary classes science teaching should be related to child’s environment.
- At upper primary level emphasis should be on acquisition of knowledge and ability to think logically, to draw conclusions and to make decisions.
- At lower secondary level science should be developed as a discipline of mind. The newer concepts in physics, chemistry and biology and the experimental approach to the learning of science should be stressed.
- Science teaching should be linked to agriculture in rural areas and to technology in urban areas.
- The method of teaching science should be modernized, stressing the investigatory approach and understanding of the basic principles.
- Guide materials should be made available to help teachers adopt investigator approach.
- There should be flexibility in the curriculum in order to cater to the special needs of the gifted children.
As a follow up of the report, a top level conference on Science Education was convened under the chairmanship of Dr. Kothari. It was held to plan an effective programme for the development of total curriculum of science education at different stages. The Ministry of Education and Social Welfare appointed an expert group in 1973 to develop curriculum for 10 +2 pattern.

"The Curriculum for the Ten Year School — A Framework", published by NCERT was developed by the expert group under the chairmanship of Prof. Rais Ahmad. This model curricula, recommended the school science to be taught as 'Environmental Studies' at primary stage and as 'Integrated Course' at middle stage.

A review Committee was appointed in 1977 under the chairmanship of Shri Ishwar Bhai Patel. The Committee suggested the strengthening of abilities under affective domain through curriculum. The curriculum should not be too bookish.

10 + 2 system of school education recommended by Kothari Commission became the National System of Education.

Science courses, as you will find, are always developed keeping objectives and national development goals in view. These courses are designed by NCERT at national level for various stages of school education. The new framework document of the Ten Year School, titled 'National Curriculum for Primary and Secondary Education — A Framework' developed by NCERT is a forerunner of the National Policy on Education - 1986. NCERT develops its courses through various workshops and seminars in which academicians and experts from various institutions take part. Personnel like school teachers, subject experts from colleges and universities, teachers from vocational and professional institutions, teacher educators, state representatives and experts from NCERT itself take part in curriculum construction.

Experts review these curricula periodically and make it up-to-date.

Check Your Progress

Notes:

1) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

6. a) Mention various principles of curriculum planning.

b) Give salient features for each of them.
1.6 LET US SUM UP

In this unit you have learned about science - nature of science and how children learn science. Science is both PROCESS and PRODUCT. The processes of science are the skills required for learning science. There are six basic processing skills, observation, classification, communication, measurement, estimation and prediction. With the help of these basic skills individuals acquire problem solving skills which are also called as Integrated Skills. There are seven integrated skills, viz., identifying and controlling variables, defining operationally forming hypothesis, experimenting, tabulation and graphing, interpreting data and investigating. These skills equip the individual with the ability to explore and learn his physical and social environment. The knowledge or information an individual acquires through these processes is known as the PRODUCT of science. The depth and authenticity of the knowledge acquired by individuals depend on the processes applied by them. The Product of Science comprises of Facts, Concepts, principles, theories and laws.

**NATURE OF SCIENCE**

<table>
<thead>
<tr>
<th>Process (Skills)</th>
<th>Integrated Skills</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Skills</strong></td>
<td><strong>Integrated Skills</strong></td>
<td></td>
</tr>
<tr>
<td>1. Observation</td>
<td>1. Identifying and Controlling Variables</td>
<td>1. Facts</td>
</tr>
<tr>
<td>2. Classification</td>
<td>2. Defining Operationally</td>
<td>2. Concepts</td>
</tr>
<tr>
<td>5. Estimation</td>
<td>5. Tabulation or Grouping</td>
<td>5. Law</td>
</tr>
<tr>
<td>6. Prediction</td>
<td>6. Interpreting Data</td>
<td></td>
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<tr>
<td>(Inferences)</td>
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</tbody>
</table>

The second part of the unit dealt with the objectives of teaching science. The definitions and differences of goals and objectives were given in the beginning. Goals are ultimate targets/aims in life which individuals want to achieve. These are long term objectives and require a long period of time to be achieved. Objectives, on the other hand, are targets to be achieved in short duration of time. Objectives are very specific.

The emphasis given to science education by various Commissions and Committees were discussed. The common emphasis was on the following:

- development of process skills
- acquisition and understanding of knowledge
- ability to think logically, reach generalisations and application of knowledge
- understanding related to the inter-relationship of science, technology and society
The goals set up by National Science Foundation, Washington for teaching Science were discussed. There are four major goals 1) Personal development of learner, 2) Inter-relationship of science, technology and society, 3) Development of learner's academic and process skills and 4) Expansion of career awareness.

The taxonomy of educational objectives as given by Bloom was also discussed. Bloom classified the objectives under three major domains viz., cognitive, affective and psychomotor. There are six objectives under cognitive domain, which are knowledge, comprehension, application, analysis, synthesis and evaluation. Five objectives under affective domain deal with the abilities like receiving, responding, valuing, organisation and characterisation.

The psychomotor domain comprises of the abilities related to the action or manual work like imitation, manipulation, precision, articulation and naturalization.

On the basis of this classification the general instructional objectives were designed. They are structured as Knowledge, Understanding, Application, Skills, Interest and Attitude.

The behaviour specifications for these objectives were discussed.

Cognitive Behavioural Terms for Stating Specific Learning Outcomes

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>defines</td>
<td>converts</td>
<td>changes</td>
<td>breaks down</td>
<td>categorizes</td>
<td>appraises</td>
</tr>
<tr>
<td>describes</td>
<td>defends</td>
<td>computes</td>
<td>diagrams</td>
<td>combines</td>
<td>compares</td>
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<tr>
<td>identifies</td>
<td>distinguishes</td>
<td>demonstrates</td>
<td>differentiates</td>
<td>compiles</td>
<td>concludes</td>
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<tr>
<td>labels</td>
<td>estimates</td>
<td>discovers</td>
<td>discriminates</td>
<td>composes</td>
<td>contrasts</td>
</tr>
<tr>
<td>lists</td>
<td>explains</td>
<td>manipulates</td>
<td>distinguishes</td>
<td>creates</td>
<td>criticises</td>
</tr>
<tr>
<td>matches</td>
<td>extends</td>
<td>modifies</td>
<td>identifies</td>
<td>deiveses</td>
<td>describes</td>
</tr>
<tr>
<td>names</td>
<td>generalizes</td>
<td>operates</td>
<td>illustrates</td>
<td>designs</td>
<td>discriminates</td>
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<tr>
<td>outlines</td>
<td>gives examples</td>
<td>predicts</td>
<td>infers</td>
<td>explains</td>
<td>justifies</td>
</tr>
<tr>
<td>reproduces</td>
<td>infers</td>
<td>prepares</td>
<td>outlines</td>
<td>generates</td>
<td>interprets</td>
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<tr>
<td>paraphrases</td>
<td>produces</td>
<td>points out</td>
<td>modifies</td>
<td>states</td>
<td>relates</td>
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<tr>
<td>predicts</td>
<td>relates</td>
<td>relates</td>
<td>organizes</td>
<td>recalls</td>
<td>supports</td>
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<tr>
<td>rewrites</td>
<td>shows</td>
<td>selects</td>
<td>plans</td>
<td>recognises</td>
<td>summarises</td>
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<td>solves</td>
<td>separates</td>
<td>rearranges</td>
<td>reconstructs</td>
<td>reconstrucst</td>
<td>revises</td>
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<td>uses</td>
<td>uses</td>
<td>subdivides</td>
<td>reorganizes</td>
<td>rewrites</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>tells</td>
<td>summarises</td>
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<td></td>
<td>writes</td>
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</tbody>
</table>

The third part of the unit dealt with the curriculum in Science Education. The meaning and importance of curriculum was discussed in the beginning. Then the basis for curriculum construction were mentioned before giving the description of the Principles of Curriculum Construction. The principles discussed were:

- child centeredness
- community centeredness
- principle of integration
- activity centeredness
- conservation of culture
- discipline centeredness
- principle of creativity
- flexibility

The efforts of various commissions and committees in defining and framing national curriculum with emphasis on science education were highlighted.

In the end it was mentioned that people from various fields of society take part in framing the curriculum under the guidance of national framework. NCERT is the national institution which delivers the responsibility of preparing curriculum for various stages of school education.
1.7 UNIT-END EXERCISES

1. Write a suitable definition of ‘Science’.

2. Explain what do you understand by the term ‘Process’.

3. Give any three predictions and also write in few words, the previous experiences on which these predictions are formed.

4. Write down a meaningful sentence and identify the concepts present in it. Analyse the concept for its characteristic properties. List the facts on which the concepts are formed.

5. Write down in your own words what do you understand by the terms Aims or Goals and Objectives. Is there any difference between the two? If yes, state the difference.

6. You have decided to become a science teacher. Keeping in mind the definition of aims and objectives, list down the reason as to why you want to teach science.

7. State any principle and
   a) identify the concepts used in the principle and relationship of the concepts in making the principles.
   b) list and sequence the processing skills used in acquiring these concepts.

8. Suppose you want to study any one of the following.
   i) effect of heat on various substances
   ii) favourable condition for germination of seed and growth of plant.
   Describe the procedure indicating the integrated skills used.

9. Suggest an activity which may help to develop the basic skills of pupils. Describe the activity in detail indicating the steps where basic skills are used.

10. After becoming a science teacher what aims will you set for yourself? Give any three. What will you do to achieve them?

11. Do you agree with the objectives set for science teaching in secondary school? If yes-discuss how successfully they are achieved. If no -explain why?

12. Do you think method of teaching plays an effective role in achieving the objectives? Support your answer with examples.

13. Select a topic from the syllabus of class VIII and write down 5 objectives in behavioural terms each for knowledge, understanding and application.

14. In your opinion what should be the goals of teaching science for our country?

15. Do you agree with the national goals for expansion of career awareness for Indian students? Justify your answer.

16. Define curriculum and distinguish it with the syllabus.

17. In the light of the principles set for curriculum construction, discuss the present science curriculum for secondary classes.

18. Science is included as general science upto class X in secondary school. Do you agree that it is integrated science? Support your answer with examples.

19. Discuss the relevance of present curriculum for achieving the objectives of teaching science.

20. Suggest some activities through which the objectives under psychomotor domain could be achieved.

21. How far is the present curriculum successful in achieving objectives under affective domain?

22. List 5 (five) skills which you think are most essential for science students. Describe your efforts in helping students acquire those skills.

23. Select any topic and discuss how will you integrate Biology, Chemistry and Physics in teaching it.
1.8 ANSWERS TO CHECK YOUR PROGRESS

1. 'Seeing' is the act of looking at various objects, people, animals, plants or phenomena around us without any intention of getting any particular information about them.

'Observation' is the act of looking at or using other sense organs to acquire useful information about the nature or characteristics of some objects, people, plants, animals or phenomena in our surroundings. 'Observation' is 'intentional viewing'.

2. (a) The logical sequence of Basic Process Skills is - observation, classification, communication, measurement, estimation, and prediction.

(b) In this sequence classification comes after observation, obviously we cannot classify anything without observing. Similarly we 'Communicate' in term of 'Class behaviour' of things. Estimation require the ability or knowledge of measurement. Prediction comes at the end because for predicting we need all other preceding skills.

3. Facts: What we observe through sense organs at any particular time and place is a fact.

Concept: Concepts are words which can be described on the basis of their characteristics. Their characteristics depend on the observation of individual facts about them.

Principle: These are the statement of related concepts used to explain certain behaviour of objects or phenomena.

Theory: Theories are the extended form of principles used to explain, relate or predict phenomena.

4. a) I- Science must enhance each learner's personal development.

II- Learner must understand the interrelationship of Science, Technology and Society.

III- Science must develop each learner's academic and process skills.

IV-Science must help to expand each learner's career awareness.

b) Yes.

c) Because they cater to the need of all round development of individual (Intellectual, academic, social, personal) as well as of society.

5. The essential characteristics are:

● possess a keen desire to learn about his/her surroundings
● keenly observe his/her surroundings
● record, report and interpret their observations
● not accept/reject anything without valid reasons
● suspend judgement till confirmed
● be unbiased in their approach to problem
● admit their mistakes
● have an open mind
● show spirit of team work, and
● be prepared to face any hazards in their investigation.

6. a) i) Child centred
   ii) Community centred
   iii) Integration of science
   iv) Integration of needs of child and society
   v) Creativity
   vi) Activity centred
   vii) Flexibility
viii) Preservation of Culture
b) Child's needs for intellectual, physical, social, emotional, moral development are given the priority.
- Development of society is to be the focus for curriculum planning. Keeping in view the future need of human resources for the development of society, children are equipped with required knowledge and skills.
- Integration of knowledge for understanding physical and social environment is the focus for the planners.
- Integration of the needs of child, society and discipline is synchronized.
- To maintain and preserve the creative nature of human mind, curriculum is planned as creativity oriented.
- Science is activity based and provisions are made to provide the learner for experimenting in classroom, laboratory or at home.
- Flexibility, diversity of physical and social environment of Indian culture is to be taken care of during the planning. Also the expansion of knowledge is accommodated.
- Values, attitude, morals, customs, folklore etc. are given importance while planning activities of the curriculum.

7. i) First attempt-Secondary Education Commission (1953)
- General science to be made a compulsory subject in school education.
- Diversification of science courses as optional channel at higher secondary level.
- Uniform system of Secondary Education for the entire country. (Suggested in Seminar on Teaching of Science in secondary school held in Tara Devi 1956).

ii) Indian Parliamentary and Scientific Committee set up in 1961
- took up a study of 'Science Education in Schools' in 1962.
- DESM in NCERT undertook the responsibility of development of science and mathematics curriculum at Secondary level.
- UNESCO Team visited Indian Schools and suggested Experimentation and Inquiry based teaching method to improve science education.

iii) Kothari Commission
- Science and Maths should be taught or compulsory basic during first 10 years of schooling.
- In primary classes science teaching should be related to child's environment.
- In upper primary level emphasis should be on acquisition of knowledge.
- At lower Sec. level science should be developed as discipline of mind.

- Curriculum for the Ten Year School — A Framework, published by NCERT.

Features
- Science as Environmental Studies at primary stage.
- Integrated Course at middle stage.

v) Ishwar Bhai Patel Committee review it in 1977.

1.9  SUGGESTED READINGS

Thurber & Cullette; *Teaching Science in Today's Secondary School*.
NCERT: *Instructional Objectives of School Subjects*.
NCERT: Education Commission (1964-66); Educational Development — Govt. of India.