Physical Science
Nature and Scope of Science - Unit I
Code No:BEDN126
Hand outs

Meaning and Structure of Science

Science is a cumulative and endless series of empirical observations which result in the formation of conc4epts and theories, with both concepts and theories being subject to modification in the light of further empirical observations. Science is both a body of knowledge and the process of acquiring it.

Definition

The term 'science' is derived from Latin Verb 'Scire' meaning 'to know' and Latin noun 'Scientia', meaning 'knowledge' commonly speaking, 'Science is a systematized body of knowledge'.

Science is an accumulated and systematized learning in general usage restricted to natural phenomenon. - Columbia dictionary.

Science is a way of looking at the world. - Nash. [chemist]

A store house of knowledge of natural phenomena -Wigner [physist]

An organised common sense - T H Huxley [biologist]

Knowledge of the natural world obtained by sense interaction with that world. - Bube

Science can be best described by as, "Science is an accumulated and systematized learning in general usage restricted to natural phenomenon. The progress of science is marked not only by an accumulation of fact, but by the emergence of Scientific Method and of the Scientific Attitude".

– Columbia dictionary.

Structure of Science

Components of Science

Universe	**Methods of Inquiry**	**Knowledge**
Earth,	Observation	Concepts
Surface, Atmosphere,	Experimenting	Generalizations
Plants, Animals,	Thinking	Principles
Energy,	Investigating	Explanations
Stars, Planets,	Searching	Conclusions
Atoms,	Calculating	Laws, Facts
Others	Others	Others

The structure of science is built in two parts

a) Substantive structure – it represents major conceptual schemes which constitutes the basic knowledge used in science, which includes: definitions, knowledge, statements, observation statements etc.
b) Syntactic structure – it is concerned with process of inquiry i.e. by which the scientific knowledge is acquired and verified methods through which the new knowledge is developed.

Substantive Structure

It consists of interrelated collections of powerful ideas. These ideas help scientists in research.

Body of knowledge

Empirical Knowledge	Theoretical knowledge
1. Direct Observation statements. **2.** Instrumental Observation Statement **3.** Facts	1. Vocabulary 2. Concepts 3. Principles 4. Theories 5. Generalizations 6. Laws 7. Hypothesis

Syntactic Structure of Science

Syntactic structure describes the pathway of inquiry scientists' use, what they mean by verified knowledge and how they go about this verification. It is concerned with issues such as the ways in which new substantive structure concepts are formed and the ways in which different kinds of knowledge statements generated by the discipline may be validated. It is related to the modes of thinking and reasoning and is called scientific inquiry.

Scientific Inquiry

Methods	**Processes**	**Attitudes**
Scientific method Emperical testing Controlled experiments Reasoning inductive-deductive	**A. Basic Skills** ▪ Observing ▪ Classifying ▪ Quantifying ▪ Measuring ▪ Using space-time relationships ▪ Communicating ▪ Predicting	a. Scepticism b. Faith in the possibility of solving problems c. Desire for experimental experimentation d. Precision e. A liking for new

	▪ Inferring B. **Integrated Skills** ▪ Defining operationally ▪ Hypothesisning ▪ Interpreting data ▪ Controlling variables ▪ Experimenting	things f. Willingness to change opinions g. Humility h. Loyalty to truth i. An objective attitude j. Liking for scientific attitudes k. Respect for quantification l. Acceptance of probabilityes m. Acceptance of warranted generalisations

Scientific Inquiry

Inquiry begins with stimuli that are contrary to expectations. John 1976 classifies inquiry as a broad range of activities performed to explore and search out variables and attributes relevant to discrepant stimuli. He categorises the events that invoke inquiry as:

- Curious events or observations that cannot be explained by habitual responses.
- Data gaps or failure to find observations that have been predicted by a theory or law.
- Chance observations or events that are recognized by the inquisitive mind that tries to find a rational reasoning for the observations.

A. Methods of Scientific Inquiry

Scientific Method

Steps in scientific method are as follows

a. Sensing the problem
b. Defining the problem
c. Analyzing the problem
d. Collecting of data's
e. Interpreting the data
f. Formulation of tentative solution-hypothesis- to the problem
g. Selecting and testing the most likely hypothesis
h. Drawing conclusions and framing principles and generalizations
i. Application of generalization to new solution

Empirical Testing

Scientists are interested in relentless testing of data. They try to find answers to know about a phenomena or event or discovery. This they do through observations and record data without

errors etc. Unless one's data is replicated by anyone it cannot be considered to be scientifically trustworthy. This process of observation and verification is called empirical testing.

Controlled Experiments

In controlled experiment all the factors but one are controlled. I.e. controlled experimental method is based upon the law of single variable. The method establishes a systematic and logical association between manipulated factors and observed effects. Experimental method comprises of control, manipulation, observation and replication.

Reasoning (Inductive – Deductive)

Inductive reasoning is weighing of probabilities, in discarding details deemed to be irrelevant in devising general rules according to which events occur, and in testing hypothesis by devising suitable experiments.

Deductive reasoning is deduction of the special events which, under certain circumstances, would happen in obedience to the assumed laws of nature. Thus when laws are discovered or assumed their utilization depends entirely on deductive reasoning.

B. Process of Science

The major items in the process of science as advocated by the national science teachers association, Washington are as follows:

1. Science proceeds on the assumption, based on centuries of experience, that the universe is not capricious.
2. Science knowledge is based on observation of samples of matter that are accessible to public investigation in contrast to purely private inspection.
3. Science proceeds in parts even though it also aims at achieving a systematic and comprehensive understanding of various sectors or aspects of nature.
4. Science is not, and probably never will be a finished enterprise, and there remains very much more to be discovered about how things in the universe behave and how they are interrelated.
5. Measurement in as important feature of most branches of modern science because the formation as well as the establishment of laws are facilitated through the development of quantitative distinctions.

C. Attitudes of Inquiry

- Scepticism: Not taking things for granted.
- Humility: Scientist accepts truth when it is proved beyond doubt and accepts facts with understanding.
- Desire for scientific explanation: They analyze things based on already conformed norms and standards.
- Desire for completeness of knowledge: Scientist try to improve their knowledge of a subject to fit every piece into its place like a jib-saw puzzle. They find great pleasure in accomplishing tasks. This constantly motivates them to gain knowledge.

- Suspended Judgement: scientist tries hard not to form an opinion on a given time until he has investigated it, because it is so hard to give up opinions already formed and they tend to make us find the facts that support the opinion.
- Respect for Theoretical Structure: Theories are formed based on intense observation and by following strict scientific norms. When new theories are developed, old ones are modified to accommodate new theory.
- Respect for quantification: this forms the basis through which science has grown to this level. Researched materials are properly quantified and sequentially arranged for betterment of all.
- Acceptance of warranted generalizations: General statements about classes of phenomena are the goals of science not statements about particulars and that such general statements based on research are necessary to enable the mind to grapple with the complexity of experience.

Facts

Definition

Science is built of facts as a house is built of stones; but an accumulation of facts is no more a science than a heap of stones - Henri Poincare

Fact is something known to be true or accepted as true

- Oxford Advanced Learner's Dictionary

Facts can be usually defined as something that is known to exist or happen, the existence or happening of which is supported through some source.

Functions of facts: Good and Hatt have enumerated the functions of facts as

- Facts initiate theory.
- Facts modify existing theory.
- Scientific facts are open to various interpretation.

Concepts

Concepts are nothing but the generalized ideas of notions formed by us towards an object, person or event. They are the critical components of an individual's cognitive structure.

Definition

The concept may be termed as idea underlying a class of things.

- Oxford Advanced Learner's Dictionary

The concepts are systems of classifying informationand are generalized ideas. Concepts emerge through process of science. Thus, concepts and process as are inter-related and inter-dependent.

- NCERT

Characteristics of Concepts

- Acquisition of Knowledge: Concepts are formed through varied experiences, including the acquisition of factual knowledge and activities.
- Generalised Ideas: Concepts are generalized ideas suggested to the individual by objects and symbols.
- Complete Ideas: As children grow up, ideas become more and more complete.
- From Simple to Complex: concepts may be either simple or complex.
- Learning by Activites: Concepts learning is facilitated by learning through activity in a variety of situations and in a variety of contexts.
- Abstraction to Classify Words: A concept is an abstraction to classify words, ideas, and feelings, which have certain common qualities.

Hypothesis

A hypothesis is a statement temporarily accepted as true in the light of what is at the time, known about a phenomenon and employed as a basis for action in the search for new truth. It is a tentative assumption drawn from knowledge and theory which is used as a guide in the investigation of facts and themes that are yet unknown.

Definition

It is a shrewd and intelligent guess, a inference, provisional statement or generalization as to the existence of some fact, condition or relationship relative to some phenomena which serves to explain already known facts in given area of knowledge and guides the search for new truth on the basis of empirical evidence.

Importance of Hypothesis

- A hypothesis provides direction in the search of solution to problems stated and chosen and helps in chanellising the efforts of the research.
- It sensitizes the investigator to certain aspects of situation, which are relevant from the standpoint of the problem at hand.
- It acts as a guide to the thinking process and the process of discovery.
- It places clear and specific goals before the researcher. It serves as a basis for the investigator to select samples and procedures to attain the goals.
- It serves the function of linking together related facts and information and organizing them into one comprehensible whole.
- It serves as a framework for drawing conclusions.

Different forms of Hypothesis

1) *Null form*: It states that no significant difference exist between the variables concerned.
E.g. there exist no significant difference between men and women in their attitude towards working.
2) *Prediction form*: It is stated in the form of a principle which the investigator expects to emerge out from his search investigation or experiment. This form will be useful in action research.

E.g. Black board technique is best suited to teach a unit on geometry.

3) *Declarative form*: It generally states a relationship between variables concerned.

E.g. There will be a significant difference in the peer relations of private school students and government school students.

4) *Question form:* The hypothesis is in the form of a question.

E.g. Is there any relation between achievement and self-concept of high school students?

Theory

Theory is a tool of science in many ways

Definition

A theory is a set of interrelated concepts, definitions and present a systematic view of phenomena by specifying relations among variables with the purpose of explaining and predicting the phenomena. - Kerlinger

Theory refers to the relationship between facts or to the ordering of them in some meaningful way. - Good and Hatt

A theory specifies the relationship between events for the purpose of explaining the occurance of the events and predicting future events.

- Matheson

When a scientist endeavours to fit the available broad interrelations and general principles into orderly, logically constructed systems, such as system is called a theory.

- Groot

Characteristic of a theory

1) Theories relate two or more findings.
2) It explain scientific findings in an efficient way.
3) It predict a wide range of experimental findings.
4) It helps in broadening original ideas by suggesting additional applications.
5) Theories sometimes cannot be completely verified. E.g. the Big-Bang theory of universe.
6) Theories are formulated by creative scientists to explain certain phenomena.

Characteristics of a good theory

George J. Mouley has given the following list of characteristics of a good theory:

I. Theory is based on facts.
II. Theory should be precise and clear.
III. Theory must be grounded in empirical data.
IV. Interpretation and verification.
V. Law of parsimony (that theory is best which explains the most in simplest form).
VI. Meaningful structure.
VII. Applicability.

Experiments

This is the highest order process. It is developed through a continuation of the sequence for controlling variables and includes the interpretation of accounts of scientific experiments as well as the activities of understanding problems, constructing hypotheses and carrying out experimental procedures. This process encompasses most of the other processes.

Inference

Inference gives the meaning for a work done. It is generally in the form of a paragraph or line. Technical data are interpreted for easy understanding of all parties required. It is given as a summary of the entire process which will help in further understanding of the situation or event.

Laws

Confirmed and verified thoughts are described as scientific laws.

Definition

A scientific law may be defined as a factual statement of what always happens in certain circumstances. - Oxford Advanced Learner's Dictionary

A scientific law is a general statement that purports to describe some general facts, or regularity of the universe. - Encyclopedia Americana

A verified generalization is considered a scientific law
- Encyclopedia Colombia

Characteristics of scientific laws

- Scientific laws are often explained lay deduction from laws of broader scope.
- Although scientific laws are based on observational evidence, they go beyond that evidence.
- Scientific laws are descriptive in nature.

Principles

Principles are formed when generalizations, based on many direct observations and repeatable demonstrations, are made. Principles differ from concepts in that principles state some kind of relationship between two or more concepts, objects or events. Principles have concepts integrated in them.

Characteristics of Principle are:

1. The principle is a statement of relationship.

2. Frequently casual in nature between two or more facts. Principle is formed on the basis of reasoning or action.
3. Principle usually has some significant application.
4. Principle should always be a fact.
5. Principle should be illustrated.
6. Principle is not a definition.

Scope and importance of Science

Science is one of those human activities that man has created to gratify certain human needs and desires and curiosity has been the greatest motive power of scientific research. The search of truth became the dominant motive in the prosecution of science.

In the early days of twentieth century, science subject was considered meant for less promising students, the more promising students were encouraged to study the Classics and Mathematics as being more worthy and suitable subjects. Now science has been on its rightful place as a compulsory subject form elementary stage and one of the core subjects at higher secondary stage. Science takes its place side by side with other subjects as an essential element of one's education. It affords knowledge of certain facts and laws and an insight into methods and data peculiar to the domain of science. However the inclusion of any subject in the curriculum should satisfy the intellectual, utilitarian, vocational, cultural, moral, and aesthetic values. Besides these, the teaching of science imparts training in the 'scientific method' and develops 'scientific attitude', which are very valuable and at the same time are transferable to other situations in life.

The rapid advancement of science and technology and increasing need for scientists and technologists have made it all the more important to provide for science based education in the schools. The secondary education commission has recommended that every secondary school pupil should study general science as a compulsory subject, so that he gains a basic quantum of scientific knowledge as a part of his general education. In addition provision should be made for providing elective subjects in science for those students who want to pursue higher study.

Kothari commission lays great emphasis on making science an important element in the school curriculum. It has also recommended that science and mathematics should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling.

Impacts of science and technology on society

Science and technology must become essential components in any educational enterprise; they must be incorporated into all educational activity intended for students and adults.
The goal of education is all round development of the individual. Intellectual development is an equally important factor. Science has become increasingly important part of general knowledge. Scientific education is best fostered as a part of a general emphasis on intellectual activity. Science has become a compulsory subject in the school curriculum because of its multifarious value to the individual as well as the society.

Intellectual value

Science has introduced us to new ways of thinking and reasoning. It has made person to be more independent in his thinking and execute things in his own wish and will. It has given the freedom and confidence to analyze and express one's individuality. Science gratify our intellectual universe we live in and helps us to gain insight of ourselves and the things around us. It sharpens our intellect and makes us intellectually honest, critical in observation and reasoning. It teaches to arrive at conclusions without any emotional bias or prejudice.

Utilitarian value

This is the age of information and technology. Science has become part of every one in this world as one cannot think of living without its influence. As days pass by our dependence on science has increased. Elementary knowledge of science is needed at least for becoming a useful member of the community. To raise the standard of living in any country, two things are needed-scientific knowledge, and a population sufficiently educated to understand how to apply it to everyday.

Vocational Value

Science has many streams and each stream is considered as a separate vocation. E.g. Engineering, medical.

Cultural value

Science has played an important role in determining the culture and civilization of a country from time to time. Science is multifarious. It has a direct influence in dispelling many traditional beliefs, and the adoption of scientific methods.

Moral value

Moral values talks about goodness, beauty, and truth. Science helps individuals to overcome superstitions, false thoughts and also disciplines him to be a civilized citizen.

Aesthetic value

It is one of the deepest needs of human nature which manifests itself as the desire for beauty. For a scientist it is the aesthetic aspect that the whole charm of science lies. Scientist feel an intrinsic charm in revealing the harmony of nature. The search of universal laws and comprehensive theories is undoubtedly the manifestation of the aesthetic motive is very apparent and many of them have written about their work in a sort of prose, poetry and the satisfaction they get form it seems indistinguishable from those of an artist. Aesthetic value give a sense of satisfaction and love for the work and takes great pride in accomplishment.

Aims and values of Teaching Science

Science is taught in secondary schools today because of the recognized need for general scientific literacy, our dependence upon scientists and engineers and the value that we place on critical thought. In general aim is a declaration of intent which gives direction to a teaching programme. Hence aims in teaching science are as follows:

1. Towards understanding the nature of science.
    - develop basic knowledge of the nature of the scientific enterprise
    - increase the mathematical and observational skills.
    - Develop an understanding related to the interrelations of science and society

- Increased understanding of the concepts and theories which describe and unify the fields of science.

2. Meeting the goals of general education
   The purpose of general education is to provide experiences through which young people can acquire knowledge, skills and attitudes that lead to patterns of behaviour that are acceptable to the society in which they live.
3. Help young people fit themselves into their society.
4. Maintaining physical health and well being.
5. Helping pupils with personal adjustment.
6. Provide training for development of attitudes and values.
7. Giving pupils exploratory experiences.
8. Provide opportunities to develop vocational and avocational interests

These are some of the basic aims of teaching science in school.

Unit II

THE HISTORY OF SCIENCE
Origin and Development of Science
A brief Introduction to Oriental and Western Science
A Brief Introduction to Aristotian, Newtonian and Einsteinium Paradigms of Science.
Seminar: Aryabhatta & Bhaskara.
Seminar: C V Raman & Subramanian Chandra Sekhar.
Seminar: Galileo, Lavoiser & Copernicus.
Seminar: Neil Bohr, Dalton & Faraday.
Seminar: Maxwell, De-broglie & Paul Direc.

Western Science

Greeks
- were interested in Science and Technology.
- adopted, expanded and refined basic mathematical principles.
- Archimedas wrote the science of mechanics.
- Golden Age 600 B C.
- Geometry & Physics in architecture.
- Astronomy, planetary motion.
- Laid the foundation of western science.
- Mining, preparation, & cupellation of silver ore.
- Use of lever to move large stones.

Egyptians
- Agricultural tool (rakes, sickles & ploughs using wood and stone).
- Used animal labour (pigs -& sheep to trample ground and soften it up)
- (donkeys to trample harvested stalks and separate grains)
- *Greatest Achievement* – building dikes and irrigation ditches to manage flooding of the Nile.

Medieval Period (from AD to 19th Century)

Maya
- Remembered for being advanced mathematics and astronomy.
- Use of pictographic symbols.

- Use of zero letter.

Incas
- Continued in their innovation in using science (15th century).
- Practicing medicine, even brain surgery.
- Skillfully constructed bridges, tunnels, terraces and building.

Chinese
- First book printed using wood block technique in 868 AD.
- Paper invented during 'Han' period.
- Build imperial city.
- Under 'Ming' rule scholarship (academic) flourished and an enormous encyclopedia of 11,000 volumes was compiled.

Raman – Semi-independent princes helped to develop scholarly movement.
- Intellectual activity flourished as scholarship movement was encouraged.
- Noticeable, Anselm of Canlebury & Abelard of Paris contributed to development of universities through which students learn – grammar, logic, rhetoric, medicine & theology.

Renaissance
- (1450 AD) Invention of printing press (movable).
- Other inventions – cast-iron, pipe, portable clock, rifle barrel, shot gun, screw driver & wrench.
- Nicolaus Copernicus, keenly observed and said with surety that the sun appeared to be at rest.
- Trial-blazing expeditions were undertaken to explore the planet.
- Christopher Colombus - August 3, 1492, with three ships namely Nina, Pinta and Santa Maria, set sailing from Spain. He was the first naviagator to sail across Atlantic Ocean and reach America.

Elizabeth era
- World exploration, study of universe, medicine.
- Sir Francis Drake, First English man to sail around the world (1577). [England – south America – North America – Indian Ocean to Africa coast – England (3 years traveling 36,000 miles)].
- Advancement in medical science. (study of human anatonomy.
- Development in dissection and surgerical operations.
- Invention of graphite pencil, modern calendar, time bomb, wind power, saw mills and thermo-scope (primitive thermometer).
- Galileo discovered natural laws (e.g. uniform accelerated motion, gravity & oscillation, pendulum, inclined plane & projectiles.
- Galileo also invented microscope and telescope. He used his telescope and observed the planets.
- Kepler later studied astronomy and developed laws of planatory motion in 1609.
- Mathematicans Pascal, Newton etc. developed geometry, probability and integral calculus.
- Syringe, slide rule, barometer, wind gauge, pressure cooker, turning fork, steam engine, electromagnet, and discovery of lithium, cadmium, selenium, aluminum, thorium, and vanadium.
- In 1714, Fahrenheit invented mercury thermometer.
- In 1742, Anders Celsius invented Centigrade thermometer.

- Development of vaccine for small pox, cure of scurvy, invention of cotton gin, refracting telescope, telegraph, hydraulic press, stethoscope, galvanometer, fire extinguisher, submarine, helicopter and steam boat.
- Laws like faradays law, ohms law, wheat-stone network were developed.

By the dawn of Regency period, industrial revolution already begun to dramatically transform western civilization. Train was used as a major transport during this period.

Victorian Era
- Tremendous surge in technological inventions happened during this period.
- Victorians believed in progress and viewed with optimism about their industrial revolution.
- Steam boats were used for trade as never before & rail roads connected north and south east and west of USA.
- Thomas Edison invented electric light bulb Phonograph and improved inventions like telegraph, telephone, motion picture projector.
- In 1852, Elisha Graves Otis invented first safety elevator.
- In 1890 Henry Ford developed internal combustion engine.
- Bicycle was invented in the Victorian era, a symbol of freedom for both men and women.

Oriental Science

In ancient days technological discoveries took place without any knowledge of the underlying scientific principles, through hit and trial and by experience. The focuses of these methods were governed by utilitarian values and not why and how things happen.

In India, earliest application of chemistry took place in the content of medicine, metallurgy, construction technology (cement and paints) and textile production & dyeing. By undertaking these processes slowly one started thinking about the process so as to improve on it.

Natural phenomenons were studied in the context of tides, rainfall, appearance of the sun, moon & stellar formations, changes in season, weather patterns and agriculture. (Vedic literature talks about condensation of water vapour from seas due to evaporation caused by sun's heat & subsequent formation of clouds & rain).

- Religious beliefs particularly religious taboos and irrational indoctorine often pose a serious impediments to the advancement of science especially in finding answers to why, where and how questions.
- Societies which believed in 'God' knows the secrets of nature were not able to substantially justify. In certain cases the influence of priest could serve as an obstacle to scientific progress
- Ancient India generally did not suffer from religious opposition to science, but did suffer due to proliferation of rituals and superstitions. The progress of science was linked to challenges to the domination of the priests and resistances to the proliferation of rituals and sacrifices. Hence the advancement of science and technology came in parallel with advancement of rational philosophy in India.

Ancient India there were attempts to record physical properties of different types of plants, natural substances, summarizing and classifying the observations made about natural phenomena, these were never crucial to humanity reaching it's present stage of knowledge in fields of physic, chemistry, botany, biology and other physical sciences.

- In the medical field, Indian medical texts had postulated that proper human digestion and the successful absorption of medical pills and potions also required the presence of 'catalytic' substances. The requirement of catalytic substances relating to the manufacture of acids and alkalis had also been documented.
- During the first century AD when Susruta posited that it was light arriving from an external source at the retina that illuminated the world around us.
- Cakrapani suggested that both sound and light traveled in waves, but that light traveled at a much higher speed.
- Mimamsakas imagined light to comprise of minute particles in constant motion and spreading through radiation and diffusion from the original source.
- Prastapada hypothesized that sound was borne by air in increasing circles similar to ripples in water.
- Musical theory was elaborated on the basis of concepts such as
- In 6^{th} C, Varahamihira described reflection of light particles by scattering as rasmipravartana, Uddyotakara talks about reflraction of light.
- Aryabhata (5^{th} – 6^{th} C) made a pioneering discovery in the realm of planetary motion.
- Yalivrasabha's work Tiloyapannatti 6^{th} C gives various units for measuring distance and time and also describes a system of infinite time.
- The study of astronomy led to great interest in quantifying very large and small units of time and space. Solar day was considered to be made up of 1,944,000 ksana (units of time) according to the Nyaya-Vaisesikas. Each ksana thus corresponds to 0.044 seconds. Truti was defined as the smallest unit of time 2.9623X10^-4.
- Silpasastra records the smallest measure of length as the paramanu i.e. 1/344525 of an inch.
- In 7^{th} C, Prasastapada, in addition to linear motion talks about curvilinear motion (gamana), rotatory motion (bhramana) and vibratory motion. He also differentiated motion due to external action and motion due to gravity or fluidity.
- In 10^{th} C Sridhara reiterated what had been observed by Prasastapada and expanded on what he had documented. He also talks about elasticity, opposite motion etc.
- Bhaskaracharya 12^{th} C, took a crucial first step in quantification and measured average velocity (v)= Distance covered (s) / Time (t).
- Prasastapada's work and Sridhara were considered quite significant at that time. However, later Indian treatises was a failure to follow up with further attempts at quantification and conceptual elaboration.
- Magnetism is referred to by Bhoja (10^{th} – 11^{th} C) as well as by Shankara Misra later. Udayana 10^{th} C recognized solar heat as the heat-source of all chemical

changes, and also that air had weight in a discussion of balloons in his kiranawali.

- Sankara Misra (15^{th} 16^{th} C) talks about electrostatic attraction (magnetism – as he saw grass & straw attracted by amber). He also talks about kinetic energy and has also dealt on properties of heat and tried to relate to process of boiling to evaporation. He also gave e.g. of capillary motion citing the ascent of sap froom root to stem in a plant and the ability of liquid to penetrate porous vessels.
- Later during 15^{th} – 16^{th} C several factors posed as hindrance to the development of modern science. The Mugal rulers spent time of their treasures on cultivating fine arts and promoting manufacture of decorative objects of exquisite beauty. Science and technology simply attracted little attention (except on improving tools of war). The growing influence of religion whether Quranic or Brahminical also had its negative effects.
- While quran claimed that all the world's knowledge was already desrribed in it, Brahminical orthodoxy prevented scientist from going beyond passive observation and intuition to practical experimentation, active theorizing and quantification. But, Akbar and Jehangir took active interest in books on botany and zoology, Aurangzeb was skeptical towards science.

European scientists drew on the best works produced in the East and developed their own methods and went ahead. In this context when the British came to India their influence was predominant, slowly science and technology gained more importance and is catching up with many of the western world. To summarise, though science and technology of the ancient India was not realized fully, their works need to be appreciated. India is fast catching up with the west in developing science and technology and our scientific past has motivated us to reach this level.

Aryabhatta

- Born in 476AD in Kusunapura (Patna), died in 550AD.
- Kusumapura was one of the two major mathematical centers in India other being Ujjain.
- Pataliputra being the capital of Gupta empire at the time of Aryabhatta was the center of communication network which allowed learning of other parts of the world reach the place easily.
- Aryabhatiya which is a astronomical treatise written in 118 verse giving a summary of Hindu mathematics upto that time. Its mathematical section contains 33 verses giving 66 mathematical rules without proof.
- Aryabhatiya contains an introduction of 10 verse followed by a section on mathematics and planetary models with the final section of 50 verses being on the sphere and eclipse.
- Mathematical part of Aryabhatiya covers arithmetic algebra, plane trigonometry, and spherical trigonometry. It also contains fractions, quadratic equations, sums of power series and a table of sines.
- He invented the system for representing numbers and used it in the Aryabhatiya, giving numerical values to the 33 consonants of Indian alphabets.
- He wrote pie's accurate approximation.

- He gave a systematic treatment of the position of the planets in space.
- He said moon & planets are moving in ellipitical orbits and shine by reflected sunlight.
- His value for length of the year was 365 days, 6hours, 12 minutes & 30 seconds.

Antoine Lavoisier, **Chemist**

- **Born:** 26 August 1743
- **Birthplace:** Paris, France
- **Died:** 8 May 1794 (beheading)
- His **wife,** Marie-Anne Pierrette Paulze
- **Best Known As:** French chemist who proved the law of conservation of mass
- **Occupation:** chemist, economist and nobleman.

- A Parisian aristocrat, Lavoisier studied law but went into science. He was the first to announce that air was made up of two gases -- oxygen and what he called azote (now called nitrogen).
- Son of an attorney at the Parlement of Paris
- Lavoisier entered the school of law, where he received a bachelor's degree in 1763.
- In 1766 he was awarded a gold medal by the King for an essay on the problems of urban street lighting.
- Oxygen Theory of Combustion
- The relationship between combustion and respiration had long been recognized from the essential role which air played in both processes.
- He also demonstrated that water is not an element by separating it into hydrogen and oxygen and then reversing the process. During the "crucial year," 1772–1773, he identified oxygen (and hydrogen) as elements.
- He was tireless in establishing a Bureau of Weights and Measures and the adoption of the metric system.

Louis Victor Pierre Raymond duc de Broglie

Born:15 Aug 1892 in Dieppe, France
Died: 19 March 1987 in Paris, France
At this stage he did not envisage a career in science, but was interested in taking literary studies at university. He entered the Sorbonne in Paris taking a course in history, intending to make for himself a career in the diplomatic service. At the age of 18 he graduated with an arts degree but he was already becoming interested in mathematics and physics.
In 1913 de Broglie was awarded his Licence ès Sciences

Taking up research in mathematical physics, de Broglie nevertheless maintained an interest in experimental physics. His brother Maurice de Broglie was at that time carrying out experimental work on X-rays and this proved a considerable interest to de Broglie during the first few years of the 1920s during which he worked for his doctorate. De Broglie's doctoral thesis Researches on the quantum theory of 1924 put forward this theory of electron waves, based on the work of Einstein and Planck. It proposed the theory for which he is best known, namely the particle-wave duality theory that matter has the properties of both particles and waves.

In a lecture de Broglie gave on the occasion when he received the Nobel Prize in 1929 he explained the background to the ideas contained in his doctoral thesis
In 1933 de Broglie was elected to the Académie des Sciences becoming Permanent Secretary for the mathematical sciences in 1942

Baskara Charya
Born : 1114 A D in Vijayapura, India
Died : 1185 A D in Ujjain, India

Aristotle
Born : 384 B C in Stagirus, Macedonia, Greece
Died : 322 B C in Chalcis, Euboea, Greece.

Unit III

NG SCIENCE
Science process skills, & Psychological basis of science
gical basis of science
Science process skills
Inductive Vs Deductive Methods
Concept Development in Science.
Learning difficulties in Physical Sciences.

Science process skills
Science is best described by the following two statements

1. It involves methods of inquiry or processes of science
2. Inquiry results in a body of systematized knowledge or content or concepts.

The first part of science called the process plays an important role in the growth of science.

Science processes
Observing

- Involves using five senses to obtain information
- It provides basic and new inferences
- Scientists develop explanations using observation
- Helps us to identify observable properties of objects that include weight, size, shape, colour, temperature, and ability to react with other substances

Classifying

- Involves imposing order on corrections of objects or events. Eg. Metals, acids, covalent etc.
- Classification schemes to identify objects or events to show similarities, differences and interrelationships.

Quantifying (using numbers)

- Begins with identifying sets and their members and progresses through ordering, counting, adding, multiplying, dividing, finding average, using decimal and powers of ten.

Measuring

- Using measuring instruments, using standard measurements; using mathematical operations etc.
- Carrying out calculations, and manipulations.

Using space-time relationships

- Identification of shapes movements and direction.
- Learning of rules applicable to straight line and curved paths, direction at an angle, change in position with time.

Communicating

- Scientist use various forms of communication like the oral and written word, diagrams, maps, graphs, mathematical equations and different kinds of visual demonstrations.
- Students have to learn to communicate scientific ideas and principles as universally accepted (using appropriate terminology/symbol/equation etc).
- Sharing the information in appropriate forum.

Predicting

- Using knowledge to identify and explain observations or changes in advance. Use of mathematics allows for greater or lesser certainty of predictions.
- Predicting includes testing the reliability of predictions and predicting behaviour based on collected data and graphs.

Inferring

- It involves explaining observations.
- Scientists cultivate the ability to make at least one and frequently more than one carefully thought out inferences to explain an observation or set of observations.

INTEGRATED SKILLS

This means involving more than one skill at a time to attain the target. The following are some of integrated skills:

- Defining operationally
- Hypothesizing
- Interpreting
- Controlling variables
- Experimenting

Psychological Basis of Science Learning with Special Reference to Selected Learning Theories

Piaget's stages of intellectual growth

Piaget revolutionized thinking and understanding about the intellectual growth of children. According to him child goes through a series of developmental stages. However understanding intellectual development as suggested by Piaget can help us design the science curriculum and teaching accordingly

- Cognitive development arises as a result of interaction between the individual and the world and passes through a series of sequential stages.
- To know an object one must act upon it either physically or mentally.
- People have cognitive structures called schemata for processing information and these undergo significant transformations during development.
- Piaget speaks of four important stages of cognitive development.
  Sensory motor stage (0 – 2 years)
    - Immediate experience through the senses.
    - It is pre verbal
    - Object exist only within perceptual field of the child (hidden objects are forgotten are found randomly).
    - Development of rudimentary memory
    - Gradual progression from reflex behaviour to intentional behaviour.

Develops practical intelligence like sucking, seeing, grasping etc.

Pre-operational stage (2 – 7 years)

- Learning through trial and error corrections.
- Lacks ability to coordinate variables, has difficulty in realizing objects have several properties.
- Concept of conservation are not developed, the child lacks operational reversibility in thought.
- Ego-centrism(use of words with unique meaning); animism(treating inanimate objects as living ones); realism(dreams are considered real eg. children driving scooter); centring(can concentrate on one aspect at a time)
- Thinking is concrete and rigid but can follow elementary logical operations.
- Inability to understand and follow rules.

Concrete operational stage (7 – 11 years)

- Develops concepts of conservation (numbers, substances of length, of area, weight etc)
- He can perform a mental representation of a series of acts (i.e. think sequentially in the mind as what had happened yesterday in the function etc.).
- Concept of reversibility and transferability develops.
- Evaluate crime in terms of magnitude and not on motive.
- Can't visualize others point of view as thinking is quite rigid even at this stage.

Formal operational stage (11 years and above)

- Starts evaluating crime in terms of motives.
- Understands rules and manipulates rules as per his requirements.
- Able to comprehend logics as age progresses.
- Development of the ability to perform controlled experimentations.
- Starts believing that there could be many points of view on any problem.

Contribution to education

- Emphasis on discovery learning.
- Curriculum should provide specific educational experience based on childrens developmental level
- Arrange classroom activities to assist and encourage self-learning.
- Co-curricular and extracurricular activities have equal importance.
- Fruitless pushing beyond child's cognitive ability is meaningless.
- Moral and intellectual growth go together only after the age of 11 years.
- Activity approach (concrete) at the primary level and abstract learning at higher levels only.

Ausubel's Theory Of Cognitive Subsumption (include/ under a rule)

- Proposed meaningful verbal learning is based on concept of cognitive subsumption (learning is acquired by relating to existing knowledge).
- Prior learning is the most significant factor in determining the effectiveness of new learning.
- Cognitive structure can be conceived as a hierarchical framework with highly general principles and concepts at the top subsuming more concrete and specific kinds of knowledge at lower levels.
- Teachers role is to facilitate acquisition of stable generalized and inclusive set of abstractions to facilitate later acquisition of specifics. (eg. Abstractions like - Numbers, symbols, etc. are internalized, only then new learning can be meaningfully built above it.)
- Concept of advance organizer: it is a generalized statement presented prior to presentation of specific facts relevant to the statement. In other words it is an introductory statement which attempts to establish an overview of the main concepts which is to be dealt for teaching on that period.
- Teacher should carefully consider prior learning of the students and relate the advance organizer to that learning by citing similarities and differences between the new concepts and already learned ones.
- Advance organizer serves two purposes
    1. enhances meaningfulness of reception learning by subsuming concepts to which new ideas can be related.
    2. strengthens retention by providing a clearly stated concepts and stable set of association of ideas.

Gagne's Model Of Sequential Learning

- Robert Gagne proposed a model of sequential learning which is particularly useful for organising lessons on principle learning and acquisition of problem solving skills.
- Teaching should be based on specific to general, concrete to abstract.
- All learning is not alike and proposed hierarchy of learning. Each learning, begins with a different capability for performance. The mastery attained in performance of one type becomes the pre-requisite for the next higher type of learning.

The following are the types of learning according to Gagne:

- Signal learning
- Stimulus response
- Chaining
- Verbal association
- Multiple discrimination
- Concept learning
- Rule learning
- Problem solving

Example: a is given Rs.500 and is asked to buy 10 kg of brinjal and 15 kg of carrot. With brinjal a kilo cost Rs.5 and carrot Rs.25, how much is spent and what is the balance?

Solution: Problem : Calculating
Rule : when to multiply and add etc.
Concept : multiply and divide, add and substract
Discrimination : what is to be bought, how much?
Verbal association: able to understand the sentence.
Chaining : able to read
Stimulus response : meaning of identify meaning of words and form words.
Signal learning : letters, symbols, numbers etc.

Bruner's model of concept learning

- According to Bruner concept learning involves use of certain strategies and hypothesis testing.
- Some people arrive at the correct solution in concept learning experiments by a kind of random selection.
- In general it is evident that individual use some sort of organized plan or selection strategy in learning the essential attributes that constitute a concept.
- Science should be taught as a comprehensive whole and not as parts as he belied parts have no meaning outside the whole.
- He created 81 cards with each card having 1 or 2 or 3 borders and the figures could be black, green or red.
- Bruner proposed four types of strategies can be adopted by individual in learning
  - *Conservation focusing* – individual concentrates one attribute at a time. eg shape / colour etc.
  - *Focus gambling* – focuses on two or more attributes at a time. Eg. Colour and shape.
  - *Simultaneous scanning* - The subject uses positive instance (each correctly identified card) to deduce which combinations of attribute values are no longer valid. The subject must keep in simultaneously all the rejected combinations in order to narrow down on correct (card)instance.
  - *Successive scanning* – subject makes overall estimate of each correct characteristic of the concept and tests each one by one. Here subject tests individual hypothesis about the correct characteristic one at a time in succession.

Inductive and Deductive approaches:

Inductive Approach:

Inductive approach is a method of teaching, which leads pupils from particular situations to generalizations. It proceeds from concrete to abstract principles. The solution and conclusions are drawn taking these concrete examples.

Steps in inductive approach:

1.Sense the problem.
2. Analysis the problem
3.Organize the information
4. Arrive at a suitable solution.
5.Verify the solution.

Use of Inductive method:

1. The teacher provides suitable examples having same concepts and concept rule.
2. The teacher, through questioning elicits the attributes and characteristics of the concepts.
3. The teacher shows examples & non-examples to students.
4.Students categorize the examples by explaining whether they fit (or) not in concept is discovering.

Merits:

1. Develops scientific attitude.
2. Develops skill of observation & critical thinking among students.
3. Develops self-confidence & self-dependence.
4. Makes classroom instructions interesting.
5. A logical method based on – " Learning by doing".

Demerits:

1. A slaw & lengthy method.
2. It is time consuming.
3. It cannot be applied to all the topic of science.
4. Insufficient data leads to hasty and wrong conclusion.
5. Conclusion needs to be verified by detective methods.

Deductive Approach:

A 'deductive approach' is used when a teaching material is very complex and cannot be illustrated. In this method is general to particular situation.

Steps in Detective approach:

1. Understanding the problem.
2. Collecting information.
3. Reviewing the principles and generalization.
4. Drawing conclusions.
5. Verifying the solutions.

Merits:

1. It is suitable for primary classes.
2. It provides a get ready material
3. It saves the time.
4. It simplifies teacher's work.

Demerits:

1. It is an unnatural method.
2. It does not impart any training in scientific methodology.
3. It does not develop thinking skill, self-confidence.
4. It only encourages memorization of facts.

Inductive Method	Deductive Method
• Based on inductive reasoning • Proceeds from Particular ⟶ General Concrete ⟶ Abstract • A psychological method • A method of discovery that stimulates intellectual powers. • Emphasis is on reasoning. • Encourages meaningful learning • Most suitable for initial stages of learning. • Suitable for lower classes. • Enhances active participation of the students. • Lengthy, time-consuming and laborious • Not absolutely conclusive, based on probability Facilitates discovery of rules and generalizations.	• Based on deductive reasoning. • Proceeds from General ⟶ Particular Abstract ⟶ Concrete • An unpsychological method. • A method of presentation that does not develop originality and creativity • Emphasis is on memory. • Encourages rote learning. • Suitable for practice and application • Most suitable for higher classes • Makes the student passive recipient of knowledge. • Short, concise and elegant • Makes the probability a certainty Enhances speed, skill and efficiency in solving problems.

Concept Development in Science.

- Known to unknown
- Simple to complex
- Concrete to abstract
- General to specific

Are some of the maxims of teaching and learning science.

<u>Learning Difficulties in Physical Science</u>

1. Experimental method: students have fear for doing practicals
2. Vast Subject content
3. Complex principles, equations, derivations which are abstract in nature, scientific terminologies etc.
4. Lack of infrastructure facilities like library, laboratory, etc.
5. Lack of facilities

Unit IV

OBJECTIVES OF TEACHING PHYSICAL SCIENCES
Meaning and importance of Objectives.

Bloom's Taxonomy of Educational Objectives.
Specific Objectives of Behavioral Objectives.
Critique on Bloom's Taxonomy.
Learning Experiences

Meaning

Carter V Good defines, objectives as "an end towards which a school sponsored activity is directed".
Radha Mohan defines an objective as a point or an end view of the possible achievement in terms of what a student is able to do when the whole educational system is directed towards educational aims.

Aims are like ideals and are long term goals, while objectives are ways and means of achieving the aims in a more practical and definite way.

Importance of objectives

The revolutionary developments in the field of science and technology in the 21st century have had a profound influence on the ultimate objectives of education also. Educational objectives talks about desired change in behaviour in a person. In addition

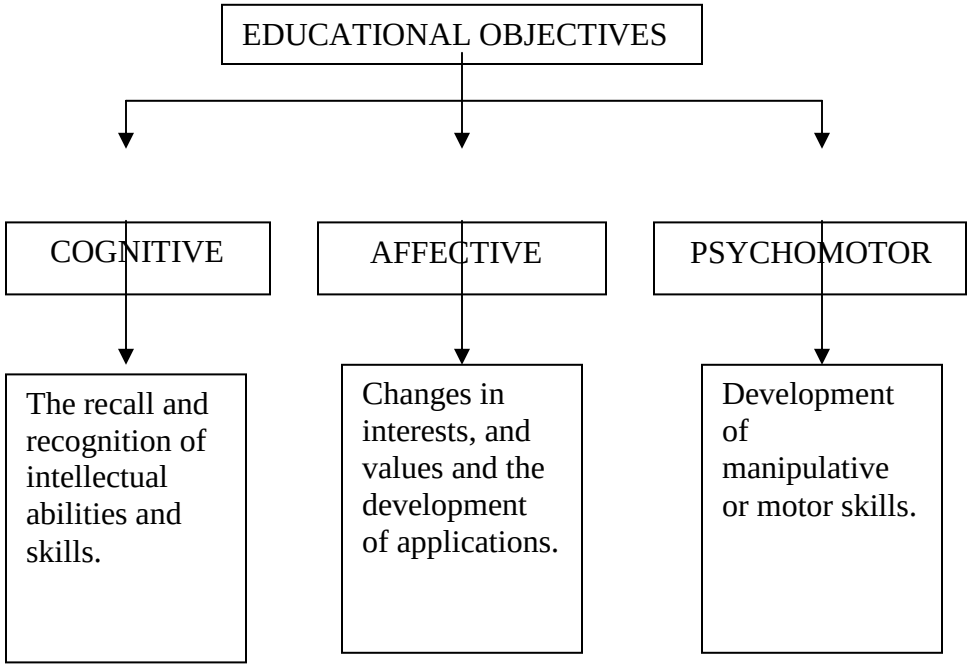
1. Physical science objectives are directed towards building of scientific precision, scientific attitudes and science process skills like measurement, observation etc.
2. Physical sciences can develop experiences which are child-centered.
3. It can train the child for vocation and useful pursuits.
4. It supplements the other subject in the all round development of the child.

Blooms Taxonomy of Educational Objectives
The idea of developing taxonomy was formed at an informal meeting of college examiners attending the 1948 American Psychological Convention in Boston. Following this a series of meetings were held till 1953 by the group of college examiners, whereby a three-fold division of educational objectives was developed : Cognitive, Affective and Psychomotor.

Purpose / Importance of Classification

1. To establish a common understanding about the hierarchical classification of objectives.
2. To establish the accuracy of communication regarding the objectives of education among teachers, educators, curriculum framers and evaluators.
3. To help educators plan and evaluate learning experiences.
4. To make a comparison between curricular goals and possible outcomes.
5. To bring uniformity in evaluation.
6. To help in clearly defining and meaningfully evaluating educational standards of a school.

According to Bloom's Taxonomy of educational objectives, the objectives are classified into three domains which are represented in the figure given below:



Cognitive Domain

The hierarchical arrangement of the six major classes of objectives arranged on the basis of complexity of tasks and arranged from simple to complex and from concrete to abstract behaviour. The components of cognitive domain are as follows:

1. Knowledge: ability to recall and recognition of facts, information, ideas etc.
2. Comprehension: ability to understand facts and concepts.
3. Application: ability to use facts and concepts to solve new problems.
4. Analysis: ability to identify pertinent components parts of information and their interrelationships.
5. Synthesis: ability to integrate components into a new whole.
6. Evaluation: ability to judge and compare procedures, products etc.

Affective Domain

It deals with interest, attitudes, values, appreciation and adjustment. These objectives describe behaviours ranging from students merely being aware that a given phenomenon exists to behaviour where they are willing to respond with a feeling and attach value to it. A hierarchy of objectives in the affective domain was developed by Krathwohl et.al. in 1960. The components of affective domain are as follows:

1. Receiving: sensitization of the learner to the existence of certain phenomena and stimuli.
2. Responding: compliance of learner to learning task and actively attending to received stimuli.
3. Valuing: acceptance of a value and commitment to or a conviction with regard to a certain point of view.
4. Organising: forming a value system (more than one relevant value) finding relationship between values and establishment of the dominant and pervasive value.

5. Characterising: integration of one's beliefs and attitude into a total philosophy.

Psychomotor Domain

It concerns with levels of neuro-muscular coordination. As the level of coordination goes up, the action becomes more refined, speedy and automatic. A hierarchy of objectives in the psychomotor domain was developed by R H Dave in 1969. Under this domain five categories were formed, they are as follows:

1. Imitation: inner rehersal of any act i.e., rudimentary co-ordination in any physical activity.
2. Manipulation: following directions, selection of certain actions in preference to others and acting accordingly.
3. Precision: ability of learner to control action in response to requirements and reproduce action with speed and refinement.
4. Articulation: learners handling a number of actions in unison, keeping in view their sequence and harmony.
5. Naturalisation: perfect habituation ranging from automatisation to routinisation. Actions are generally mechanical without thinking or planning reflex actions.

Specific Objectives Or Behavioral Objectives

An instructional objective is an intent communicated by a statement describing a proposed change in a learner – a statement of what the learner is to be like when he has successfully completed a learning experience. It is a description of pattern of behaviour. We want the learner to be able to demonstrate. The objectives which are achieved by a particular lesson are called 'specific objectives'/ 'behavioural objective'.

Critiques of Bloom's Taxonomy

Some apprehensions, doubts or criticisms have been raised against the taxonomies of educational objectives. They are:

1. It seeks to fragment or separate into particular artificial categories of learners' behaviour. It looks as if classification might be very different from the more complete objective with which one started.
2. Human behaviour cannot be classified as they cannot be completely manipulated or observed.
3. Classroom teachers may not be able to use and master them so meticulously that they may remain as pedagogic rhetoric.
4. Criticism is that the availability of the taxonomy might tend to abort the thinking and planning of teachers with regard to curriculum, particularly if teachers merely selected what they believed to be desirable objectives from the list provided in the taxonomy.
5. Objectives are misleading at times.

Learning Experiences

Learning experiences are active interactions between the stimuli and the pupil. It is the reaction of the students to the learning situation created by the teacher in the form of activities. Listening, speaking, thinking, etc., are all part of learning activities.

Characteristics Of Learning Experiences

1. Learning experiences help in providing hands on experience to the students.
2. Science is best learnt by doing and these experiences help in creating conditions to do science.
3. they help in focusing primary concepts thereby allowing students to construct the meaning and acquire a better understanding of the concepts.
4. provision of learning experiences help students to develop thinking process and encourage them to question and seek answers that enhance their knowledge.
5. Help in developing skills needed to seek information and solve problems.
6. Help in integrating real life aspects with science teaching learning process.

Classification Of Learning Experiences

1. Direct Experiences

These represent reality as we experience it first hand. It is the best possible method of teaching effectively. Eg. Periscope, hydrogen puts off fire.

A. Direct purposeful Experiences

These are experiences which are handled, tested, felt, touched and smelt. They are gained through senses.

B Contrived Experiences

They are similar to real experiences. It is like a working model, which is a replica of reality and differs from the original in size or in complexity.

C Dramatised Experiences

Not every experience can be gained through direct interaction and hence dramatic experiences are means by which certain real events are represented so that we can get as close to reality as possible. E.g. puppet shows, mock conventions, plays dramas etc.

2. Indirect Experiences

Learners gain experience by observing others experience. Learning is indirect. It includes *demonstration, study trips and exhibits*. These are obviously more abstract than direct. Here students do not get any hands on experience but an indirect experience of observing reality.

3. Vicarious Experiences

They are representative experiences based on direct experiences. They substitute direct experiences. It includes experiences gained through television, motion pictures, recordings, radio and still pictures. This methods are usually one or two dimensional and appeal to only one or two senses. Almost all these experiences are generally outside the classroom.

Sources of Learning Experiences

A person lives amongst thousands of stimuli around him. All the stimuli will lead to different kinds of learning experiences. There are many sources of learning experiences, which are generally grouped under the following common heads.

1. Home 2. Peer Groups 3. School (Experiments, Excursions, Exhibitions, Audiovisual aids, Co curricular activities, Sports and Games, School Library etc.)

Relevance of Learning Experiences

1. Learning experiences can be made relevant by:
2. Creating a good learning environment.
3. Identifying teaching / learning strategies to further enhance learning.
4. Identifying and supporting learner's needs.
5. Preparing and acquainting students with different learning experiences.

Learning is an active process and learning experiences are a means to creating such an environment.

Unit V

INSTRUCTIONAL PLANNING IN PHYSICAL SCIENCES
Year Plan
Unit Plan
Lesson Plan
Planning Science Laboratories – Importance, Administration.
Construction of Science Laboratories
Maintenance of Registers, First-aid.
Science kit & Development of Low Cost improvised apparatus.

Year Plan

The most general type of planning one does as a classroom teacher is the year planning. It is a long re-arrange plan in which on plans the layout of one's instruction for the year. The teacher has to divide the whole subject into small sets of related facts. These facts have to be then structured and organized into meaningful material, which should be based on psychological and logical principles of learning.

A year plan should act as a guide for the teacher to organize her day-to-day class work keeping in mind the long-term goals. The annual plan should be flexible and allow the teacher to make necessary changes as and when required.

Importance of Year Plan

1. The year plan helps the teacher in smooth conduct of the teaching activity.
2. The entire syllabus to be covered in a year is divided into terms/months/weeks/period. Since content is divided into logical units and subunits and the topics are subdivided into periods, it helps in easy preparation for the classes.
3. It helps in deciding allotment of periods required for teaching different units.
4. It helps in planning curricular and co-curricular activities like excursions, discussions, debates and workshops.
5. Methodological year planning leads to effective teaching.

The Annual Plan Format

School **:**
Subject **:**
Class **:**

Total number of periods allotted **:**

Month	Unit/Sub Units	Broad Objectives			Periods Required		Curricular / co curricular activities
		Cognitive Domain	Affective Domain	Skills	For Teaching	For Testing	

Unit Plan

The second level of planning involves unit planning. A unit plan contains multiple lessons that are related.

Morrison, H.C says a unit may be defined as a means of organising materials for instructional purpose which utilizes significant subject matter content, involves pupils in learning activities through active participation intellecturally and physically and modifies the pupils behaviour to the extent that he is able to cope with new situations more competently.
Hoover defines a teaching unit as a group of related concepts from which a given set of instructional and educational experience is derived. Units normally range for three to six weeks.
Preston says, a unit is a large chunk or a block of subject matter as can be viewed by the learner.
Proforma for a Unit Plan
Proforma 1
Subject : Class :
Name of the Unit :
Major Objectives of the unit :

S. No.	Concepts (Topics)	Number of lessons required	Time Required	Content (scope)	Procedure	Teaching Aids	Evaluation Procedure

After completion of proforma 1, a detailed unit plan in Proforma 2 can be prepared
Proforma 2
Subject : Class :
Name of the Unit :
Major Objectives of the unit :
Lesson Number :

S. No.	*Sub Concepts*	*Behavioral Objectives*	*Procedure: Teaching-Learning activity*	*Evaluation*

Advantages of Unit Plan

Unit planning is an important phase of teaching learning process that has the following advantages:

1. It breaks up the entire work into small sections, small enough so that pupils can easily group the scope of these during the observation.
2. It helps in classifying the general and specific objectives of teaching.
3. It helps to cater to the needs, nature and aptitudes of the students.
4. It helps in saving time and planning work effectively.
5. It makes teaching learning clear, precise and comprehensive.
6. It develops self-confidence among students for it evolves opportunities for meaningful experiences wherein they can organize and review their learning.

Disadvantages of Unit Plan

1. It requires committed and hard working teachers.
2. It increases the work of a teacher.
3. Difficulty sets in when topics are unrelated and unsystematically arranged.
4. Evaluation becomes a difficult process.

Lesson Plan

Definition

Outline of the important points of a lesson arranged in the order in which they are to be presented to students by the teacher. - Good

Plan of action implemented by the teacher in a classroom - Lester B Stand

The teacher who has planned his lesson wisely related to his topic and to his class will be in a position to enter the classroom without any anxiety; ready to embark with confidence upon a job he understands and prepared to carry it to its logical conclusion. He has foreseen the difficulties that are likely to arise, and prepares himself to deal with them. He knows the aims that his lesson is intended to fulfill, and he has marshaled his own resources for the purpose. And because he is free of anxiety, he will be able to coolly estimate the value of his work as the lesson proceeds, equally aware of failure and success and prepared to learn from both.

- G H Green

Advantages of a Lesson Plan

- Helps in carrying out teaching learning systematically.
- Enables the teacher to be well organized and orderly in his presentation.
- A teacher follows a well thought of and a definite plan of action and hence avoids haphazard and thoughtless teaching.
- It enhances the self confidence and self-reliance of the teacher.
- It helps in saving time since every step is pre-planned and there is no scope for repetition.

- Lesson planning establishes proper connection between different lessons of study, thus ensuring continuity in the teaching learning process.
- Activities can be preplanned keeping in mind availability of resources and capability / ability / level of students.
- Lesson planning helps in choosing appropriate learning procedures.
- Lesson planning provides for adequate processes to evaluate the learning outcomes.
- Lesson planning helps in linking the past lesson with the present.

Approaches to Lesson Planning

There are different approaches to lesson planning two common approaches are

1. Herbartian approach, 2. Evaluation approach or Bloom's approach

Herbartian Approach

John Fredrik Herbart, a German Philosopher and educationist divided teaching units into six steps. The six formal step for the development of a lesson plan are

- *Introduction / Motivation:* It pertains to preparing and motivating the child to the content of the lesson by linking it to the previous knowledge of the study by arousing their curiosity and appealing to their senses.

  This step involves

  a. Testing of previous knowledge

  b. Arousing curiosity by means of activity like demonstration, chart, showing models etc.

  c. Sustaining students' curiosity and receptivity using various measures like story telling etc.

- *Presentation:* the first step is to state the objectives explain clearly the purpose of exposure of students to new information. The next step is the actual presentations were students and teacher should be active participant.
- *Comparison or Association*: students are provided with examples and are asked to compare them with other set of similar examples and facts e.g. eye with camera lens. Etc.
- *Generalization:* students are made to reflect and the whole knowledge learnt in presentation step is systematized leading to generalizations, formulae, and rule etc. through comparison/ association. Generalization involves the following steps:
  a) Reiterating definitions of new terms.
  b) Providing occasional summaries and restatement of important ideas.
  c) Using alternative explanations when necessary.

The aim of the lesson is achieved in this step.

- *Application:* students will make use of knowledge gained in familiar and unfamiliar situations. Science without relevance to daily life would end up being meaningless at times. Forms of application are: solving problems, writing an essay or an article, drawing maps or charts, preparing some models, doing some practical work, setting of new type of tests.
- *Recapitulation:* this is the last step of the lesson plan in which the teacher tries to ascertain whether his students have understood and grasped the subject matter or not and to do so he: a) asks questions on topic; b) give short objective type test; c) make them solve problems etc. It is very important as this helps the teacher to judge as to how well the students have learnt the concepts.

The above mentioned Herbartian steps are just tentative guidelines and need not be followed rigidly.

Blooms Evaluation Approach to Lesson Plan

According to this approach, teaching activities are objective centered. Bloom considers education as a triangular process with educational objectives, learning experiences and evaluation.

Lesson Plan Steps in Evaluation Approach

In planning a lesson, the lesson plan has the following six steps:

- Teaching Points or Content to be taught.
- Behavioural objectives with specifications
- Teacher Activities (asking questions, use of materials etc)
- Students Activities (answering questions, responding to teachers activity etc.)
- Teaching Aids
- Evaluation

Merits of Bloom's Lesson Planning

The following are the advantages of Bloom's approach to preparing lesson plans:

- Based on Psychological and scientific principles
- Objectives are written in behavioural terms.
- Content is analysed point-wise.
- Teaching objectives are achieved by organising teaching activities.
- Teaching activities are based on learning experiences.
- It helps in integrating objectives, teaching activities and learning experiences.
- Helps in making teaching purposeful and objective oriented.

Demerits of Bloom's Lesson Planning

- It does not provide opportunities for the creativity and originality since it is highly mechanized and structured.
- Teaching activity becomes wide and vague since it caters to more than one domain.
- The mental abilities are not given due consideration while writing objectives.
- Personal factors of teacher do influence the planning and organization of the teaching activities.

General Instructional Objectives
Specific Instructional Objectives
Teaching Aids
Books Referred
Previous Knowledge and Experience
Teaching Points

Teaching Steps	**Content**	**Objectives/ specification**	**Teaching Learning Activity**		**Teaching Aids**	**Black Board**	**Evaluation**
			Teacher activity	**Student activity**			
Motivation: *Presentation:* *Association*:							

Generalization: Application: *Recapitulation:*							

Assignment:

Planning science laboratories

The theoretical and practical work in science should complement each other and activities need to be planned integrating both the aspects. The objectives of laboratory work are:

- To awaken and maintain an atmosphere of curiosity.
- Illustration and verification of abstract scientific ideas.
- Development of skills such as measurement, accuracy, use of telescopes etc.
- To use it as an educational device for answering questions experimentally and thereby provide training in scientific methods.

Laboratory planning for science

In every school which provides education in physics a provision has to be make for a laboratory for physics. The size of the laboratory will depend on the number of students likely to work in it at a time. About 30 sq. ft. space be provided for each student. The structural details are generally provided by the architects but the following points be kept in mind.

Planning

The following points has to be kept in mind while planning

- Laboratories and classrooms should not exist in the same corridor.
- Laboratories should be situated, mostly in the ground floor and probably should be should be the only floor.

Planning individual laboratories

- Each student is easily accessible to the teacher
- There is minimum of movement.
- Each student has a cupboard, bottles, heating point and a sink near him.
- Teacher can easily observe each student.
- Blackboard is visible to every student.
- Each student can easily see the demonstration.
- There is enough space (4.5) between two laboratory tables.
- Master switches have to be provided to control electricity, gas, water etc. in each laboratory.

Lighting

Proper lightning arrangements have to be made for laboratory tables and classrooms. Special attention should be given to the lighting of demonstration table and blackboard. It would be preferred if a provision could be made for electrical lights over tables through pulleys so that their height may be varied from 2 to 8 ft. Two-way switches can be provided for controlling the main lighting from doors and preparations rooms. Dark blinds or curtain must be provided for each laboratory to conduct optics experiments.

Ventilation

If possible each laboratory should be surrounded by a 6' verandah on all sides to keep away the direct heat of the sun. Ventilators should be provided as usual. In case of chemistry laboratory ceiling should be high and exhaust fans must be provided. In general full height windows are desirable.

Water Supply

Provision of water supply must be made in every laboratory. Water supply is most essential item and for this purpose proper arrangement of water taps and sinks is a must in every laboratory.

Sinks

Provision of sinks in each laboratory is one of the essential requirements. For a laboratory of ordinary size generally four sinks of 15''/ X 12'' X 8" are sufficient. These sinks should be fitted on side walls. These sinks are in addition to the one provided with the demonstration table. Waste water from these sinks is carried to the drains with the help of the lead pipes fitted with the sinks.

Electrification

Proper attention should be given in providing electrical wiring in the laboratory. There should be some arrangement for darkening and controlling the intensity of light. Proper attention should be given for switches, fans and other electrical arrangements.

Waste Disposal

Two types of waste (i.e. liquid and solid) are often generated. Arrangements have to be made for disposal of these wastes. For disposal of liquid wastes use of lead pipes or earthen ware pipes is considered most suitable. Care should be taken to avoid flow of solids like pieces of filter paper, cork, broken glass pieces etc. through these pipes. For solid wastes metal boxes have to be placed in the corners of the laboratory and students should be instructed to put all solid wastes in these boxes.

Laboratory Tables

The provision of laboratory tables is a must for each laboratory. Tables and chairs should be made of sheesham or deodar wood. The tops of table should be atleast 1'' thick. In addition provision for blackboards can be provided or movable wooden black boards with stands can be used.

Arrangement of the apparatus

It is essential to store the apparatus in an orderly manner and some definite plan or procedure needs to be followed. This will avoid any type of breakage and the apparatus will be easily available when required. Glass apparatus in one place and non-breakable apparatus separately. Apparatus stored should be properly spaced. Sensitive costly apparatus and dangerous chemicals should be kept under lock and key. The apparatus of daily use should be stored within easy reach.

Importance, administration and maintenance

The laboratory must be under the supervision of a laboratory attendant. Attendants for laboratories must be persons having middle school qualifications. Each school should also be provided with a storekeeper-cum-laboratory assistant and the minimum qualification for persons to be appointed as storekeeper-cum-laboratory assistant should be matriculation. If there is enough work, then mechanic may also be provided to the school.

For conducting practicals in physics/chemistry, atleast two consecutive periods must be allotted during a week. An effort should be made to provide apparatus and equipment so that each student can complete his experiment individually. However if enough materials resources are not available then students may be asked to do the practicals in groups. A group should not be of more than two students in case of practicals of physics.

If instructional cards for each experiment are prepared then it would help and facilitate the work in a practicals class.

Registers to be maintained in Science Laboratories

A proper record of the science apparatus is very important to check any article at any time, also it facilitates in giving concrete answers to management during auditing.

Types of registers, which a science department can maintain, are:

Permanent Stock Register

Month and Date	**Particulars**	**Details of Company Rate**	**No. Of Breakage Items**	**No. On Hand**	**Teacher's Signature**

Breakable Stock Register

Date	**Details of Broken Items**	**Signature of Student**	**How the Breakage Took Place**	**Signature of the Science Teacher**	**Head of the Department**

Consumable Stock Register

Chemicals and other fluids liable to be consumed like distilled water, copper sulphate, magnesium wire, sulphuric acid are entered in this register.

Order Register

The order register includes a record of the requisition sent for the purchase of new apparatus. The entries should include serial number and date of order, name of the company, the articles ordered, articles received, cost of each item, total cost of each item etc. it is a good practice to staple the copy of the order on hand, page of the register and voucher on the right hand page of each order.

Requirement Register

The most suitable way of collecting suggestion for new resources for the science staff, including the head of the departments, is to note the ideas in a requirement register. These suggestions

should be dated, contain a clear specification, name the supplier and give an suggestions as essential, highly desirable or a luxury, so that priorities can be drawn when placing orders.

Safety in the Laboratory

Laboratory safety is best regarded as a positive undertaking, which is an integral part of every activity in which the science teacher is engaged with her students. The acquisition of safety conscious attitudes by pupils is an important part of a science teacher's task and teaching and learning activities should be designed to minimize all safety hazards. The teacher as a good example should be careful in making science laboratory a safety place.

Some Common Laboratory Mishaps and their Remedies

Poison

Consumed Poisons / Non-corrosive Poisons

Victim should be made to vomit so put two fingers inside the mouth or give chilled salt water (two teaspoon salt to one glass).

Corrosive Poisons

Acids: Do not make the patient vomit. Dilute the acid with plenty of water. This will reduce irritation. Plenty of water followed by milk of magnesia.

Alkalis: Do not make him vomit. Plenty of water followed by lemon juice.

Unknown Nature: Universal antidote-activated carbon, Magnesium oxide and tannic acid in the ratio 2:1.

Inhaling Poisonous gas:

Check Breathing and take the patient into fresh air; loosen his clothes, if conscious serve hot tea or coffee.

To counter chloride or bromine fumes, the patient should smell ammonia and rinse mouth with sodium bicarbonate.

Fire

1. *Ignition of solvent vapours:* (eg. Carbon disulphide); some of these vapours ignite well below red heat. Flammable, volatile liquids should not be poured from one container to another near a naked flame.
2. *Uncontrolled chemical reactions:*
3. *Inadequate storage and disposal techniques*
4. *Loose clothing or hair ignited by Bunsen burners*
5. *Inadequate maintenance*

Causes of Fire	**Suitable Extinguisher**
Ordinary combustibles, eg. Dry heat like hot glass rod.	Water or carbon dioxide from fire extinguisher
Flammable liquid fires, eg. Oil, fat, solvents	Carbon dioxide from fire extinguisher of fire blanket
Electrical fires	Switch off power first. Carbon dioxide from fire extinguishers
Metal fires, eg. Use of zinc, etc.	Use dry sand

Eye Injuries

Acid in eye: Wash the eye with plenty of water. Then apply weak solution of sodium bicarbonate.

Alkali in eye: Wash with plenty of water. Then wash with 1% solution of boric acid.

Solid in eye: Do not rub the eye. Try blowing off the solid. The eyelid may be turned back gently over a matchstick. Any foreign matter may be removed with fine camel hairbrush dipped in glycerine or with the end of a cloth.

Burns

Heat burns are accompanied by loss of fluid from the blood into the tissues causing blisters to form. Small burns should be treated by cooling the ing=jured areas as rapidly as possible using running water. A suitable sterile dressing should be applied.

Chemical burns should be washed with copious amount of water. Some chemicals viz. phosphorus and bromine, cause severe burns and medical advice must be sought as a matter of urgency.

Acid burn should be washed with plenty of water and then with sodium bicarbonate solution followed by topical application of Vaseline or burnol to soothe the burnt area.

Phosphorus burns should be immersed in water so that all traces of the substance are washed away. Then the affected part is treated with dilute silver nitrate solution.

Cuts, usually the minor ones should be washed thoroughly with waster and a suitable sterile dressing applied. Anti tetanus injection or a toxoid boost should be given if serious.

First Aid Kit

General Items	**Chemical / Medicines**
Cotton	Antiseptic liquid / dettol
Roller bandage in 3 sizes and triangular bandage	$KMnO_4$ solid.
Scissors	Eye lotion like Optrex
Plasters	Vaseline
Dressing gauge	Common salt
Linen for burns	Sodium bicarbonate 1%
Forceps	Glycerine
Eye dropper	Milk of Magnesia
Camel hair brush	Boric acid 1% solution
Tea spoon	Tincture iodine
Thermometer	Silver nitrate – dilute solution
	Acetic acid 1%
	Sal volatile
	Gentian violet
	Sulphonamide cream
	Burnol
	Universal antidote
	Brandy
	Aspirin

All teachers should have a knowledge of simple first aid.

Science Kits

Most of the apparatus and materials belonging to the kits can be improvised or made in the workshop by carpenters or blacksmiths.

1. Demonstration Kits: The kits are helpful to teachers in performing certain experiments for demonstrating certain scientific facts and principles.
2. Students Kits: help students to experiment and draw inferences by themselves for studying facts and principles of sciences.
3. Multipurpose Kits: the kits are helpful to both teachers as well as students. These can be used for demonstration purposes by the teachers and also can be employed by the students for their own experimentation and observation work to study the facts and principles of sciences.

Development of low Cost Improvised Apparatus

Definition

I. A make shift arrangement to accomplish the intended learning task.
II. A contrived situation created out of readily available material for the sake of convenience.
III. A stimulated situation to demonstrate and impart learning in respect of controls and operations with low – cost materials.
IV. A term which refers to learning aids prepared with simple and readily available inexpensive materials by involving students and teachers.

Significance

A. Improvisation brings the cost of apparatus down, as funds are scarce in a developing country like ours. It is good step in making school self-reliant.
B. Improvisation has instructional value too, as during improvisation we get a proper feel for the scientific process and designing. It is quite related to learning by doing.
C. Improvisation develops the dignity of working with one's own hands. It satisfies the urge of creative production of a utility item and provides a sense of achievement to both the teacher and students.
D. Improvisation requires working in groups and holding discussions. Therefore, it is helpful in fostering the habits of coordination and co-operation, which are important social skills.
E. Improvisation provides training in thinking skills through the process of looking for low-cost substitutes or alternatives.

Some Improvised Experiments

1. Kaleidoscope
2. Telescope
3. Transverse wave motion simulation

Electric bell

UNIT –VI

METHODS AND APPROACHES OF TEACHING PHYSICAL SCIENCES
Nature, Element and Process of Communication.
Concept of Teaching, Levels of Teaching (conditions, training instruction and indoctrination).
Teacher Centered Vs Pupil Centered Approach
Lecture Method.
Demonstration Method.
Heuristic Method.
Project Method.
Laboratory Method.
Problem Solving Method.

Nature, Element and Process of Communication.

Communication is a basic prerequisite of all human performance and interaction. In broad sense communication refers to the transmission of thoughts, information and commands by employing the sensory channels. The art of communication ensures that the message is conveyed intact – undiminished and undistorted. It is also considered as a process of exchange of information as it tries to blend into a mutual understanding of a fact, principle or theory.

- Etymologically communication has been derived form the Greed word "communis" meaning 'to make common'. Thus when something is communicated it becomes common knowledge of communicators and receivers.
- According to Aristotle, communication is a means of persuasion to influence the other so that the desired effect is achieved.
- The Latin root of the word of 'communication' is 'communicare' which has three possible meaning: 1. to make common which is probably derived form either 2 or 3.
  2. cum + munus, i.e. having gifts to share in a mutual donation.
  3. cum + munire, i.e. building together a defense like the walls of a city.
- Dewey defines communication as a process of sharing experience till it becomes a common possession. He says it modifies the disposition of both the parties who partake it.
- Edger Dale defines it as sharing of ideas, feelings in a mood of mutuality.
- Communication is therefore a process whereby we attempt to transmit our thoughts, ideas, wishes or emotions to others.
- the goal of communication is the acceptance of sender's message by the receiver. If the receiver understands the meaning of the message which calls for action, but fails to act effectively, the goals of communication is not achieved.
- in contrast, if the receiver responds to the message by taking appropriate action, then the goal of communication is said to have been achieved.

Characteristics of Communication

- It is a universal phenomenon, which exists in all spheres of life.
- It is a continuous process, which involves give and take policy.
- It involves the sensory perceptions.

Elements of Communication

Kumar, K L has listed the following elements of communication, which are essential to understand communication models, and networks.

1. Communication context : Physical, Social, Psychological, Temporal(time and period).
2. Communicator / source
3. Receiver
4. Message
5. Symbol
6. Channel
7. Encoding
8. Decoding
9. Feedback
10. Noise

Concept of Teaching

Teaching is a system of actions intended to induce learning. Teaching is a social process on which the political system, social philosophy, values and culture of every nation leave their impression.

H C Morrison has defined teaching in an autocratic country as an intimate contact between a more, mature personality and a more, mature personality and a less mature one which is designed to further the education of the latter i.e. the teacher impresses the students according to his own will.

In contrast, in a democracy **N L Gage** defines teaching as an inter-personal influence aimed at changing the behaviour potential of another person i.e. not only the teacher influences the student but also the reverse also happens. Thus we can conclude that teaching is a bipolar process; its one pole is the teacher and the other is the student.

Teaching is a highly skilled job and therefore requires adequate training. Every teacher must have a clear understanding of his task – its meaning and intricacies involved. It is more or less a skilled trade, in which one went with a complete command of knowledge armed with the skill of explanation and testing.

Characteristics of Teaching

1. Teaching is a complex social phenomenon
2. It is an art
3. Teaching is a science
4. Teaching is basically a communication process.
5. It is amenable to scientific observation and analysis.
6. It can take place through various forms.

Levels of Teaching

Teaching is aimed to bring about change in behaviour of the learner. In classroom teaching-learning process involves joint, co-operative task between the teacher and student. Teaching task takes place at various levels ranging from the least thoughtful to the most thoughtful mode of action. Psychologists and educationists have clearly identified three levels of teaching-learning act namely memory level, understanding level and reflecting level.

1. **Memory level of Teaching – Learning**

   Teaching is at the memory level is the least thoughtful activity. Emphasis is placed on the presentation of facts and information and its organising. Thus there is not much relation with

intelligence as cramming is the point of focus in this level of teaching-learning and hence teaching lacks insight. Here information at cognitive level are supplied to the learner, which he stores in his brain, and recalls /recognizes this knowledge when needed.

1. In this the teacher is like a dictator who suppresses the independence, interests, attitudes and competencies of student.
2. Teacher tries to impose facts and information upon the students.
3. Teacher is active while learners are passive.
4. Teaching learning is mechanical, and practically no interaction.
5. Signal learning, chain learning and stimulus response learning is emphasised.
6. In evaluation, traditional methods are used in the form of essay, short answer and objective type questions.
7. Motivation is largely extrinsic.
8. learners engage in memorization due to external factors like fear of punishment, getting favour of teacher, passing a test or getting promotion to next grade.

Understanding Level of Teaching

Here the thought process is higher as it calls for using thought processes and cognitive abilities in the form of reasoning and thinking powers, powers of imagination, analysis, synthesis, comparison, application, generalisation, drawing inferences etc. through five steps.

1. preparation and previous knowledge of the student is explored, hence need of learning something new is felt.
2. systematic presentation of subject matter is done by relating it with old ones.
3. & 4.Comparison and generalisation in which students are supposed to identify common elements in the present material/factual information and make generalization in the form of generalized facts, rule or principle.
1. Application in which they are supposed to make use of the generalized principle by applying it to new situations.

In general in this method, teacher plays a dominant and authoritarian role in this level of teaching. The teacher takes care that the student gains complete mastery of the subject matter in terms of its full understanding and generalized insight than in its mere memorization i.e. retention and reproduction.

- The learner is relatively more active than in memory level but still has to act within the framework set up by the teacher.
- The motivation is extrinsic as in the case of memory level.
- The teacher uses lecture-demonstration, question-answer types of methods to develop knowledge and understanding.
- The evaluation procedures adopted make use of tests to know the student's ability to analyse, synthesis, compare, generalize and apply to new situation.

3. Reflective Level Teaching

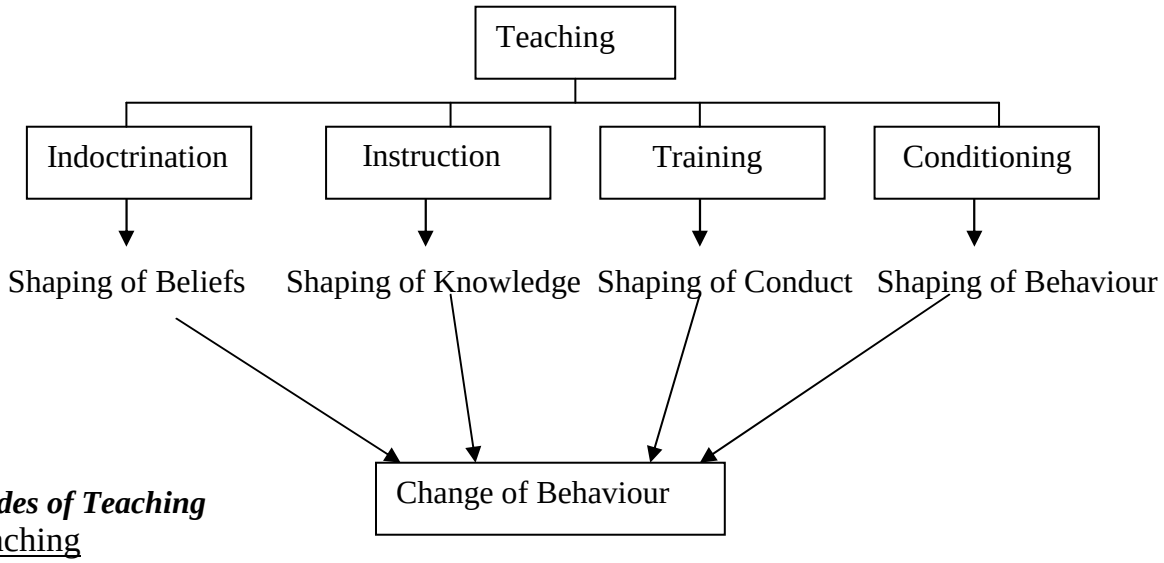
This level of teaching includes both understanding and memory-level teaching. Essentially reflective level means 'problem centred' teaching. It represents the highest levels of teaching learning act that can be carried out at the most thoughtful modes of operation providing the

desirable quality of teaching-learning situation and experiences to the learner for utilizing and enhancing their cognitive abilities to the maximum.

- It provides opportunities for the learner to utilise his cognitive abilities to the maximum.
- It is based on the principle of problem solving / discovery method.
- This theory has its root in cognitive field theory of learning.
- It emphasis upon the learning of generalized insight, ways of discovering the facts and acquiring the skill of problem solving.
- Teacher assumes the role of a guide, he does not play a dominant role. He helps students to discover facts or generalisations and does not present facts.
- Learner remains active participant, as he has to make use of his cognitive abilities in solving the problem in hand.
- Motivation is intrinsic and is filled with curiosity to learn for his own personal satisfaction.
- It is student-centered method.
- Evaluation procedure are used to test problem solving ability, ingenuity (originality) or creativity etc.

Modes of Teaching

Terms like conditioning, training, instruction and indoctrination are used to denote modes of teaching. At times they are even used as synonyms for teaching. But each of these, thought they denote one or other types of teaching, they are inherently different. Teaching is a larger concept and each of these is a part or aspect of this large concept.



Modes of Teaching

Teaching

Teaching as a whole is aimed to bring about changes in the behaviour of the students. These changes are brought about by –

a) Teaching them how to perform a task
b) Teaching them how to respond to a situation or stimuli.
c) Teaching them those aspects that contribute to their enrichment of knowledge.
d) Shaping their behaviour, attitudes and beliefs in teaching, an interaction occurs between the teacher and the students as a result of which students are diverted towards the planned objectives.

Conditioning
It is the lowest level or mode of teaching. We as humans are conditioned or taught to respond to signals, alarms, signs, language (alphabets, pronunciation etc), and warnings through conditioning. Most of our desirable or undesirable behaviours and habits are the creation of the process of conditioning. Ex: saying sorry, when unintentionally our leg touches another person while traveling. (It comes naturally/conditioned).

Training
It is the next level or mode of teaching after conditioning. It helps in shaping conduct and teaching various skills. We are trained for specific task, eg. to drive bicycle. Similarly we are trained to use gadgets and machines – their operations etc., with training less intelligent or simple behaviour is produced and in comparison teaching produces higher intelligence behaviour.

Instruction
It is concerned with development of knowledge and understanding in an individual about a thing, system or process. Instruction caters towards the development of intellect and affects the cognitive domain of ones behaviour. In comparison teaching is aimed towards shaping a total aimed including conative and affective domains with the cognitive domain.
Another aspect is the presence of teacher. In instruction the human instructor can be replaced by computer, teaching machine, programmed material, radio, television, video etc. but teaching necessarily involves face to face interaction. In teaching, teacher can use any of the aids mentioned above to enhance his teaching.

Indoctrination
It refers to the transmission of doctrine, firm faith or system of beliefs. It represents a fairly high level of teaching which leads to the establishment or shaping of beliefs and ideals. It requires higher order of intelligence and results in bringing quite stable changes in the cognitive and affective domains of ones behaviour.

Let us now compare the four modes of teaching conditioning, training, instruction and indoctrination.

Comparison between Modes of Teaching Instruction

Aspect	**Conditioning**	**Training**	**Instruction**	**Indoctrination**
Purpose	Shaping behaviour	Shaping skills and behaviour	Transmitting knowledge	Shaping beliefs
Teaching aim	Making someone to do something as one desires	Teaching some one how to do something	Teaching some one that this is the way to do something.	Teaching some one that so and so is the only way of doing it
Objective	Formation of habits	Formation of skills	Formation of knowledge	Formation of attitudes, beliefs
Domain	Psychomotor	Psychomotor	Cognitive	Affective

Type of learning	Signal learning	Chain learning	Concept learning	Principle learning
Level of learning	Thoughtless : memory level	Thoughtless: memory	Thoughtful : Understanding level	Thoughtful : Reflective level
Nature	Memorization	Performance	Response	Reflection
Example	Teaching alphabets, symbols	Development speaking, reading skills	Teaching concepts, theories principles	Developing attitudes, beliefs, feelings
Application	Small children	Training for certain acts	Teaching at higher level	Higher level teaching
Outcome	Behaviour shaping	Conduct shaping	Knowledge transmission	Belief and value formation

Conclusion

Teaching is a dynamic and well planned process with the main objective of providing a variety of learning experiences. In narrow sense it means imparting knowledge. In broader sense each individual gains variable experience from birth to death. Teaching is a scientific process and its major components are content, communication and feedback. The whole exercise called teaching is taken to bring about a change in the learners behaviour.

Approaches to science teaching can be classified into two types:

- Teacher-centered and
- Student centered approach.

I. **Teacher centered Approach:** This mainly uses telling, memorizing and recalling information. The students are passive recipients of knowledge. The paticipation is restricted to only asking and answering questions on what teacher has taught. The teaching environment is formalized and teacher occupies a central position in the classroom. The following are examples of this approach:

1. Lecture Method
2. Lecture – Demonstration Method
3. Historical Method

1. Lecture method:

Lecture method is one of the oldest teaching methods. A lecture is an exposition of knowledge, facts, principles, & information a teacher wishes to provide the students.

According to the **Carter Good** it is**,** 'an instructional procedure by which the lecture seeks to create interest, to promote activity, to develop critical thinking, and to impart information etc. largely by the use of the verbal message, with minimum of class participation; illustration, maps, charts, oral techniques or other visual aids may be employed to supplement the oral technique.'

Planning a lecture:

A teacher has to plan the lecture in a systematic way for its effective delivery.

1. The audience:
   The students are the audience for a teacher. The abilities, the needs and the level of knowledge of the students should be taken into consideration.
2. Purpose of lecture:
   The teacher has to identify the purpose of the lecture.
   i) It provides an overview of the subject.
   ii) Introduce a new Topic.
   iii) Bring changes in the student attitude.
   iv) Provide detailed information.
   v) Teach a particular skill.
3. Time available:
   The teacher should plan her lecture for a given time. Appropriate examples, interesting questions, discussion to make the lecture interesting, etc.
4. Subject matter:
   The teacher should possess an extensive knowledge of the subject matter. She should have a command over the Topic. Poor knowledge of the subject may lead to failure of the lecture.

Steps in a Lecture Method:

Planning Stage: 1. Determining the Aim of lecture
2. Formulation of Objectives of Lecture
3. Preparing the Outline of Body of Lecture

Presentation of the Lecture: 1. Discussion
2. Demonstration
3. Illustrations

Conclusions: 1. Questions
2. Summarizing

Advantages:

1. Helps to channalise the thinking of students in a given direction
2. It is an efficient method of delivering a large amount of content to a large group of students.
3. Abstract topics can be covered by using this method.
4. Introducing & summarizing a lesson become very easy.
5. Saves time, money and energy.
6. Good lecture motivate & inspire the learner to develop their critical thinking.

Limitations:

1. Students are passive recipients of information & their participation is negligible,
2. Only theoretical knowledge is given importance.
3. If students are not attentive it fails to inspire them.
4. Science is best learnt by doing and there is no provision for activities.
5. Poorly delivered lecture may cause disinterest & demonstration among the students.
6. It does not promote independent thinking and learning in students.

Role of the teacher:

The teacher plays a central role in this method.

II. Lecture –cum-Demonstration Method:

This method includes the lecture and the demonstration together. This method based on the principle of "Concrete to abstract".

Process of Lecture Demonstration Method

1. aim of the lesson
2. objective of the lesson
3. introduction of the lesson
4. demonstration – illustrations & precautions
5. questions
6. conclusions

Steps :

- Planning and Preparation
- Introduction of the lesson
- Presentation
- Performance of experiments
- Blackboard summary
- Supervision

Advantages:

1. It combines all the plus points of lecture and demonstration methods, eliminating shortcomings of lecture method.
2. It is economical as wells as it leads students from concrete to abstract situation and thus is more psychological.
3. The teacher uses this method when the apparatus is costly & dangerous to handle individually.
4. The teacher provides more information in less time.
5. It involves the active students participation in the teaching learning process.
6. This method can be used to impart manual and manipulative skills to students.

Limitations:

1. It provides no scope for 'learning by doing' for students as students just observe what the teacher is performing.
2. since teacher performs the experiment at his own pace, many students cannot comprehend the concept being clarified.
3. It fails to impart training in scientific attitude.
4. The teacher may follow his (or) her own way of demonstrating.
5. It does not give training in laboratory skills to the students. They do not handle the apparatus (or) perform the experiments themselves.
6. This method is not child cantered.

Role of a Teacher:

The teacher has an important role in this method. This method exposes the students to practical science teaching. Here the teacher should possess knowledge of both the theoretical and practical skill in science in order to be effective.

HISTORICAL METHOD

This method of teaching was developed out of a concern that although each student would not be expected to become a scientist, but each citizen should have some understanding of the role science and scientists and their contribution to society. Here students are exposed to a series of case stories, which attempt to show how context, concept, processes and individual creativity of scientists have combined to establish structure of science.

Approaches of Historical Method

There are several ways of using this method while teaching science. We shall discuss some feasible approaches in the classroom.

- Anecdotal Approach: teacher can start the lesson with an interesting incident of anecdotes from the lives of scientists, eg. Archimedes and Eureka, or Newton and ripe apple falling down.
- Biographical Approach: complete study of the life history and work contributed by scientists such as Raman, Faraday, etc., would be really useful to the students. It would enable students to look into their life and project themselves onto the life experiences of scientists.
- Evolutionary Approach: different theories arranged in a chronological order may be presented as they developed. Eg theories of evolution, classification of the elements, etc.
- Social Approach: scientist have often engaged themselves in tackling the problems of immediate importance and interest to the society. The potentialities of atomic energy for destruction and peaceful purposes are the best examples of science and society relations. Similarly with space research, etc.

Role of a teacher

The teachers role is to guide the students in understanding the history of scientist in cognitive, affective and psychomotor aspects of their life. Teacher has to be a guide and a philosopher to the students.

Advantages of Historical Method

1. Science is viewed as an evolving area of study which is tentative and subjective which is the real nature of science. Eg. Newton's corpuscular theory of light then followed by Huygens wave theory and now Quantum mechanics to explain dual nature of light.
2. Science is humanistic Endeavour and students understand humanness of science. The relation between science and society can be made explicit using this method.

Limitations Of Historical Method

1. It is difficult for science teachers to link the past thinking in science with the current thinking.
2. Difficult to find relevant case histories for different age groups.

3. Inclusion of historical aspects will increase the burden of children as their syllabus is already heavy.
4. Not suitable for a vast number of topics.

III. Pupil centered methods:

Pupil centered method are the following

1. Heuristic method.
2. Project method.
3. Inductive and deductive approaches.

Heuristic Method:

Science is a thing to be talked about but a practical subject and the correct way to touch, sight and hearing. This method was proposed by H.E.Armstrong, Professor of chemistry in London. This method is mainly based on the principles of imparting practical learning of science.

Definition:

According to Prof. Armstrong, ”Heuristic method is a method of teaching which involves our placing the students as far as possible in the attitude of a discoverer”, The word Heuristic is derived from the Greek word ‘Euriskein’ which means to discover and ‘Heurisco’ means to find out of.

Any method which is opposed to dogmatic methods of teaching in which the observing and reasoning powers are most excited; in which pupils work and think for themselves; in which the habits of self-activity and self-dependence are fostered, is called the Heuristic method of teaching.

This method is mainly based on the principle of “Learning by doing”.
Heuristic method basically trains in scientific methodology.

Principle of the Heuristic Method:

The Heuristic method is based on the following principles

i. Principle of learning by doing.
ii. Principle of freedom of activity.
iii. Principle of logical thinking.
iv. Principle of experience.
v. Principle of individual work.
vi. Principle of purposefulness

Procedure of the Heuristic Method:

In this method the teacher assigns a problem to the class, & the students are given equal scope to work out the problem & obtain the solution. They try to solve the problem in a scientific manner. The conduct experiments, collect the data, analyses the data the result & arrive at a conclusion. In this method the student develop solve problem.

The Heuristic method can be fully utilized when the teacher,

- Encourages the process of searching.
- Respects creative thinking.

- Welcomes the new ideas.
- Corrects and checks the mistakes.

Role of Teacher:

Much is demanded of the teacher under this method:

1. Studious: he should be a man of knowledge to give references etc.
2. Attitude of Discovery: should possess curiosity, interest and a spirit of scientific investigation because these are to be developed in the child and hence he should possess it first.
3. Skilled in Questioning: should be able to adept in the are of questioning and should encourage the students to ask questions.
4. Teacher as a guide: working partner, and a friend
5. Maintaining Atmosphere of Freedom: this to develop spontaneity, self-development and self-expression.
6. Planning according to Individual Differences: device plans and procedures according to the age, ability and interest of the pupils.

Advantages:

1. Emphasis is an individual practical work. It makes the child self-reliant.
2. Develops the scientific attitudes, and scientific methodology.
3. Individual attention is/can be given.
4. The method develops self-learning & self-direction.
5. The method is based on "Learning by doing".
6. Based on sound psychological principles and mutual respect and admiration for each others work.
7. Develops the power of critical thinking & logical reasoning in the student.

Limitations:

1. Too much expectation from the children
2. Non availability of book and reference materials as well as infrastructure needed for large scale. Hence economically not feasible.
3. Grading students performance is a problem as Evaluation of learning by this method is very lengthy.
4. It is a time consuming method.
5. The syllabus cannot be completed in the prescribed time.
6. This method is applicable only to enthusiastic teacher.
7. The method requires hard work, efficiency, technical & problem-solving skill in the teacher.

Project Method:

A Project is defined as a plan of action. It is based on the principle of pragmatism. Learning by doing and learning by living are the two cardinal principles of this method. Children learn through association, co-operation and activity.

Definition

A project is a problematic act carried to completion in its natural setting.

- Stevenson

A project is a whole hearted purposeful activity proceeding in a social environment.

- *Kilpatrick*

A project is a unit of activity in which pupils are made responsible for planning and purpose.

- *Ballard*

A project is a unit of activity in which pupils are made responsible for planning and purpose.

- *Parker*

Principles of the project method:

1. The principle of freedom
2. The principle of reality
3. The principle of purpose
4. The principle of activity
5. The principle of experience
6. The principle of social experience
7. The principle of utility.
8. The principle of correlation.
9. The principle of interest.

Types of Project:

According to W.H. Kilpatrick projects are of following four types:

1. *Producer project*: The major emphasis is on the actual construction of a material object or article
2. *Consumer Project*: The main objective is to obtain either direct or indirect experience.
3. *Problem project*: The main purpose is to solve the given problem involving intellectual processes.
4. *Drill Project*: The aim is to learn certain degree of skill.

Another type of classification

1. individual project; 2. group project; 3. construction project; 4. Investigatory project; 5.verificatory project; 6. display project;

The steps in Project Method:

- Providing a situation
- Choosing and proposing
- Planning of the project
- Executing the project
- Judging/evaluating the project
- Recording the project

Example:

1. Formation of ice on freezing – refrigeration and air-conditioning, rain etc.
2. Planning a garden in the school.
3. Various water sources with general reference to existence of water cycle.

Role of a Teacher:

- A friend, guide and a working partner.
- He should learn with the students and should not claim to know everything.
- Provide democratic atmosphere in the classroom.

- He should have thorough knowledge of individual children so as to allot them work accordingly.
- He must be well read and well informed, and should be willing to organize events like field trips, visits to museum, library etc.

Advantages:

1. The method is based on psychological principles of learning by doing.
2. It develops reasoning, analysis and critical thinking.
3. It develops scientific attitude.
4. It develops power of observation.
5. It throws challenge to the students and thus stimulates constructive and creative thinking.
6. It develops self-confidence and self-discipline.

Limitations:

1. The teacher has to be talented and experienced.
2. She should be motivated and flexible attitude to guide student
3. It requires lot of time and can only be used as a part of science work only.
2. Lack of availability of proper resource in school.
3. The project work may hamper regular classroom instruction.
4. Difficulty in finishing the syllabus.

Note : Inductive and deductive method is discussed in detail in chapter III – Learning Science

Laboratory Method

In laboratory method the teacher initiates activity in determining the laboratory exercise, and the students gain the information by doing the experiment. Students manipulate the various variables that are under exploration. This develops scientific attitude in students. The development of powers of observation, measurement, inferences are all dependent on laboratory work. Laboratory is a starting place for the systematic development of science own ideas.

According the *John Dewey*, 'in the hands of a good teacher laboratory is an excellent vehicle for instruction. It gives insight into authentic science. It is intellectually exacting. It requires careful attention during planning, execution and observation. It demands interpretation and abstraction. It couples cognitive activities with hands on action-oriented, concrete operational activities. It is a stimulating change from lectures and other forms of instructions.'

Aims of laboratory method

- Illustration of abstract scientific understandings
- Development of scientific concepts and principles
- Development of scientific skills
- Awakening and maintenance of curiosity about the environment.

Steps to follow for laboratory method

1. Planning
   - Identify need for experiment
   - Plan the experiment
   - Aims and objectives are formulated

- Introduces /demonstrates experiment

2. Execution
- Student perform experiments
- Records observation in observation sheet
- Tabulates observation
- Calculates

3. Evaluation
- Prepares a lab report
- Infers and interprets

Role of teacher

The teacher has an active role in this method. He/she is responsible for smooth conduct of practical work in laboratory. Here the relation between the theory and practice is made to be realized(students) by the teacher.

Advantages of laboratory method

- Develops skills in the uses of laboratory equipment is a worthy goal.
- Provides opportunity to view science, as it is practiced rather than merely reading or hearing about it.
- Students gain real experience with the processes of science.
- Develops self-confidence and a sense of achievement.
- Sound psychological principle of 'learning by doing'.

Limitations of laboratory method

- It is not an efficient means of learning new, factual information of the form that appears in external examinations.
- Often resources are not available to present laboratory exercises.
- There is a strong possibility that well designed demonstration will be more beneficial than a poorly defined laboratory.
- It is an expensive method of teaching and learning as many number of similar items are needed to organize sufficient laboratory activities.

Problem Solving Method

This is another method of discovery. This method is useful as it discourages traditional approaches like demonstration and laboratory methods.

Problem solving involves the use of reflective thinking or reasoning. Problems can also be solved through trial and error.

Definition

Problem solving in teaching refers to the task making decisions or doing things that the learner wants to make or to do, the nature of which he is able to understand but for which at the time he has no solution. - Hammonds

Problem solving is a planned attack upon a difficulty for the purpose of finding a satisfactory solution. - Risk T M

The desired outcomes of using this method are to develop

- A curious mind alert to unfamiliar situation
- An investigatory spirit to form some plan of attack
- A courageous spirit and open-mindedness to react to conclusions

Steps in problem solving method

1. identifying and defining the problem
    - identification of problem after survey
    - statement of problem
    - explanation off the problem
    - delimitation of the problem
2. Formulating hypothesis for investigation
    - Review of related literature
    - Identify possible causes
    - Guess possible relationships between variables
    - Outline a laboratory procedure
3. Testing the hypothesis
    - Collecting data
    - Tabulate data
    - Make relevant calculation
    - Interpret data
4. Drawing conclusions and generalizations
5. Problem solved

Role of teacher

Teacher's role here is complex. Teacher and student have to work on a voyage of discovery which is neither too complex nor too long. He has to constantly motivate, give direction and sustain interest among all his students. He should be the friend, philosopher and guide to the students and should give judicious individual attention to all the students.

Advantages of problem solving method

- This nature causes the pupil to learn things for himself by use of his own powers and this is the aim of true education.
- Psychological base of learning which helps in fusing and correlating students knowledge and experience.
- Life is full of problems and this approach helps the pupils to develop the potential to solve problems of life scientifically and systematically.
- Develops habits of planning, thinking, independent learning and reasoning.
- Here learner is an active participant and is motivated for independent study.
- It takes into account individual difference and there is no time limit for achievement. The importance in given to completion of the task.

Limitations of problem solving method

- It requires lot of time and energy.
- An inexperienced learner may draw wrong conclusions and find out wrong solutions.
- Requires teachers with expertise to guide students in the right direction.

This method is not suitable for smaller classes.

Unit VII

PHYSICAL SCIENCE CURRICULUM
Meaning, Nature and Principles of Curriculum Construction
Defects in Existing School Science Curriculum.
Qualities of a good Science Textbook.

Meaning

According to Siddiqui (1998), Curriculum for teachers means, a package of instructional materials like a. syllabus b. textbooks c. teacher guides d. kits e. kit guides f. test items along with scoring key g. slide tape programmers and h. films for teacher training.

The word curriculum is derived from the Latin word 'currere' which means 'to run'. So the curriculum means a course to be run for reaching a certain goals.

Curriculum as an aid in the process of adjusting the child to the environment in which he functions from day-to-day and in the wide environment in which he will have to organize his activities later. - K G Saiyidain

Curriculum is a tool in the hands of an artist (teacher) to mould his material (pupils) according to his ideals (aims) in his studio (school). - Cunningham

Vaidya N C curriculum is an evolving concept. It is always in the making, being more in the nature of a process than a finished product. It is supposed to inform us what to teach before we can consider methods and approaches to teaching and the age at which the various ideas have to be introduced. He says it would be futile to talk, 'how' and 'when' to teach without first deciding 'what' to teach.

Purpose of Curriculum

Curriculum is considered to be the sum total of all the experiences which have to be provided for the good of the individual and the society. Hence the purposes that curriculum serves are:

- To provide pupils continuous meaningful experiences from the first day at school till the last day.
- To use all approaches for the teaching of science like process approach, conceptual approach etc. in addition to factual approach.
- To emphasize both the technical applications and pedagogical principles of the discipline.
- To provide an insight into all paradigms of the structure of science i.e. philosophical basis, history, methods of inquire, schemes etc.
- To devise and suggest techniques to cater to individual differences, abilities, needs and interest of students.

- To integrate local skills and community resources with school teaching, learning process.
- To provide built in mechanisms which provide for its continuous and critical re-evaluation.

Principles of Curriculum Construction

- Principle of Child-Centeredness: Age of the child, interest, aptitudes, abilities and socio-economic backgrounds.
- Principle of need: Pupils physical, social and emotional needs. (rural and urban children differ in their needs).
- Principle of community-centeredness: Should be relevant to the needs of the society.
- Principle of Integration: child's needs and activities on one hand and needs of society on other such that a child can lead an individually satisfying and socially useful life.
- Principle of Conservation: help in preserving and transmitting the traditions, standards of conduct on which the culture and civilization depends.
- Principle of Utility: application in day-to-day life of the child.
- Principle of Elasticity and Variety: should be flexible enough to carter to different types of students.
- Principle of Totality of Experience: facilitator of total experiences needed for a child.
- Principle of individual interests: creativity, interest, vocational requirements innate abilities and leisure time pursuits etc.
- Principle of activity centeredness: learning by doing.

Defects in Existing School Science Curriculum

Science curriculum of India is a subject centered curriculum which is considered to be jumbling of facts from different branches of science in an unorganized and un-psychological manner.

The present science curriculum suffers from the following defects:

- It is subject-centered and topical. Science curriculum is loosely packed with varied topics from physics, chemistry and biology. It is very bookish and academic and lays more emphasis on acquisition of knowledge and pays little attention to application to daily life.
- It is not in conformity with the aims and objectives of science as it is more confined to cognitive domain and mostly to the knowledge specific objective.
- It is examination ridden
- Curriculum does not provide for a variety of experiences and activities.
- It is cut off from the real life of the child and does not satisfy either vocational requirements or needs of the society.
- It is not built on sound psychological principles and does not take into account individual differences. (Gifted & backward students are completely neglected).

<u>Needed action to Improve Science Curriculum in India</u>

The reorientation of science curriculum should be done keeping in mind the following criteria:

- The topics chosen should be in conformity with the aims of science teaching and should be able to achieve objectives under all the three domains i.e. cognitive, affective and psychomotor.
- Curriculum should be flexible enough to cater to different groups of students – rural, urban and gifted/average/slow learners.
- Provisions should be made in curriculum to provide experiences, which lead not only to the 'mastery of the subject' but also to the mastery of the 'processes of science' and 'skills of science'. Students should be taught 'how to think' rather than teaching them 'what to think'.

- Curriculum should provide variety of experiences that leads to the all round development of the child.
- Should be 'activity-centered' as far as possible.
- Should be based on sound psychological principles and logical sequence.
- Should integrate with the condition between different subjects evidenced and application with life highlighted.
- Syllabus should be flexible so that teachers can frame their own experiences keeping local needs, resources and materials in mind.

Qualities of Good Science Textbook

- Help to develop a correct understanding of the basic concepts and principles of science.
- Inculcate scientific attitude in the pupils. It should develop in students' open-mindedness, scientific temper and rational thought.
- Provide opportunity fro students to understand the steps of scientific method.
- Illustrate every scientific concept with real life applications and show clearly the correlation between science and child's daily life.
- It should be able to suggest activities which children could try with improvised aids and ultimately lead to development of science process skills.
- Help to add to classroom instruction additional information make understanding better.
- Provide variety problems so that by solving them students' problem solving skills, which is also an important aim of science teaching – learning, are enhanced.
- Helps students to recapitulate and revise what they have learnt in the classroom. It should help them to prepare for exams and tests.
- The figures and diagrams should be able to help students visualize abstract concepts.
- It should motivate students to investigate and discover scientific facts, concepts and principles by themselves.

Characteristic of a Good Science Textbook

- Author: Qualification and Experience
- Mechanical features of the Textbook: style, paper, printing etc.
- Subject Matter – Nature and organization:

1. The book should be organized keeping in mind logical and physical styles of arrangement, i.e. interest and mental age of students.
2. Content should confirm to the goals, aims and objectives.
3. Content should be presented as integrated whole.
4. Each chapter should begin with introduction and end with conclusion.
5. Each lesson should have thought provoking questions, application-oriented assignments, suggestions for project work etc.
6. Vocabulary used should be understood by most of the readers and sentence construction should be precise and simple.

Unit VIII

Team Teaching

Team teaching involves two or more teachers form a team and teach a special topic by sharing among themselves. Here experts in a particular methodology will be teaching and hence effective and teaching will become a shared enterprise.

Programmed learning

'Programmed learning is the arrangement of materials to be learned, in graded steps of difficulty, in such sequence, and in such manner of presentation that it will result in the most efficient rate of understanding and retention'.
A programme is the subject-matter to be learned by the pupils. Programming is the process of arranging materials to be learned by the student into a series of steps arranged in logical or psychological sequence and meaning, from concrete to the abstract, from the familiar to the new.
It is primarily based on the principle of 'reinforcement'. This system makes it possible to accomplish the important critical functions of teaching without the presence of a teacher. The programmes may be in the form of books, cards and machines.

Principles of Programmed Learning

1. Principle of small steps
2. Active participation
3. Self-paced
4. Immediate feedback / reinforcement
5. Individualised learning

Types of Programmes

Generally two types of programmes are in use

1. Linear (B F Skinner)
2. Branched (S L Pressy and N A Crowder)

Linear programming

This is characterised by:

(a) a stimulus in the form of a statement and a questions (S)
(b) a response by the pupils (R)
(c) an answer against which the pupil matches his own answer and receives immediate feedback whether he is right or wrong, (A) and
(d) a linear sequence which everybody must follow. The student must understand the preceding frame in order to proceed to the next.

The linear programme is diagrammatically shown below:

Branched programming

In branched programming there is provision for diagnosing errors and to provide corrective feedback. The assumption is that wrong response does not necessarily hinder the learning a correct one. Similar to the linear programming the branched programming also contains questions (stimulus) response and answers. Crowder used intrinsic programming in which multiple choice items are employed. The mistake made by the pupil in answering questions is used to build knowledge and skill. Here specific directions are given to help him find the right answer when he makes a mistake.

Merits

(a) It provides for a learning environment that encourages the child to be motivated intrinsically.
(b) It permits each child to progress at his own pace.
(c) It helps each child to learn according to his interest, abilities, and mode of learning.
(d) It increases experiences for investigating by each child..

Demerits

(a) Individualized instruction requires a small class.
(b) It needs increased time for the teacher to prepare and collect materials.
(c) Materials for individualized instruction are not available.
(d) It requires well equipped science laboratory as well as other physical facilities.

Community resource in teaching science

- Community halls and grounds to organize science exhibitions and fairs.
- Planetarium, Science museums etc
- Community TV, Radio, etc. can be borrowed in special cases for certain special broadcast.
- Internet centers which can be used.
- Library facilities available in the community.

Computers in teaching of science

A. Individualised instruction in terms of programmed learning. (Computer Assisted Learning, Teaching Machine etc).
B. Computer animations help in developing easy understanding of complex process.
C. Power point presentations help to teach effectively with live pictures.
D. Computer can be used as media player through which video and audio can be displayed / broadcasted.
E. Its ability to store data and can be used repeatedly whenever needed makes it an added advantage to use computer.
F. Printers, Scanners, etc all help in collecting live models and store data's as well as make multiple copies without loosing its original colour and this makes it an effective tool in teaching.
G. Internet helps in bringing the world into ones own computer.
H. Research data's from different parts of the world can be shared with the use of computers.
I. Scientific journals, books, dictionary, live shows etc are easily available.
J. Possible to interact with different personalities (scientists, researchers etc) without being necessary to travel.

Display ones own findings and studies to the world.

Unit IX

NON-FORMAL SCIENCE TEACHING
Role of Voluntary Science Organizations in Popularizing Science.
Science Clubs
Fairs

Science Museums
Science Exhibitions
Science in Every Day Life with reference to Controlling Pollution Protection of Environment

Role of Voluntary science organizations in popularizing science

The progress of any country depends on the advancement of science and technology. Science is a way of life; it is a philosophy of searching for truth with reasonable universal acceptance by establishing validity of day-to-day life situations. It tries to establish the cause and effect relationship or through statistical information. Scientific outlook is needed in modern world. Scientific temper has to be developed among all citizens.

The non-formal education sector has a lot to contribute. They can at the outset create awareness among the people on the need for scientific outlook and scientific pursuits. Science needs to be popularized among the masses and concerted efforts are needed. Voluntary group / organisations can be instituted for this purpose college teachers and students can give leadership and pave the way. School science teachers can also play a major role in creating scientific outlook not only among children but also in the community.

Nehru Yuva Kendra Sangathan

- It is an autonomous body under the Ministry of Youth Affairs & Sports, GOI.
- Organise meetings for rural youth and prepare them to play a constructive role for the development of their communities and villages.
- There are 500 kendras, one in each district HQ
- Over 3 lakhs youth organisations spread over the country.
  Wide network of village organisations include **:** Village youth club and Mahila Mandals with mandates to cover 150 million non-student rural youth called Sangathan (largest grass root organisations in the world).
- It functions as the governments implementing body for a major quantum of the mobilizing and developmental activities for non-student rural youth.
- It undertakes various developmental / awareness activities throughout the district by actively involving the Youth Clubs and Mahila Mandals in close coordination with district administration and development departments.
- Programmes for districts are well planned as the programme schedule for the entire year is finalized with consultations of District Presidents, Active NGOs and chaired by District Commissioner/collector.

Jawahar Bal Bhavan

- It is unique institution for developing creativity among age of 5 to 16 years.
- Established and inaugurated by Smt. Indira Gandhi on 23rd June 1966 to provide opportunities to school children for their all round development through recreational activities.
- Promote social and cultural contacts among students and to inculcate such values.

- Develop modern Indian personality with a scientific temper and to publish children literature.
- The Bal Bhavan movement has grown throughout the state and as on date there are 12 Bal Bhavan (full time) and 34 Bal Kendras (part time) working under the chairmanship of District Collectors besides state Level Institutions at Public Gardens, Hyderabad.
- Children are being trained through different media of Dance, Music, Drama, Creative Arts and Crafts, Instrumental Music, Computers, Karate, Skating, Clay Modelling and Screening of Film Shows.

Functions and Services

- Providing a second line of education to children in performing and non-performing arts and crafts during leisure time of children.
- Conducting Inter-School Competitions, children Theatre Workshops, State and National Theatre Festivals.
- Awards to Gifted Children: Recognition of Balananda Sanghams with affiliation of District Bal Bhavans and Bal Kendras spread throughout the State as Activity Center.
- Developing and Publishing of Literature with illustrations of children.
- Preparation of Children's Encyclopedia.

National Council of Science Museums (NCSM)

Nehru Science Center – Mumbai

National council of science museums, has 29 science centers / Museums all over the country, has the best infrastructure and skilled manpower to conceptualize, design, develop and organise high quality science exhibits and other related educational programmes and activities.

- Nehru science center, among the four National level Science Museums in NCSM
- It is working as the Western Zone HQ with 5 science centers in Nagpur, Calicut, Bhopal, Dharampur and Goa.
- Organises regular extensive science education programmes, activities and competitions for the benefit of the common people and students in particular.
- It was first conceived as a Science and technology Museum in late 1960 took final shape as India's largest interactive science center in1977.
- The center opened its first semi-permanent exhibition 'Light & Sight' in 1977.
- The world's first ever Science Park was established in 1979, during International Year of the Child.
- Late Mr. Rajiv Gandhi opened the full-fledged science park to public on 11-11-1985.
- It is the largest science center in the country has sprawling 14 acres of Science Park, more than 50 hands-on and interactive science exhibits on energy, sound, mechanics etc.
- It also houses several permanent science expositions on various themes.
- Over 600,000 people visit it every year, situated on Dr. E Moses Road, Mumbai 400018 in between Worli Naka and Mahalaxmi Railway Station.
- The center provides a natural and free environment for students to learn, familiarize and spend creative environment for students to learn, familiarize and spend creative holidays and for professionals in the field of science education to have a glimpse of innovations in science education.

- Close to 1,20,000 school children alone participate in the activities of the center.
- It incorporates innovative ways to communicate science to enthuse, entertain, initiate, excite and bring the developments of science and technology to the doorstep of common people.
- It promotes prosperity, awareness, and improving the quality of life.
- The center attempts to enhance public understanding of science and spread scientific literacy.

B M Birla Science Centre, Hyderabad

There have been many who have spoken of the need to put India on the technological map of the world. But only a few, barely a handful, have made any real effort to turn the thought into action. B M Birla was one of them, a man of vision, who dreamt his thoughts and turned them into reality. He was one of the pioneers of India's industrial growth; his dream was to see India at the forefront of the nations of the world. He realized that this could be achieved only if the masses of our country were made scientifically aware to the point where they would start harnessing technology for prosperity. It is for this reason that he started a number of scientific institutions like Birla Institute of Scientific Research, and several others.

Objectives

- To involve science in everyday life by creating scientific institutions which would break new ground and generate interest in the minds of average child or adult.
- To make scientific learning easy and joyful, which would generate curiosity and motivate people to greater involvement.
- To recapturing the spirit of mental adventure, making the masses scientifically aware.
- To enthuse the students about science and involving them in exciting and participatory scientific activities, so that when they grow up they can contribute meaningfully to the development of Indian Science and Technology and progress.

Functions

- Planetarium, is a center of attraction
- Centre for Applicable Mathematics and Computer Science.

Science Club

Science club movement in India is of recent origin. It began in 1957-58 under the auspices of the directorate of extension, primary and secondary education, DEPSE that assisted financially to the tune of Rs.1,200 per science club in the country. But economic situation and examination oriented curriculum have not helped in the growth and development of science clubs.

Aims and Objectives of a Science Club

- ✓ To arouse interest towards science.
- ✓ To popularize science among laymen.
- ✓ To create an awareness of science and recent developments in science.
- ✓ To explore local resources and to learn to maintain and protect the environment.

- ✓ To encourage critical thinking and keen observation.
- ✓ To develop heuristic (discovery) ability.
- ✓ Develop scientific skills like observation, manipulation, drawing, experimentation and improvisation.
- ✓ To carry out additional/supplementary experiments not possible in regular class timetable.
- ✓ To develop interest in scientific hobbies which have daily life applications.
- ✓ To develop scientific attitude.

Activities of the Club

- ➢ Science talks by experts.
- ➢ Organising field trips
- ➢ Science corner
- ➢ Science museum
- ➢ Science bulletin board
- ➢ Science projects
- ➢ Preparation of improvised aids
- ➢ Science quiz competitions
- ➢ Debates
- ➢ Organising science fairs
- ➢ Publishing in-house magazine, newsletter
- ➢ Community and social work

Role of Teacher

- o Should act as the co-coordinator and advisor**.**
- o Focus pupils' attention towards desired outcomes.
- o Use techniques to whet students' appetite (awards, prizes, social approval etc.)
- o Always emphasise the instrumental behaviour (reading, writing, computing, critical and creative thinking).
- o Arrange for activities based on abilities of learners.
- o Avoid extreme tensions and unorganized activities.
- o Utilise suspense and discovery to develop curiosity, interests and right aptitudes.

Organisation of Science Club

Facilities available within the institution.

Types of clubs: facilities electronic club, nature study club, chemistry club, physics club, photography club etc. could also be organized.

Science Fairs

A students interest is aroused when he can apply and utilise knowledge gained in real life experience. Student feels satisfied when he finds his study useful. It is the science teachers duty to provide learning experiences and create an environment conducive for doing science.

A science fair is a useful activity for improving science instruction. It serves as a forum for the display of useful activities carried out in the science club. Pupils learn about science in association with other pupils.

A science fair provides an occasion for the parents and community people to become acquainted with the schools activities.

NCERT conducts science fairs at different levels all over the country and lists the objectives of science fair as:

- To give impetus and encouragement to the students to try out their ideas and apply their classroom learning to creative channels.
- To provide opportunities to students to witness the achievements of their colleagues and there-by stimulate them to plan their own projects.
- To popularize science activities among all so that further improvements in standards of performance may be achieved.
- To give encouragement and recognition to the bright and energetic students who have special talent.
- To identify and nurture the future scientists of India.
- To provide the much needed forum for the activities of the science clubs.
- To make the people of the community to get associated with the school.

Purposes of Science Fair

- To stimulate a greater interest in science among pupils.
- To focus attention on science experiences in school.
- To stimulate a greater investigation over and above the routine class work.
- To provide stimulation for purpose of scientific hobbies.
- To offer an opportunity to students for display of their scientific talents through exhibits and demonstrations.
- To recognize and encourage pupils creativity and scientific talents.

Levels of Science Fairs

- Institutional level
- District level
- State Level
- Regional level
- National level

Organisation of Science Fairs

The following may serve as a guideline in organising science fair:

Planning
- Aims and objectives of the fair
- Themes and sub-themes of the fair
- Financing and sponsorship
- Place, time and duration of fair
- Procedure to be adopted
- Other miscellaneous aspects and facilities.

Distribution of work: to individuals, and various groups or committees. etc. some common committees are

1. Honorary or advisory committee: principal, administrators, elders etc

2. Central committee: its duty is to develop plans for staging of events. It would decide on date, venue, timings, entries, display arrangement, judgement, finances and rules of fair. It would co-ordinate the duties of all other committees.
3. Executive committee: it comprises members from sponsoring bodies which would approve the plans developed by the central committees.
4. resource committee: it assumes responsibility for arranging, advertising and conducting area meetings of teachers and children to advertise and clarify the details regarding the fair.
5. Promotion committee: their job is to aid general advertising.
6. Placement committee: arrangement of display of tables, utilities and facilities and dismantling after completion of fair.
7. Administrative committee: It is incharge of mailing, registration, enrolment and record keeping during the fair.
8. Judgement committee: it fixes judges, assigns them to various themes and sub-themes, monitors judgement and finally prepares award list and presents prizes.
9. Program Committee: this arranges the opening and closing ceremonies and award ceremony.
10. Volunteers committee: it organizes help to students, control crowds and helps in proper organisation of the fair.

Pre-science – Fair Activities:

1. themes / sub-themes
2. area
3. date and publicity
4. exhibit space
5. science fair listing of entrants- it is good to prepare a tentative list of entrants to the fair.

Execution of science fair:
Safety and first aid
Judging
Evaluation

Advantages Of Science Fairs

a. It can be a motivating force for individual projects as well as for class work.
b. It helps youth to utilise the time in a constructive way.
c. It provides a wonderful opportunity for discovering and encouraging science talent.
d. It is an excellent device for ensuring that scientifically minded youth have the opportunity to indulge in activities that gear them to become scientists of tomorrow.
e. Since it provide an excellent method of sharing science projects of individuals, small groups, or entire classes with other students within the school, other schools in a community, parents and other members of the community.

Excursions

It creates a sense of aesthetic fulfillment in the child. It positively encourages learning of science. It develops awareness among students and sensitizes the importance of science in daily

life. It also gives an direct on the spot experiencing scientific phenomena for the student. E.g. factory etc. It also helps to reinvent the past of various scientists and their achievement. e.g. visiting museums etc. develops co-curricular and extra curricular activities.

Science Exhibition

Science in Every day life with reference to controlling pollution, protection of Environment

- Developing critical awareness
- Enhancing knowledge through different modes other than classroom
- Gaining more knowledge about pollution
- Sensitizing people about ill effects of pollution
- Develop a positive attitude towards change.
- Helps to practice environmentally accepted norms.
- Motivating others to be environmentally sensitive

Develop oneself to be an inspiration and a role model

Unit X

Concept and Process of Evaluation

Kothari Commission says, 'Evaluation is a continuous process. It forms an integral part of the total system of education, and is intimately related to educational objectives. It exercises a great influence on the pupils study habits and the teachers methods of instruction and thus helps not only to measure educational achievement but also to improve it. It is a means of gathering evidence about students development in desirable direction.

Dandekar defines evaluation as a systematic process of determining the extent to which educational objectives are achieved by pupils.

R C Sharma defines evaluation as a continuous and comprehensive process which takes place in the school and outside the school, and involves the participation of the pupils, teachers, parents and community with a view to make changes in the child and in the whole education process.

Evaluation can be comprehensively defined as the process of determining the extent of realization of predetermined educational objectives and the effectiveness of the teaching-learning experiences provided in the classroom in terms of behavioural development and placing a value upon the educational accomplishments.

Evaluation = Measurement + Value + Judgement

Evaluation is a continuous process – throughout the lesson, unit and the course.

Types of Evaluation

- Diagnostic evaluation
- Formative evaluation
- Summative evaluation

Process of Evaluation

The process of evaluation consists of the following stages:

1. Identifying and defining general objectives
2. Clarifying and defining specific objectives
3. Choosing appropriate learning experiences
4. Developing and adopting suitable assessment procedures
5. Evaluating the outcomes on the basis of evidence collected
6. Modifying necessary aspects of the system for better results.

Tools of Evaluation

1. Achievement test
2. Personality test: paper pencil test & projective techniques
3. Intelligence test
4. Aptitude test
5. Interest inventories
6. Teachers observation
7. Interview
8. Sociometry
9. Records: Cumulative; Anecdotal; Diaries; Autobiographies; Case history etc.
10. Inquiry forms: Questionnaire; Checklist; Rating Scale.

Achievement test

There are two type of achievement tests: i) teacher-made test, ii) standardized test.
Teacher-made tests are further categorized into three types:

1. Oral test
2. Written test: i)essay type ii)short answer type iii)objective type
3. Practical test

Teacher - Made Test	Standardised Test
Used to evaluate the content and outcomes of the school curriculum	Used to evaluate common content and outcomes of a number of schools.
Quality of test items is unknown.	Quality of test items is known
Cannot be reliable in all cases.	Reliable most of the time
Flexible in administration.	The administration produced is standard based on given instruction.
Scores cannot be compared with another sample or context.	Scores can be compared on norm groups.

Preparation of Scholastic Achievement Test (SAT)

Achievement may be defined as a change in the behaviour in a desired direction. It is an important and essential constituent in the process of evaluation.

Assessment involves collecting information about student knowledge, skills or abilities. An achievement test is a formal assessment. The test helps the teacher to understand the level of comprehension of the students in a particular subject and allows them to know the capabilities of the students.

Good defines achievement test as a tool that is designed to measure a person's knowledge, skills, understanding etc., in a given field taught in school.

Achievement means one's learning attainments, proficiencies, accomplishments, etc.

Assessment involves collecting information about students' knowledge, skill and abilities. An achievement test is a formal assessment. The test helps the teacher to understand the level of comprehension of the students in a particular subject and helps him to estimate the capabilities of the students.

Steps in the construction of achievement test

- Planning the test
- Preparing the blueprint
- Designing questions and editing question paper
- Administering the test
- Scoring the test
- Evaluating the test

Achievement test helps in identifying:

- The capabilities of students in developing the required skills.
- The ability of the teacher in developing the required skills.
- The proficiency level of the individual students.
- Comparison between the scores of individual students of the school.

Meaning and Definition of Achievement Test:

"Achievement test as a test designed to measure the effects of specific teaching or training in an area of the curriculum."

- ***International Dictionary of Education***

"Achievement test is a test designed to measure a persons knowledge, skills, understandings, etc., in a given field taught in school." – ***Good***

"A test designed to measure the effects that learning and teaching have on individuals is called an achievement test." – ***Collin***

"Any test that measures the attainments or accomplishments of an individual after a period of training or learning is called an achievement test." – ***N.M. Dousine***

"The type of ability test that describes what a person has learned to do is called an achievement test." – ***Thorndike and Hagen***.

Important Features of Achievement Test:

- Achievement tests measure the modification of behaviour brought about by learning behaviour of the students.
- It is a standardized test to suit the needs of the students.
- It is based on the difficulty level of the students and contains a number of test items.
- It contains various items on different domains of knowledge, skill and application.
- It provides equivalent and comparable items of the test.
- A test manual is provided for administering and scoring the test.

Functions of Achievement Tests:

- To measure the knowledge gained by the students.

- To promote the students to the next higher class.
- To motivate the students for further learning.
- To place the students in different sections according to their performance level.
- To test the teaching efficiency of the teacher.
- To identify the strengths and weaknesses of the students and provide remedial measures.

Preparation for a Unit Test:

The construction of an achievement test can be divided into the following steps:

- Planning the test
- Building the Blueprint
- Framing the questions and editing the question paper
- Administering the test
- Scoring the test
- Evaluating the test

Planning the Test:

At present unit test plays an important role, as an achievement test, in most of the schools, has to administer after the completion of each unit in the syllabus. To make the unit test an effective instrument of evaluation it has to be planned in a systematic pattern well in advance. The first step in planning is setting of clear objectives. It should test those objectives, which come under the domains of knowledge, understanding, application and skills. Specifications about the portion of syllabus, which has to be tested, clearly pointed out.

While planning the test the teacher has to consider important points like:

- Purpose of the test
- Test specifications
- Weightage to the instructional objectives
- Weightage to the content prescribed
- Weightage to various questions like essay type, objective or short answers.
- Weightage to difficulty level
- System of options
- Division of test paper into various sections.

The purpose of the test:

- The teacher has to identify the exact purpose of conducting the test, whether the test is diagnostic, formative or summative.
- Once the purpose of the test is decided, the type of the test to be administered has to be properly planned.

Developing Tests Specifications:

This comprises the following:

- A list of instructional objectives
- An outline of the course content
- A two-way chart depicting the Weightage distribution to different areas of the content.

Distribution of Weightage:

After determining the objectives, content, and the number of the test items, it is important to give due weightage to the above aspects by making sure that all the aspects are covered.

Objectives should be defined in terms of the behaviour change and each behaviour change in turn should be given due weightage.

A two dimensional chart should be prepared to facilitate the distribution of test items under particular behaviour and content. This chart will serve as blueprint for the reference while constructing the test. The guides how many test items should be designed under each topic and the respective behaviour change. The chart ensures the proper coverage of the content as well as the objectives.

Planning the test

One has to have clear objectives for which one is going to frame the test.

Weightage to content means deciding upon the relative importance of topics and sub-topics and allotting marks accordingly.

Weightage specified to different objectives:

The important objectives of the teaching are knowledge, understanding, application and skills. Due weightage should be given to each and every objective included in the unit plan.

Table for Weightage to objectives

Objective	Marks	Percentage
Knowledge		
Understanding		
Application		
Skill		
Total	25	100

Weightage given to the content:

A teacher has to identify the important points in the lessons of the content while giving due weightage to the content. Due importance should be given to all sub-units of the content taught in that unit.

Table for Weightage to content

SI. No.	Unit	Marks	Percentage
1	Unit I		
2	Unit II		
3	Unit III		
	Total	25	100

Weightage to Different Types of Questions:

Different types of questions are used to test the achievement of different objectives. A single type of questions may not be able to test all the objectives. Hence a combination of essay type, short answer type and objectives should be judiciously framed.

Table for Weightage to type of questions

Questions	Marks	Percentage
Essay		
Short Answer		
Very Short Answer		
Objective Type		

Total	25	100

Weightage to Difficulty Level:

A class consists of students whose level would be above average, below average and average. Depending upon the individual capabilities of the students a teacher has to set the question paper with average, easy and difficult questions in right proportions. The questions set in the examination should be neither too tough nor too easy for the students to attempt. A test should contain about 25 % difficult questions, 25 % easy questions and about 50 % average questions.

Difficulty Level	Marks	Percentage
Easy		
Average		
Difficult		
Total	25	100%

Preparing the test:

Once the total number of test items and weightage to the objectives and content are decided, the preparation for the test should then start.

While preparing the test, the following points should be kept in mind:

- Different types of test items should be given.
- The different questions should be categorized into different groups. Eg: Essay type, short answer type etc.,
- The test items should be given at a 50 % difficulty level.
- The test items should be clear and properly structured. It should be easily understandable and should determine the entire answer.
- Appropriate directions for answering the question paper should be provided. They should be clear, precise and complete.

Preparation of Blue Print

A blue print is essentially a three way grid, with the content spread along the vertical axis and the objectives to be tested along the horizontal axis. The three dimensional chart covers: i) objectives to be tested, ii) subject matter to be covered, iii) form of questions.

The blueprint is a plan, which provides the details of the design of the question paper in concrete terms. It gives in concrete terms an assurance that the achievement test being conducted will be a measure of learning outcomes and the content knowledge of the students in a balanced manner. The blueprint is prepared in the form of a three dimensional table with appropriate specifications. The blueprint is a three-sided grid, with the content spread along the vertical axis and the objectives to be tested along the vertical axis and the objectives to be tested along the horizontal axis. The three dimensional chart covers the following:

- Instructional objectives
- Topics to be covered
- The type of questions given

The blueprint depicts the weightage given to the above areas in terms of marks or points. There are many advantages of the blueprint. Some of them are given below:

- It helps in improving the validity of the content of teacher made tests.
- It clearly defines the scope and value of the tests.
- It relates objectives to the content.
- It presents a clear picture that the test will measure the learning outcomes and the course content in a balanced manner.
- Blueprint increases the objectivity of the test.

Content/ Objectives	Knowledge			Understanding			Application			Skills			Total Marks
Topics	E	SA	O	E	SA	O	E	SA	O	E	SA	O	

E – Essay type questions
SA – Short Answer type questions
O – Objective type Questions

Designing questions

On the basis of the blueprint prepared, questions are pooled up keeping the general objectives and specifications in mind. A teacher should be able to correlate objectives and subject matter.

Framing the Questions Paper:

The question paper is set only after the finalization of the blueprint. Questions should be based on the requirements given in the blueprint by giving utmost importance to thee objectives and the content.

Two options are given to the students, internal and external. In the external type of option, students are given choice. Eg: they may select some six questions out of ten given in the test. But in the case of internal option, students have an option within the question.
For example: there would be a) and b) for the same question. The students may choose either a or b.

Following criteria should be taken into consideration while framing the questions:

- It should have the specific objectives.
- It should relate to the specific content.
- It should be designed according to the requirements of the blueprint.
- It should stimulate the process of thinking
- It should maintain the desired difficulty level.
- It should be very clear in its scope and the length of the answer.

Administering the test:

The success of any achievement test is based on the proper administration and conduct of the test. Poor planning of the administration process may leads to poor results. Therefore it is

important to see all the aspects before hand for the conduct of the like the time of the test, period of the test, place of test, mode of instructions etc.

The following suggestions should be followed while administering the test:

- The required instructions may be given orally or in written form before commencement of examination.
- The basic physical facilities like light and ventilation should be provided.
- Appropriate seating should be provided.
- Sufficient time should be provided to the examinees for completing the answers.
- The invigilators should take into account the general problems of the examinees and not to concentrate on some group or individual examinee.
- The test should be conducted in a peaceful environment.

Scoring key and marking scheme

For all the questions found in the question paper scoring key should be prepared. Marking scheme indicated, the number of points expected for the answer, outline of each point or answer and Weightage to each point.

Item analysis

After the test each question and its answerability by the students is analysed. This helps in determining the difficult value of each item; the discriminating power of each item; and the effectiveness of distracters in the given item.

Q. No.	Sub Unit	Objective	Specification	Type of Question	Marks allotted	Discriminative level	Difficulty level
1		knowledge	Recall	Objective	1		
2					1		
3			Recognise		1		
4		Understanding	Identify		1		
5							
6							
7							
8				Objective	1		
9					1		
10					1		
11					2		
12			Describe	V S A	2		
13			List out		2		
14							
15							
16		Application	Derive	S A	5		
17		Skill	Solve	S A	5		
18		Understanding & Skill	Draw & Explain	Essay	10		
	Total	--	--	--	30		

Characteristics of a Good Test

GOOD TEST

Technical Criteria	Practical Criteria
Reliability	Ease of administration
Validity	Cost
Objectivity	Time Frame
Discrimination	Acceptability
Standardization	Scoring and Interpretation
Norms	Usability
Clarity	Gradation

Characteristics of a Good Test:

Validity:

The test should perform the function that it is meant to. It should not measure the things, which are not required.

For example:

The test meant for testing the scientific knowledge should not measure the arithmetical or linguistic ability of the student.

Reliability:

A good test should be reliable, that is it should be repeatable and work similarly with similar groups. A particular student should score same points even if examined by different examiners at different times. The difference in the score should be negligible.

Objectivity:

The test should score, irrespective of the persons who are scoring it.

Practicable:

The test should be practicable, that is the students should be provided with sufficient time to complete it. It should neither be too lengthy nor too short. Students should be busy all through the test and this is also good from disciplinary and administrative angle.

Easy Scoring:

The test should be made in such a way that the conventional type of scoring should be minimum. The test should be provided with keys for automatic evaluation. It should not be subjective.

Clarity:

Instructions given in the test should be precise and concise. It should not mislead the student in any way. The language used in the test should be simple and understandable.

Comprehensive:

The test should cover the whole syllabus. Care should be taken to cover each topic in the syllabus.

Analysis and Interpretation of Scores

The teacher after marking the answers of all the students puts up various statistical calculations to get a overall input about the performance of individual and the class as a whole. The following are some statistical methods which could be adopted by a teacher.

- Mean, Median & Mode
- Standard Deviation, Quartile Deviation, & Mean Deviation
- Range, Correlation, Percentile
- Skewness & Kurtosis
- Normal Probability Curve

Mean, Median & Mode

In mathematics, an average, or central tendency of a data set is a measure of the "middle" value of the data set.
There are many different descriptive statistics that can be chosen as a measurement of the central tendency of the data items. These include arithmetic mean, the median and the mode. Other statistical measures such as the standard deviation and the range are called measures of spread and describe how spread out the data is.
An average is a single value that is meant to typify a list of values. If all the numbers in the list are the same, then this number should be used. If the numbers are not the same, the average is calculated by combining the values from the set in a specific way and computing a single number as being the average of the set.
The most common method is the arithmetic mean but there are many other types of central tendency, such as median (which is used most often when the distribution of the values is skewed with some small numbers of very high values, as seen with house prices or incomes
Arithmetic mean
In mathematics and statistics, the arithmetic mean, often referred to as simply the mean or average when the context is clear, is a method to derive the central tendency of a sample space. The term "arithmetic mean" is preferred in mathematics and statistics because it helps distinguish it from other means such as the geometric and harmonic mean.
In addition to mathematics and statistics, the arithmetic mean is used frequently in fields such as economics, sociology, and history, though it is used in almost every academic field to some extent. For example, per capita GDP gives an approximation of the arithmetic average income of a nation's population.
While the arithmetic mean is often used to report central tendencies, it is not a robust statistic, meaning that it is greatly influenced by outliers. Notably, for skewed distributions, the arithmetic mean may not accord with one's notion of "middle", and robust statistics such as the median may be a better description of central tendency
Suppose we have sample space $\{a_1, \ldots, a_n\}$. Then the arithmetic mean *A* is defined via the equation

$$A := \frac{1}{n} \sum_{i=1}^{n} a_i .$$

If the list is a statistical population, then the mean of that population is called a population mean. If the list is a statistical sample, we call the resulting statistic a sample mean.
Median
In probability theory and statistics, a median is described as the numerical value separating the higher half of a sample, a population, or a probability distribution, from the lower half. The *median* of a finite list of numbers can be found by arranging all the observations from lowest value to highest value and picking the middle one. If there is

an even number of observations, then there is no single middle value; the median is then usually defined to be the mean of the two middle values.

In a sample of data, or a finite population, there may be no member of the sample whose value is identical to the median (in the case of an even sample size), and, if there is such a member, there may be more than one so that the median may not uniquely identify a sample member. Nonetheless, the value of the median is uniquely determined with the usual definition. A related concept, in which the outcome is forced to correspond to a member of the sample, is the medoid.

At most, half the population have values less than the *median*, and, at most, half have values greater than the median. If both groups contain less than half the population, then some of the population is exactly equal to the median. For example, if $a < b < c$, then the median of the list $\{a, b, c\}$ is b, and, if $a < b < c < d$, then the median of the list $\{a, b, c, d\}$ is the mean of b and c; i.e., it is $(b + c)/2$.

The median can be used as a measure of location when a distribution is skewed, when end-values are not known, or when one requires reduced importance to be attached to outliers, e.g., because they may be measurement errors. A disadvantage of the median is the difficulty of handling it theoretically.

Mode

In statistics, the mode is the value that occurs most frequently in a data set or a probability distribution.[1] In some fields, notably education, sample data are often called scores, and the sample mode is known as the modal score.[2]

Like the statistical mean and the median, the mode is a way of capturing important information about a random variable or a population in a single quantity. The mode is in general different from the mean and median, and may be very different for strongly skewed distributions.

The mode is not necessarily unique, since the same maximum frequency may be attained at different values. The most ambiguous case occurs in uniform distributions, wherein all values are equally likely.

Mode of a probability distribution

The mode of a discrete probability distribution is the value x at which its probability mass function takes its maximum value. In other words, it is the value that is most likely to be sampled.

The mode of a continuous probability distribution is the value x at which its probability density function attains its maximum value, so, informally speaking, the mode is at the peak.

As noted above, the mode is not necessarily unique, since the probability mass function or probability density function may achieve its maximum value at several points x_1, x_2, etc.

The above definition tells us that only *global maxima* are modes. Slightly confusingly, when a probability density function has multiple local maxima it is common to refer to all of the local maxima as modes of the distribution. Such a continuous distribution is called multimodal (as opposed to unimodal).

In symmetric unimodal distributions, such as the normal (or Gaussian) distribution (the distribution whose density function, when graphed, gives the famous "bell curve"), the mean (if defined), median and mode all coincide. For samples, if it is known that they are drawn from a symmetric distribution, the sample mean can be used as an estimate of the population mode.

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