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COURSE – 7 (VIII)

PEDAGOGY OF PHYSICAL SCIENCE – PART I

(FIRST YEAR)

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UNIT- I NATURE OF PHYSICAL SCIENCE

1.1 WHAT IS SCIENCE?

Science is a domain of inquiry. The organized knowledge with inquiry, logical reasoning and experimentation as its central themes, that we call science.

1.2 NATURE OF SCIENCE

Nature of science is defined by certain characteristics which distinguish it from other spheres of human endeavor. These are discussed below

1.2.1 Science is a particular way of looking at nature

A morning walker looks at the rising sun, pays obeisance to the sun-god, for bestowing the earth with light and energy. Another walker with a scientific bent of mind or scientific attitude tries to understand the process of energy generation

At the time of an epidemic, people take to praying and seek divine intervention to save humanity. A scientist, on the other hand, seeks to isolate the pathogen responsible for the epidemic and develops preventive and curative strategies to fight the disease and save people.

At the time of an eclipse, people pray, observe fast, and give alms, as insurance against any ill effects flowing from the phenomenon. A Nature of Science scientist considers eclipse a natural phenomenon, enjoys the sight and tries to understand what caused the event and investigates whether it could have any ill effects.

1.2.2 Science is a rapidly expanding body of knowledge

Newer disciplines are being discovered and established everyday and the older ones are being enriched by researches being carried out in institutes of higher learning. For example, the audio tape is now almost obsolete; its place has been taken by compact disc, which itself is being rapidly replaced by other media devices. In this respect science is a highly dynamic body of knowledge.

1.2.3 Science is an interdisciplinary area of learning

There cannot be any rigid demarcation of one discipline from another. Several scientific topics fall under more than one discipline. In fact, at the present time the trend is towards studying more than one discipline, or interdisciplinary subjects. Consider, for example, the new and powerful disciplines like biotechnology, molecular biology and biochemistry which have Pedagogy of Science. Phy sical Science emerged in recent times that necessitate the study of biology along with physics, mathematics and chemistry.

Let us take an example of thermodynamics which shows the interdisciplinary nature of science. Thermodynamics is a branch of science which deals with relationships between the various forms of energy and the rules governing their inter-conversion.

Let us consider physical processes. Suppose we heat a given volume of water. Its temperature increases. If we keep supplying heat energy, the water starts boiling and then its temperature stops increasing even if we keep supplying heat energy. How do you understand this strange behavior? You need knowledge of thermodynamics to get the answer. How do the two phases of water - liquid and gas - coexist in equilibrium? Again, we need thermodynamics to get an answer. As another example of a physical process, suppose we wish to cool a room. It would imply that we have to transfer heat from the colder air of the room to the hotter air outside. Thermodynamics tells us that we need to spend extra energy to do so. This extra energy is supplied by electricity which enables an air conditioner to cool the room.

Thermodynamics is involved in all biological processes also. Take life process such as digestion or respiration or cell division. They all involve exchange of heat energy, and therefore, thermodynamics. Moreover, metabolism in all living organisms is nothing, but chemical process. These systems cannot be studied without understanding the laws of thermodynamics. In fact, specialized subjects such as biological thermodynamics have been developed which study thermodynamics of biochemical reactions.

Biomolecules are chemical compounds found in living organisms. For example, carbohydrates, proteins, vitamins, nucleic acid, lipids, etc. Study of biomolecules is closely related to several areas of study such as biochemistry, molecular biology, bioengineering and the like.

Surface Chemistry deals with the phenomena that occur at the interface of surfaces. Some of these phenomena that are observable at the interface are adsorption, corrosion, heterogeneous catalysis, crystallisation, and colloid formation. Let us take the example of adsorption which arises due to the fact that surface particles of the adsorbent are not in the same environment as the particles inside the bulk. Inside the bulk, forces acting on the particles are balanced, but surface particles are subjected to unbalanced or residual attractive forces. During adsorption there is decrease in residual forces, because particles of adsorbate (substance getting adsorbed) attach to adsorbent (surface on which adsorption is taking place). Therefore, there is decrease in surface energy which is released as heat.

The concepts of force and energy which are important for understanding adsorption in chemistry come from physics. Surface chemistry is closely related to surface physics and surface engineering. Surface physics aims to study the topics like spintronics, nanostructure, surface diffusion and surface engineering aims at modifying chemical composition of the surfaces using suitable materials.

1.2.4 Science is a truly international enterprise: International collaboration in most projects is the order of the day. In this sense, science does not belong to any single country or a group of countries, and it would be morally and ethically wrong to deny the fruits of scientific development to any country in the world.

1.2.5 Science is always tentative: All theories, even the seemingly well-founded ones, can be revised or improved upon, or abandoned altogether whenever new evidence emerges, either as new experimental observations or as new theoretical developments.

The earliest theories of the universe held the earth to be the centre of the universe. Such a universe was called the geocentric universe. So strong was the belief in this theory that it became part of the religious faith. Those who thought that the Sun was at the centre of the universe were ignored. Elaborate schemes, involving epicycles (several epicycles in some cases), were developed to fit the observations of planets to the geocentric theory. Even when, due to the work of Copernicus, Kepler and Galileo, it became apparent that the Sun must be at the centre of the universe (heliocentric universe)

1.2.6 Science promotes skepticism, scientists are highly sceptic people: Scientists are highly sceptic people. Scientists look at everything with suspicion. Every new observation or a new theory is received with a lot of scepticism. It leads to a lot of debate among scientists. A new observation is accepted only when experimental observations have been checked by independent individuals or groups at various places with identical results. Similarly, a new theory is accepted when theoretical calculations have been repeated by other scientists independently with identical results. In this debate the status of the scientist who proposes something new does not matter; science breeds a truly egalitarian culture.

1.2.7 Science demands perseverance from its practitioners: This is the tenacity and perseverance that science demands from scientists. A scientist, getting an inspirational idea or a creative thought on making a chance observation, or otherwise, has to persist with the idea to take it to its logical conclusion.

1.2.8 Science as an approach to investigation and as a process of constructing knowledge: Most investigations in science involve some form of scientific method. It shows creativity of humankind in seeking solution to its problems. The scientific theory follows Observations, formulating hypothesis, testing hypothesis and generalization of scientific theory.

1.3 VALUES IN TEACHING PHYSICAL SCIENCE: INDIVIDUAL, SOCIAL

Imbibing the Values through Science Teaching The Delor's commission (1996) of UNESCO in its report entitled 'Learning : the Treasure Within' advocates the need to cultivate core universal values like human rights, sense of social responsibility, social equity, democratic participation, tolerance, cooperative spirit, creativity, environmental sensitivity, peace, love, truth, non-violence, etc. within the learner. Education for human values is an important area that needs to be promoted at all stages of education.

Values are abstract and multi-dimensional and present an ideal for the members of the society to shape their personalities. Science offers many opportunities for value inculcation. These cannot be imposed, but need to be part and parcel of the teaching-learning process. There is no need to have a separate period for value education.

Teachers can integrate values during teaching-learning of different subjects like science, language, social studies, mathematics, arts, crafts, etc. For example, during the teaching-learning of the concepts such as the States of matter you can discuss the values of coordination, unity and staying together based on how the bonding and forces of attraction vary between the molecules of the three states. Similarly, while discussing friction one can talk about how reducing friction increases the efficiency of the machine by preventing energy dissipation. In the same way, quarrelling leads to wastage of energy and time. Thus, science offers many opportunities of value inculcation for students.

The following values can be developed through teaching-learning of science:

1.3.1 Values in teaching physical science : individual

Patience: In waiting for results of experiments.

Perseverance: In doing the experiments again and again until result is achieved.

Co-operation: Willingness to work with others, and share equipments and materials.

Honesty: In gathering and recording data.λ Integrity: Whose work can be relied upon?

Concern for life: Caring for health and hygiene and others.

Preservation of environment: Keeping surroundings clean, caring for plants and animals, switching off the light when not in use.

Open- mindedness, keen observation, divergent thinking, accepting success and failure are some of the individual values.

1.3.2 Values in teaching physical science : Social

Societies have changed over time and consequently science has evolved over the time. The need of the society has always played a very important role in the development of science. Therefore, science responds to the needs and interest of the society in which it is practised and developed.

Physical science for environment: Environment may be defined as everything present in the universe. The universe has air, water, soil, the sun, the moon and many other things. It also has plants, animals, rivers, mountains, deserts and oceans. Broadly, the environment has four segments— atmosphere, biosphere, lithosphere and hydrosphere.

Physical science for health: One indication that the progress of a society has taken place is that its members are healthy. Science has served humankinds to a great extent for making its members healthy and free from diseases.

Physical science for peace: Science has brought about an overall betterment of life of humankinds. Therefore, it is expected that if there is full collaboration in knowledge acquisition in pure and basic sciences and in the application of scientific knowledge to the developmental work, peace should rule on every aspect of human psyche. The scientific knowledge is universal and it has no boundaries. Utilitarian side of science also has no conflict in serving the society. Therefore, if peace does not prevail in the society, there must be other factors which have to be controlled

Physical science for equity: Science learning should be used as an instrument of social change to reduce the socio-economic divide. It should help fight prejudices related to gender, caste, religion and region. Science education ought to empower students to question the social beliefs, notions and practices that perpetuate social inequality. Equitable educational systems foster the maximum development of individual potential. A commitment to equity ensures that all children have access to quality education; they develop knowledge and skills needed to participate effectively in community life as workers, citizens, parents, leaders and role models for future generations. To assure educational excellence for all students, schools must appreciate the diversity that students bring to the environment and organise schools and classrooms in such a way that the overall development of all students is ensured.

Physical science for trading, for economy, for technology, modernization, for defence and for agriculture are some of the social values of teaching physical science.

UNIT :II AIMS OF LEARNING PHYSICAL SCIENCE

2.1 AIMS OF LEARNING SCIENCE

The science education is aimed for the learner to

- know the facts and principles of science and its applications consistent with the stage of cognitive development
- acquire the skills and understand the methods of processes that lead to generation and validation of scientific knowledge
- develop a historical and developmental perspective of science
- enable to view science as a continuing social enterprise
- relate science education to environment (natural environment, artifacts and people, local as well as global
- appreciate the issues at the interface of science, technology and society
- acquire the requisite theoretical knowledge and practical technological skills to enter the world of work;
- nurture the natural curiosity, aesthetic sense and creativity in science and technology
- imbibe the values of honesty, integrity, cooperation, concern for life and preservation of environment
- cultivate scientific temper– objectivity, scepticism, critical thinking and freedom from fear and prejudice

2.2 KNOWLEDGE AND UNDERSTANDING THROUGH SCIENCE

An important trait of humans is to wonder, observe and interact with the surroundings and look for the meaningful patterns and relations by making and using new tools and build conceptual models to understand this universe. This humans' endeavor has led to modern science which took thousands of years to get crystallized. So one can say that science leads to generation of ideas helping to make sense of observed facts that get accepted if they fit observations, but may be refuted until tested through evidence. These ideas represent a broad view and are generalized as the scientific principles that are true universally.

According to Albert Einstein, **'science is a refinement of everyday thinking, a belief that becomes evident when one studies the work of scientists in their attempt to construct ideas that explain how nature works.'** The different aspects of science are viewed differently by scientists, philosophers and historians. When we speak about science, we do not refer to a particular aspect, because it is a broad-based discipline with many faces.

It is important for children to acquire the knowledge of science content, i.e., concepts and underlying principles as they provide a sound base to explore the unknown and build further knowledge, yet these cannot be passed to children directly. In addition, their Pedagogy of Science: Phy sical Science understanding cannot be developed by rote learning. It can be done by providing children relevant and age appropriate learning opportunities that allow them to undergo experiential learning through exploration and interaction with their environment and construct their knowledge.

To help children understand the concept that light cannot pass through all materials and when it does not, shadows are formed – one way is to tell the definitions of transparent, translucent and opaque objects. Showing some of such objects is still better, but letting children observe and try different objects for the formation of shadows and then engaging them with those objects that form shadows under different conditions, such as distance from the source of light, direction of light, etc. can help them understand this concept better.

Creation of knowledge is crucial to children's learning. Their previous experiences are very important for it, as the experiences lead them to develop new ideas. Teachers need to collect such experiences of children to build further knowledge on their previous knowledge. For this they may engage the children in meaningful discussions through questioning and listening. Even children's drawings, concept maps also serve as good tools to acquire such information.

2.3 NURTURING PROCESS SKILLS OF SCIENCE

Science is about asking questions and finding answers to them through scientific method and inquiry. The processes that scientists use in it are science process skills.

Science is important to all young people for not only to acquire the knowledge associated with it, but also to imbibe its inquiry and process skills. These skills enable them to develop into adults who are able to take informed and responsible action while engaging and reflecting upon different ideas, opinions, beliefs or values. These are long lasting; thus, tend to be useful throughout each area of our lives. These skills involve the use of all the sense organs providing hands-on experiences for enjoyable and effective learning. While we figure out many questions in our everyday experiences, we also use these skills.

However, often, the investigations are carried out in a routine fashion to let the children score in examination. If conducted properly, these activities not only raise the motivation but also develop interest and curiosity to learn and try things in different ways.

In their strive to answer, 'what if,' children get actively involved in different processes such as observation, discussion, collecting information, manipulation, comparing, classification, improvisation, experimentation, critical thinking, logical reasoning, etc., thus enabling them to go through the processes of not only 'hands-on' but 'minds-on' as well.

For example, children could be facilitated to observe natural phenomenon such as condensation, evaporation, rusting, seed germination, reflection, refraction, interference of light, electromagnetic induction, etc. Based on the observations and questions raised in the minds of children and asked by the teacher, problems could be identified and defined and hypothesis could be made. To test the hypothesis (es), experiments should be performed to validate or discard their hypothesis.

2.3.1 Six basic Science process skills: Science process skills refer to the following six actions without any particular order

1. Observation
2. Communication
3. Classification
4. Measurement
5. Inference
6. Prediction

Applying these skills one can conduct objective investigation and reach at conclusions, based on the results. These are integrated together when scientists design and carry out experiments. All the six basic skills are important individually as well as when they are integrated.

Eg: Boiling of water with lid off and on

The problem may either be posed by the student or the teacher. It may also arise as an idea during discussion. The teacher needs not provide the whole plan to carry out the investigation, but should involve children to evolve the plan through discussion. She may help children to work in groups to carry out the investigation. Some children might be trying to heat water in beakers of different sizes/materials. Some might use unequal amount of water in the beakers. There could be variations in taking the temperatures, readings of the thermometer, etc. Through questioning, discussion and sharing the work mutually and with the whole class, the children may be trained in this approach over a period. This can help them develop the skills of scientific process and inquiry.

2.4 BASIC AND INTEGRATED SCIENCE PROCESS SKILLS AND THEIR FOSTERING

Role of a teacher in Basic and Integrated Science Process Skills and Their Fostering: The teacher has an important role to play in providing children with experiences, which can help nurture these skills. Teacher may consider the following points:

Opportunities to develop process skills of science: Children should be given various opportunities to develop process skills of science. Action provides the practical basis for thinking, e.g., simply telling what it means to observe,

investigate, experiment and interpret have no meaning until given an opportunity to try these.

Opportunities for discussion: Opportunities for discussion in small or large groups and in the whole class may be provided. These allow children to listen to others, explain, argue, express and share their ideas, thus involving them in thinking what they have done, relating to the evidence and considering multiple ways of approaching a problem.

Help children to develop process skills: To help children develop process skills, it is important for the teacher to know how children are using those skills. The teacher can observe their work and listen to their discussions to pick up information on how children have collected and used the evidence.

Realizing area of skills need to improvement: The children need to realise the area of the skills in which they need improvement. For this, they may be allowed to discuss their investigation and critically reflect on it. The teacher can encourage them to try alternative courses of action for improvement.

Increasing accuracy in acquisition of some skills: For increasing accuracy in acquisition of some skills, there may be a need for introducing new techniques and tools. For example, for measurement of different quantities children require various instruments such as balance, vernier calipers, screw gauge, thermometers, graphs, etc.

2.5 DEVELOPMENT OF SCIENTIFIC ATTITUDE AND SCIENTIFIC TEMPER

2.5.1 Scientific Attitude: Scientific attitude is a composite of a number of mental processes or tendencies to react consistently in certain ways to a novel or problematic situation. These include accuracy, intellectual honesty, open-mindedness, respect for evidence, scepticism, suspended judgement, critical thinking, perseverance and looking at true cause and effect relationship. Scientists, because of their thirst for knowledge become perpetual learners. They are constantly curious and continually seeking knowledge by inquiring. This in turn nurtures the trait of scientific attitude.

2.5.2 Scientific Temper: It is an attitude of mind which calls for a particular outlook and pattern of behaviour through logical thinking, discussion,

argument and analysis to avoid bias and preconceived notions. It is neither knowledge of facts nor rationalism, but promotes knowledge and rational thinking.

Scientific attitudes and scientific temper have many overlaps in their meanings. Therefore, we are dealing both of these together. We can say that development of attributes such as respect for evidence, open-mindedness, truthfulness, critical and logical thinking, scepticism, objectivity, perseverance, curiosity, creativity and inventiveness, sensitivity to living and non-living and cooperation with others through exploration of the world around leads to inculcation of scientific attitude and scientific temper. These qualities affect the willingness of pupils to take part in the activities, respond to persons, objects, situations or events in rational manner. These may not be placed in a sequential order and looked upon as water tight compartments. Also their development is not spontaneous. These qualities can be nurtured over a period of time through the process relevant learning situations that require creating an open classroom environment encouraging children to perform activities and experiments and reading scientific literature, freely interacting with their surroundings and asking questions.

2.5.3 Developing and nurturing scientific attitude and scientific temper:

Role of a teacher in the process of developing scientific attitude and scientific temper among students during teaching-learning in a class room.

Respect for evidence: There should not be any haste in making and evaluating a judgement in science. It should be based on suitable evidences. While developing skills of collecting evidences for verifying and testing ideas, the students must be trained to confront ideas with evidences.

If ideas conflict with evidences, students should be encouraged to check again and collect more evidences for reaching a conclusion. They should be flexible and willing to change their ideas where there are convincing evidences to the contrary

Open-mindedness: For true learning in science, it is important not to have a set mind with preconceived notions. An open-minded person is one who can

modify plans or discard hypotheses, if necessary and accepts a new explanation, model or paradigm, because it explains the evidence better, is simpler, has few inconsistencies or covers more data. An open-minded person evaluates all reasonable inferences, remains open to alternative interpretations, accepts new priorities in response to a re-evaluation of the evidence or re-assessment of the existing ideas and does not reject unpopular views outrightly. He structures and restructures his ideas as he progress in learning. In short, it is to learn that 'my way is not the only way.'

The teachers can help students acquire this through activities and experiments, frequent collaborative work and discussions in which each child must be given an opportunity to express her viewpoint. Others can reflect on it in socially acceptable manner.

Truthfulness in reporting observations: In scientific procedure, observations in an experiment are repeated and verified before arriving at conclusion.

Teachers should encourage honesty in reporting the result of the experiments among students and should create a fear free environment in which students do not feel scared if the results deviate markedly. If need arises,teacher should work with the students to help them find out the reasons for the discrepancies and guide them, so that they don't manipulate the results.

Critical thinking: In science, critical thinking increases science learning potentials. It requires deliberate review of the way in which activities are carried out, the ideas emerges and the way these can be improved. It is the ability to analyse information and experiences in an objective manner. Reflecting on the processes of thinking does not come readily to young children as it involves abstract thinking as well.

Teachers can facilitate this by engaging the children in discussions through activities.

- Willingness to review the work done for its further improvement.
- Considering alternative ways.
- Identifying the aspects that are for and against the way adopted.

- Reflecting on the previous work to identify the mistakes and avoid those in the next.
- Focusing on relevant scientific facts and asking open-ended questions

Logical thinking: The process of linkage of the past experiences in terms of cause and effect relationship on a model of set rules, i.e. thinking with reasoning is known as logical thinking.

Children should be helped to reason out consistently before arriving at conclusion. Scientific temper is the refined logical thinking. The refinement in logical thinking can be brought in by taking observation, quantifying the observation to increase the resolution of our observation and organising the information gathered from observation.

Scepticism: Scepticism is questioning the accepted beliefs, ideas or facts in the society on the basis of scientific investigations. For instance, superstitions amongst the people are developed due to ignorance and customs that people follow due to fear and mythical explanations of the events.

Science teaching-learning can help students in questioning such beliefs. For example, the ancient people believed that the earth was balanced on the horns of a bull and when the bull shifts it from one horn to the other, an earthquake occurs. This belief proved wrong only through science when the occurrence of the earthquakes were established as the tremors caused by the disturbances deep inside the earth.

A lot of superstitions still prevails in society and even some educated people continue to follow them, sometimes out of fear of the unknown. You can look objectively (weigh the evidence) at the practice of throwing away all food items after solar or lunar eclipse. Sneezing at the time of stepping out of your house or a cat crossing your way are bad omens. Mother is responsible for the gender of a child are some examples of superstitions.

The teachers need to organise planned debates on such issues and encourage children to participate in the discussions, thus, sensitising them gradually against the causes by promoting rational and critical thinking.

Objectivity: Objectivity is looking at the things without any preconceived notions, biases, prejudices or discrimination. It can be developed by understanding the importance and use of evidence. This would also help in developing respect for evidence. Learners should be open to others' ideas and should respect others' point of view, but they should accept the ideas only after testing and verification or with sufficient evidences. This also requires a change in our traditional authoritarian attitude. While developing skills of collecting evidence, verifying and testing their ideas, following points should be emphasised.

- Respect others' ideas or point of view, based on sound logic.
- Confront your ideas with evidences. If ideas conflict with evidences, collect more evidences before reaching a conclusion.
- Treat all ideas and statements as provisional.
- Be flexible and willing to change your own ideas if they are notλ consistent with the evidences.

Perseverance: It is expected that the students are given opportunities to work repeatedly to arrive at conclusion which is scientifically valid.

The teachers may elaborate on this aspect through narration of the efforts of scientists such as Marie Curie, Howard G. Rogers and Thomas Alva Edison.

2.6 NURTURING THE NATURAL CURIOSITY, CREATIVITY AND AESTHETIC SENSE

2.6.1 Nurturing the Natural Curiosity: Natural curiosity led to questions in student"s mind like why, what and how. When students ask such questions, the teacher should not discourage them. She should facilitate them to find answer using scientific principles. Aristotle had once made the statement, All men by nature desire to know. Children learn more due to their natural curiosity. They should be made curious by developing interest in science by observing, asking question and experimenting. Science is nothing but all that happens around us. Students come across many questions out of curiosity.

Curiosity leads to inculcation of learning to learn aspect of education. Curiosity can be generated in the learners by taking them to science centres; providing opportunities to work on science projects and to read scientific literature; facilitating interaction with persons having scientific attitude; encouraging to participate in science exhibition and science quiz, etc. Science activities can be designed to encompass several factors making up curiosity.

Curiosity gets aroused as a result of doubt, perplexity, contradiction, cognitive conflict, ambiguity, lack of clarity, etc.

For nurturing curiosity, the teacher should create learner-friendly classroom environment where they are free to interact with the teacher and the peer group. It is generally observed that classroom conversation is dominated by few vocal students. Some shy students do not ask any question. The teacher should try to involve the whole class in the teaching-learning process by encouraging the students to ask questions and get involved in activities, experiments and projects.

2.6.2 Nurturing Creativity: Creative thinking is a novel or innovative way of seeing or doing things. It has four components—fluency (ability to express oneself readily and effortlessly), flexibility (shifting perspective after getting convinced easily), originality (conceiving of something new) and elaborating (building on other ideas). It is also referred to as thinking 'out of box'. Creative thinking enables a learner to explore available alternatives and consequences of actions or non-actions and contributes to decision-making and problem solving.

For nurturing creativity the teacher can follow a variety of activities such as questioning, gathering relevant information and analysing and processing it to solve problem, looking for a number of ways to approaching a problem, thinking aloud, enacting a play/drama, writing poem, constructing models, conducting open-ended experiments, etc. These activities can bring out the hidden talent of the learner. Children should not be stopped to ask questions saying, 'your question is irrelevant or out of syllabus.'

Creativity is doing or seeing the things differently. It cannot be taught, but developed in children by using planned strategies and techniques. Emphasis should be given on providing appropriate concrete experiences which nurture creative traits in a learner, viz. curiosity, ability to fantasise, playfulness, as well as cooperative and helpful attitudes in teaching-learning of science.

The teacher plays an important role for nurturing creativity in learners. From pedagogical perspective of physical science, inquiry and activity oriented, process based teaching-learning can facilitate in nurturing creativity. Therefore, the role of the teacher should be,

- to assist students in developing models of inquiry and discovery
- guide students in the use of multidisciplinary approach
- recognise and appreciate creative ideas and products of students
- provide rich variety of learning experiences to students
- encourage students to frame questions and browse variety of reading materials
- express to the students that their ideas have value.

Teacher should be respectful to unusual questions and imaginative unusual ideas of learners. Occasionally, provide opportunities to them to do tasks without any fear of evaluation. Let the learners evaluate the task on their own without pointing it as right or wrong. Do not tell the results of an experiment in advance. Help them to reach the conclusion.

A creative child thinks differently, expresses unending curiosity and possesses divergent thinking ability. She wonders what makes things work. She is always a keen observer who ponders over the outcome of an event of phenomena and seeks information. She has original, divergent, independent, fearless and intuitive thinking and welcomes new ideas. She likes to ask thought-provoking questions rather than fact seeking or memory type questions. Teachers should identify these traits and provide a variety of learning experiences of inquiry and discovery of science to nurture creativity. Creativity is not related to any particular subject area. Science education

provides opportunities to a person to create something new for the society and the nation. It has a wide scope of fostering and encouraging creativity.

2.6.3 Nurturing aesthetic sense: Aesthetics deals with the creation and appreciation of beauty that gives us happiness. Harmony, order and pattern are some of the criteria which define beauty. A learner of science is also concerned with them. She gets motivated to see some patterns in the properties of substances and other things in her surroundings. She appreciates her creation and derives joy when finds that a particular toy or a gadget works on same scientific principle that she has already learnt.

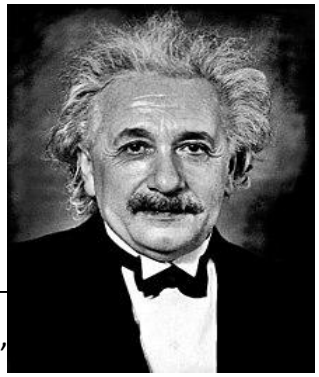
Theory of gravitation is a prime example of universality. Since science is a body of knowledge acquired through the application of the scientific method and process, this knowledge at several stages has some pattern, order and harmony and universal acceptability. Therefore, studying science nurtures aesthetic sense amongst children.

Learners should be encouraged to explore harmony, pattern and order in properties of substances and various natural phenomena and principles of science to infuse aesthetic sense among them. For example, during learning of the properties of different oxidation states of vanadium element we see a definite pattern and beauty in the change of colour from one oxidation state to another.

For nurturing aesthetic sense through science teaching learning, the teacher may encourage students to consider the following steps: Observe keenly while doing any work. For example, observing the flowers while walking in the garden one can appreciate their colour and wonders why the flower is of that particular colour. Observe, analyse and reject what is not scientific.

7. CONTRIBUTION OF EMINENT SCIENTISTS:

2.7.1 Albert Einstein

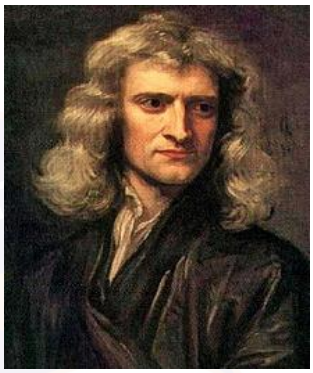


Albert Einstein (1879–1955), one of the greatest physicists of all time, was born in Ulm, Germany. In 1905, he published three path breaking papers. In the first paper,

he introduced the notion of light quanta (now called photons) and used it to explain the features of photoelectric effect. In the second paper, he developed a theory of Brownian motion, confirmed experimentally a few years later and provided a convincing evidence of the atomic picture of matter. The third paper gave birth to the special theory of relativity. In 1916, he published the general theory of relativity. Some other significant contributions of Einstein are : the notion of stimulated emission introduced in an alternative derivation of Planck's blackbody radiation law, static model of the universe which started modern cosmology, quantum statistics of a gas of massive bosons, and a critical analysis of the foundations of quantum mechanics. In 1921, he was awarded the Nobel Prize in physics for his contribution to the theoretical physics and the photoelectric effect.

2.7.2 Issac Newton

Isaac Newton (1642–1727) was born in Woolsthorpe, England in 1642, the year Galileo died. His extraordinary mathematical ability and mechanical aptitude remained hidden from others in his school life. In 1662, he went to Cambridge for undergraduate studies. A plague epidemic in 1665 forced the university town to close and Newton had to return to his mother's farm. There in two years of solitude, his dormant creativity blossomed in a deluge of fundamental discoveries in mathematics and physics: binomial theorem for negative and fractional exponents, the beginning of calculus, the inverse square law of gravitation, the spectrum of white light, and so on. Returning to Cambridge, he pursued his investigations in optics and devised a reflecting telescope. In 1684, encouraged by his friend Edmund Halley, Newton embarked on writing what was to be one of the greatest scientific works ever published : Principia Mathematica. In it, he enunciated the three laws of motion and the universal law of gravitation, which explained all the three Kepler's laws of planetary



motion. The book was packed with a host of path-breaking achievements: basic principles of fluid mechanics, mathematics of wave motion, calculation of mass of the earth, the sun and other planets, explanation of the precession of equinoxes, theory of tides, etc. In 1704, Newton brought out another masterpiece Opticks that summarised his work on light and colour. The scientific revolution triggered by Copernicus and steered vigorously ahead by Kepler and Galileo was brought to a grand completion by Newton. Newtonian mechanics unified terrestrial and celestial phenomena. The same mathematical equation governed the fall of an apple to the ground and the motion of the moon around the earth. The age of reason had dawned.

2.7.3 Neils Bohr

Niels Bohr (1885–1962), a Danish physicist received his Ph.D. from the University of Copenhagen in 1911. He then spent a year with JJ Thomson and Ernest Rutherford in England. Bohr was awarded the Nobel Prize in Physics in 1922 in recognition of his work on the structure of atoms. He received the first Atoms for Peace award in 1957. He presented his work in 115 publications; three appearing as books in english: The Theory of Spectra and Atomic Constitution, University Press, Cambridge (1922); Atomic Theory and the Description of Nature, University Press, Cambridge, 1934; The Unity of Knowledge, Double day & Co., New York, 1955.

2.7.4 C.V. Raman

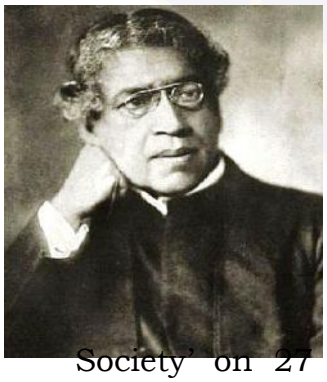
Chandrasekhara Venkata Raman (1888–1970) was born at Thiruvanaikaval, near Trichinopoly, Madras Presidency to R. Chandrasekhara Iyer and Parvati Ammal. On February 28, 1928, through his experiments on

the scattering of light, he discovered a phenomenon in spectroscopy, later named as the Raman Effect. It was instantly clear that this discovery was an important one. It gave further proof of the quantum nature of light. Raman spectroscopy is based on this phenomenon.

He won the 1930 Nobel Prize in Physics for his work on the scattering of light and for the discovery of the effect named after him. In 1934 Raman became the director of the Indian Institute of Science, Bangalore, where two years later he continued as a professor of physics. Other investigations carried out by Raman were experimental and theoretical studies on the diffraction of light by acoustic waves of ultrasonic and hypersonic frequencies (published 1934-1942), and those on the effects produced by X-rays on infra red vibrations in crystals exposed to ordinary light.

Raman retired from the Indian Institute of Science in 1948 and established the Raman Research Institute in Bangalore, Karnataka a year later. He served as its director and remained active there until his death, at the age of 82.

2.7.5 J.C. Bose



J.C. Bose (1858–1937) developed an apparatus for generating ultrashort electromagnetic waves and studied their quasi-optical properties. He was said to be the first to employ a semiconductor like galena as a selfrecovering detector of electromagnetic waves. Bose published three papers in the British magazine, 'The Electrician' in 1895. His invention was published in the 'Proceedings of the Royal Society' on 27 April 1899 over two years prior to Marconi's first wireless communication on 13 December 1901. Bose also invented highly sensitive instruments for the detection of minute responses by living organisms to external stimuli and established parallelism between animal and plant tissues.

2.7.6 John Dalton

John Dalton (1766–1844) was born in a poor family in 1766 in England. He began his career as a teacher at the age of twelve. Seven years later he became a school principal. In 1793, Dalton left for Manchester to teach mathematics, physics and chemistry in a college. He spent most of his life there teaching and researching. In 1808, he presented his atomic theory which was a turning point in the study of matter.

Dalton consolidated his theories in his book New System of Chemical Philosophy. He kept daily weather records from 1787 until his death in 1844 and published his first book Meteorological Observations (1793). His interest in meteorology led him to develop theories about water vapour and mixed gases. He studied a variety of weather phenomena and about the instruments used to measure them. He is also known for his work on colour blindness.

UNIT :III LEARNING OBJECTIVES OF PHYSICAL SCIENCE

3.1 LEARNING OBJECTIVES- MEANING

Desirable strands of remembering, understanding, applying and analysing for a particular topic/unit in terms of perceived learning are broadly known as learning objectives. These desirability should be viewed from the perspective of the existing knowledge and background of the learners

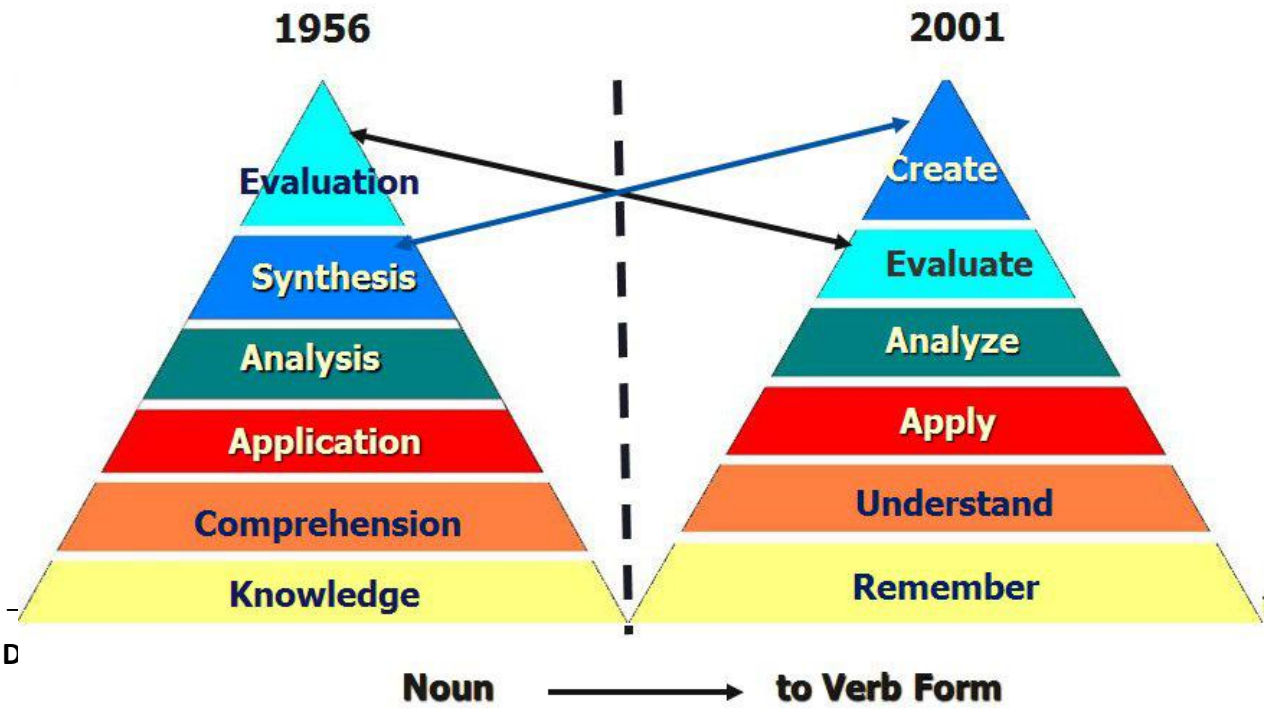
Learning objectives are the statements in specific and observable term that tell what the learner is expected to achieve as a result of engaging her in teaching-learning process. Learning objectives should reflect what the learners will do rather than what the teacher will do.

For example, writing three properties of metals.

3.2 REVISION OF BLOOM'S TAXONOMY BY ANDERSON AND KRATHWOHL

In 1956, Benjamin S. Bloom classified domains of human learning into three parts:

1. **Cognitive** - knowing; related to head
2. **Affective** - feeling; related to heart
3. **Psychomotor -** doing; related to hand as the educational objectives.



Bloom's taxonomy is a model of classification of thinking into multi levels in increasing order of complexities. As a result of this classification, a series of taxonomies was obtained in each domain that provided a means of expressing qualitatively different levels of thinking of learners.

However, over a period of time new ideas and insight emerged about teaching-learning processes. In teaching- learning scenario of the twenty-first century, 2001, Lorin W. Anderson, a former student of Bloom and David R. Krathwohl, one of the co-authors of Bloom's book, led a team of experts published A Revision of Bloom's Taxonomy of Educational Objectives.

Bloom's taxonomy has six tiers of learning arranged in a hierarchical way. With a little change in the hierarchy, revised taxonomy has also six tiers of learning that are more explicit. One of the other significant changes is that revised Bloom's taxonomy has two dimensions identified as,

1. knowledge dimension (kind of knowledge to be learnt) and
2. cognitive process dimension

Whereas Bloom's taxonomy has only one dimension.

The revised taxonomy is different in three ways –

(i) Terminology: This change is minor yet significant. It is a shift from the noun to verb words.

Knowledge is replaced by remembering: The word knowledge was considered inappropriate as a category of thinking and is replaced by remembering. Thinking is an active process and knowledge is the product of thinking. Knowledge is not viewed as a form of thinking.

Comprehension is revised as understanding.

Evaluating has replaced synthesis and

Creating has replaced evaluation.

(ii) Structure: In Bloom's taxonomy, one has to find some ways to cut across different subject areas as the nature and contents of each subject area are different. For example, the factual knowledge of science and language is different. Similarly the procedural knowledge is also different. In

languages, this can be speaking fluently; in physical science, this can be performing experiments and activities, using and handling apparatus.

Based on the theory of cognitive psychology, Anderson and Krathwohl came up with four dimensions of knowledge.

1. Factual knowledge: knowledge of facts, laws, definition, terminology, vocabulary, etc. of physical science.
2. Conceptual knowledge: knowledge of theory, generalisation and interrelation of different concepts in physical science.
3. Procedural knowledge: knowledge about scientific processes and inquiry. We come to know how to perform activities and experiments, how to use apparatus and materials for teaching- learning process
4. Metacognitive knowledge: knowing about knowledge. It is about learner's awareness about her own learning process and learning style.

The intersection of the 4 knowledge dimension and 6 cognitive process dimensions gives 24 cells making the taxonomy.

1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating

In Bloom's taxonomy, evaluation was the uppermost level of thinking. In the revised taxonomy creating is at the top of the hierarchy

(iii) Emphasis:

- The revised taxonomy is more authentic tool for curriculum planning, developing materials for teaching-learning and assessment processes.
- Bloom's taxonomy was viewed as the tools best applied for earlier years of schooling. Anderson and Krathwohl taxonomy can easily be used for higher levels also. In this sense, it is broader in use.
- Emphasis is more on the description of the subcategories of learning. For example, Recognising: Locating knowledge in memory that is consistent

with presented material. Recalling: Retrieving relevant knowledge from long term memory. Thus, we see that the revised Bloom's taxonomy has a number of subcategories of the cognitive processes. It is more explicit and provides us a powerful tool to help structure the teaching-learning strategies and processes.

3.3 LEARNING OBJECTIVES FOR UPPER PRIMARY, SECONDARY, HIGHER SECONDARY

3.3.1 Learning objectives for upper primary

Learning objectives of the same theme or topic are different at upper primary, secondary and higher secondary stage.

- The learners are encouraged to learn principles of physical science through observation and concrete examples relating to their everyday life experiences.
- They are engaged in simple activities, models and projects.
- Group activities, discussion with peers and teachers, surveys, organisation of data and their display through exhibition, etc.
- Schools should be an important component of pedagogy.

3.3.2 Learning objectives for secondary

Abstraction and quantitative reasoning come to occupy a more central place than at the upper primary level. Therefore the learners can be introduced to the abstract concepts of physical science by involving them in systematic experimentation.

3.3.3 Learning objectives for higher secondary

At higher secondary stage, emphasis is given on the rigour and depth of science and problemsolving by involving them in advanced technological experiences.

Therefore, while writing learning objectives the depth, breadth and complexities of concepts, and the suitability of learning experiences have to be considered according to cognitive level of the learners at different stages of learning.

For example, the topic on Light can be dealt in different ways at upper primary, secondary and higher secondary stage. At upper primary stage the concept of reflection of light and shadow formation are dealt with the help of concrete examples trying to relate the concepts of light with day to day observations. At secondary stage, the disciplinary approach just begins to emerge and more rigorous emphasis is given on the explanation of natural phenomena. But still the topic is discussed as a part of composite science. At higher secondary stage, it takes the shape as a discipline of physics. In-depth study of the topic with more rigorous mathematical expression and advanced experiments is required at the higher secondary stage.

Learning objectives on topic LIGHT at upper primary, secondary and higher secondary stage:

Upper primary stage:

- Identifying transparent, opaque and translucent objects from the given materials by observing through them.
- Distinguishing transparent materials from translucent materials.
- Discriminating between shadow and image.
- Inferring that light travels along a straight line by observing a candle through a straight and then through a bent pipe.
- Making a model of a pinhole camera.
- Concluding that white light is composed of seven colours by observing a beam of sunlight through prism.
- Performing an activity to understand laws of reflection using a plane mirror and pins.
- Stating the laws of reflection of light.
- Drawing a labelled diagram of human eye, etc.

Secondary stage:

- Comparing the nature of images formed by concave and convex mirror.
- Representing images formed by concave and convex mirror using ray diagram.
- Writing lens formula.

- Performing an activity to observe nature, position and relative size of the images formed by spherical lenses for various positions of the object.
- Solving numerical problems based on the lens formula.
- Describing three defects of vision (myopia, hypermetropia and presbyopia) and the way of their correction.
- Explaining dispersion of white light through a prism.
- Applying the understanding of the phenomenon of refraction toλ explain the blue colour of the sky and red colour of the sun at sunrise and sunset, etc.

Higher secondary stage:

- Applying laws of reflection to explain total internal reflection of light.
- Explaining formation of mirage on the basis of total internalλ reflection.
- Describing technological application of total internal reflection in the form of optical fibres.
- Deriving expression for the refraction at spherical surfaces.
- Deriving expression for the focal length of combination of lenses in contact.
- Deriving expression for the refractive index of the material of the prism mathematically.
- Describing construction and working of a microscope/ telescope.
- Identifying errors in the given ray diagrams.
- Evaluating suitability of spherical lenses for the construction of a microscope/telescope from the given values of the focal length of the lenses.

3.4 LEARNING OBJECTIVES IN THE CONSTRUCTIVIST PERSPECTIVE

Traditional approaches where prior planning of lesson is not acceptable to constructivist approach. In the constructivist perspective, knowledge, understanding, application, skill, etc. or remembering, understanding, applying and analysing, etc. cannot be visualised, In other words, a concept cannot be divided into different levels of learning. It has to be an integral whole.

Beginning of a lesson planning is probably most difficult time to create specific detailed learning objectives well in advance irrespective of the learning situations and learners' circumstances. During the teaching-learning process, if the original learning objectives and teaching-learning design do not match, teacher changes the objectives according to the needs of the learners rather than changing the design.

Learning is a divergent process that occurs through various exposures and not necessarily through a common, singular exposure predicted by teacher. It is essentially a participative process in which learner constructs her knowledge in her own ways, through absorption, interaction, observation and reflection. In the process, learner goes back and forth. The process therefore is not linear; it is rather spiral and complex in nature.

Learning is thus a multidimensional process and **it should centre around certain key concepts**. Teacher needs to continually assess learners' understanding of the concepts. Learners' viewpoints should be sought and valued. They should be encouraged to ask questions. Based on their viewpoints, ideas and questions on the concept, learning objectives should be constructed and reconstructed on a continual basis during teaching-learning of physical science.

learning objectives are contextual in nature. Learners construct their own meaning. We cannot guarantee they will learn specifically what we intend, but we can craft an environment that is likely to help them to develop ideas and practices that are in alignment with what we intend.

The **learning objective can be planned with the help of learners** by discussion, and involving them in inquiry and providing them opportunities to perform activities, ask questions, enter into argumentation, etc.

Learner's experience has an important place in the process of knowledge construction and understanding of the concept. Experience is perhaps the most important step in the process of discovery of science through which each learner can be made to feel, reflect, and arrive at ideas.

Relating to what they have already experienced helps in the process of reflection. It is a continuous challenge for teacher to look for suitable ways of 'creating' and 'drawing upon' experiences.

Lived experiences in the form of exercises that help learners to relate to life outside the schools or in terms of created experiences in the school have values at all stages of education.

Providing learners environment of learning encourages them to get involved in eveloping learning objectives, personalises their learning and gives an ownership to their learning.

During teaching-learning process teacher may frequently ask students to '**think-pair-share**.' A learner may discuss on the topic with the learner next to her and write two-three questions for which they do not have answers.

Teacher has to recognise that in learner-centred learning situations, curriculum 'evolves' and is not 'predesigned' for providing possible support in the process of construction of knowledge. Every subsequent learning situation cumulatively provides better insight to the teacher in discovering learners' needs and identifying varied support for learning. In this sense teacher is a participant in learners' effort at evolving learning experiences.

UNIT 4: LESSON PLANNING

4.1 LESSON PLANNING – MEANING AND DEFINITION

A lesson plan is a teacher's detailed description of the course of instruction for an individual lesson.

A **lesson plan** is a teacher's daily guide for what students need to learn, how it will be taught, and how learning will be measured

A ***lesson plan*** is a framework and a road map, which each teacher will create for course instruction.

L**.B. Stands** conceives a lesson plan as "Plan of action" implemented by the teacher in the class-room.

Lesson plan is defined as an outline of the important points of a lesson arranged in an order in which they are presented to the students by the teacher in the classroom - **Good**

4.1.1 LESSON PLANNING - NEED AND IMPORTANCE

Planning of teaching-learning experiences helps the teacher to think deeply and focus these experiences to the learners rather than on the delivery of the lesson.

Planning a lesson before going to the class may also helps a teacher in one or more of the following:

1. **Incorporate three Arms of Effective Teaching**

Lesson plan incorporates three pivotal components of teaching such as course objectives, teaching learning activities and assessment methods

2. A Perfect Time Management Tool in Classrooms

A step-by-step lesson plan will help to lecture the important sections of a topic within the prescribed time period. With this tool in hand teacher will be able to teach with a better sense of direction and control.

3. Builds Confidence in Teachers

With a lesson plan in teacher hand, will become a confident teacher. Teacher would stay abreast with the novel teaching styles that are currently in vogue. A lesson plan helps to adhere to the best teaching practices that deliver effective teaching.

4. A Clear Route-Map for Effective Teaching

What to teach and how to teach are the two basic questions that should be pre-answered by teachers. A lesson plan here sheds light on what topics are considerable as against those which are secondary.

5. A Boon to Struggling Students

With a lesson plan at a disposal, teacher will be able to avoid casual omissions or repetitions that emerge as a result of students getting promoted from one grade into another.

Once the exam ends, earlier teacher with the new class teacher can review the lesson plan in action. This will help to come up with recommendations to aid struggling students.

6. Gain Recognition as an poignant Teacher

A well-organized teacher will be able to attract the attention of students who will pattern after your planning traits.

7. Sets the Anticipatory Mood for Students

Teachers rely on teaching mechanisms like a game, a video clipping or an industrial tour. This creates a sense of expectation among students.

8. **Promotes Healthy Learning Environment**

With a lesson plan as a teaching tool, teacher can plan your lessons in the most purposeful manner. Healthy classroom management is driven by a systematic pattern of teaching.

9. Paves a way in teaching learning preparation

Lesson plan provides a predetermined idea for a teacher in preparing instructional materials suitable for the content.

10. References quotes

Planning a lesson helps the teacher to refer relevant subject content from resource books before going for class room teaching

4.2 FACTORS THAT NEED TO BE CONSIDERED FOR ORGANIZATION OF CONCEPTS

Students' potentialities Consideration: Students are constructors of knowledge and teacher is a facilitator of learning. Students are at the focus of your teaching-learning. Each student is an individual with her own interests, abilities and experiences. Each student has special strengths and limitations.

Before identifying and organising concepts for teaching-learning, teacher should keep all points in mind.

Content and process consideration: What main ideas and concepts are involved? What teaching-learning materials will need to transact the concepts? In what order should the teaching-learning activities be arranged? How can a eacher devise a variety of learning activities and experiences to transact the concepts?

Time consideration: How much time is available for it? whether needed more than one day or one period for a particular topic?

Resource consideration: What resources are available in the school and community such as laboratory, library, ICT resources, science centre and museum and with people within the community who might contribute to teaching-learning process in the school?

Teacher consideration: Teacher needs to identify the pre–existing understandings that students bring with them and creating classroom tasks and environment under which students' thinking can be revealed are important.

Technical consideration: What appropriate equipments, hardware and software are available for effective transactions?

4.2.1 BASIC PRINCIPLES IN ORGANIZING CONCEPTS:

1. Every learner constructs her own knowledge: Teacher's responsibility is to enable this process through appropriate means and process and with adequate help and support.

2. Importance of experience in learning: Experience is perhaps most important step in the construction of knowledge. All possible opportunities to observe, feel, work with hands, reflect and arrive at ideas should be provided to learners.

3. Active engagement of learner in construction of knowledge: It refers to engagement of body as well as mind. Learners can be actively engaged when they feel motivated to learn.

4. Every learner is unique: Every learner constructs her knowledge in her own way. Some learners might find a particular kind of learning process challenging and enjoyable while others might not enjoy it as much. The level of learners' engagement could vary. If the teacher involves learners and remains flexible while planning her work, individual unique abilities of learners will bring tremendous richness to classroom process.

5. Variety of situations and multiplicity of strategies are important for creating diverse experiences: Different kinds of situations provide different kinds of learning experiences to students. Therefore, it becomes important to have opportunities for self-learning, peer learning, and learning

6. The implication of aims for classroom practices: The entire organisation of the classroom and learning experiences need to be such that they promote the same ethos, values,and principles.

7. An enabling teacher-learner relationship: The process of learning requires an uninhibited participation and engagement of learners that can be largely facilitated by teachers. It is important for the teachers to develop an affectionate and equal kind of relationship with learners, irrespective of their background and specificities.

4.3 ELEMENTS OF A PHYSICAL SCIENCE LESSON

A standardised format of a lesson or unit plan cannot capture interest of all learners. A well organised teaching-learning situation can have an appeal to students yet follow curricular guidelines of the school. Therefore, teacher need to design various learning situations in creative and innovative manner to cater to the learning needs of different learners.

There are certain basic elements of a lesson plan. Knowledge of these basic elements of a lesson plan will be a great help a teacher in planning for lesson design.

1. Title of the lesson/unit
2. Learning objectives and key concepts of the time frame
3. Pre-existing knowledge
4. Materials, equipments, resources
5. Introduction
6. Presentation
7. Assessment
8. Extended learning, assignment

4.3.1 IMPORTANT ELEMENTS OF PHYSICAL SCIENCE LESSON – IN DETAIL:

Learning objectives and key concepts: Objectives are the first step in the process of planning and thus form the basis of the subsequent steps of the plan.

Pre-existing knowledge: By pre-existing knowledge, we mean the knowledge and experiences, which a teacher consider essential for students to possess for learning the lesson being planned.

Teaching-learning materials and involving learners in arranging them: While selecting appropriate teaching-learning materials for our classroom, we need to make sure that they should cater to the needs of learners learning with various learning styles. Learners should be involved in procuring the materials for the preparation of activities and experiments to be performed.

Introduction: A good beginning is crucial for the success of any endeavour. Relating learning with everyday life experiences of the learner generates interest for learning new concepts.

Presentation/Development: Presentation/development of the lesson should be in accordance with the objectives of the lesson.

Assessment: Acceptable evidences that show learners understand Purpose of this element of a lesson plan is to get feedback from learners. In fact, assessment should be an integral part of the design of a lesson.

Extended learning/assignment: The most valuable assignment is the one which a student finds interesting and important, and understands why it is important.

4.4 DIFFERENT MODELS/APPROACHES FOR WRITING LESSON PLAN

1**. Herbartian's Approach :**

Involves six steps : Introduction / Motivation, Presentation, Association, Generalization, Application and Recapitulation

2. Bloom' Approach :

Education is a tripolar process which includes formulating educational objectives, creating learning objectives and evaluating change in behavior. It covers cognitive, affective and psychomotor learning out comes.

3. RCEM Approach :

This approach was developed by Regional College of Education, Mysore, Karnataka, India. It consists of three aspects : Input, Process and Outcome

Input refers to objectives of plan, known as expected behavioral outcomes (EBO), which is classified as Knowledge, Understanding, Application and Skill.

Process refers to teaching strategies and Outcome refers to real learning outcome of students.

4. Gloverian's Approach :

This approach includes Questioning, Investigation and Pupil activity

Skill lesson plan, appreciation lesson plan and lesson plan types based on the content such as detailed lesson plan, semi detailed lesson plan, brief lesson plan are some other approaches of lesson plan.

4.5 HERBARTIAN'S LESSON PLAN APPROACH - STEPS

This approach generally known as Herbartian Five steps approach in the procedure of the Herbartian School of pedagogy propagated by **J.F. Herbart (1776-1841**) and his followers.

The formal steps involved in the approach as below

1. Introduction/Motivation
2. Presentation
3. Comparison and association
4. Generalization
5. Application
6. Recapitulation

1. Introduction/Motivation

This step is concerned with the task of preparing the students for receiving new knowledge. In preparation, nothing new is taught to students. Relevant to the topic in hand the teacher should make himself sure of what the pupils already know , by putting a few questions , based on the pupils previous knowledge. In general, with the help of this step, the teacher can check the students entering behavior before he starts teaching the lesson. Thus, testing previous knowledge, developing interest in the minds of students and maintaining curiosity of the students can be achieved with the help of this step.

The following activities involved in this step

The assumption about the previous knowledge of the students in relevance to the lesson

The testing of the previous knowledge

Utilizing the previous knowledge for introducing the lesson

Motivating thee students for studying the present lesson

2. Presentation

It is the key step and only through which the actual process of teaching is going to take place. Here the aims of the lesson should be stated clearly and the heading should be written on the blackboard. We have to provide situation for both the teacher and the students to participate in the process of teaching and learning. Our ultimate aim of the presentation is to make the concepts understandable to the students.

Therefore simple language is used. Appropriate and specific examples and illustrations of the concepts will make the understanding better. The interest of the students on the subject matter should be maintained continuously by the way of asking questions from time to time in this stage. The teacher should carefully and skillfully arrange his material so that his

pupils may clearly and readily grasp it. The teacher should make proper use of questions, charts, graphs, pictures, models and other illustrative for demonstration and explanation.

At the end of each section a few questions concerning that section only should be asked to whether the pupils are now ready for the acquisition of knew knowledge.

3. Comparison or Association

More importance should be given in this stage to compare the facts observed by the students with another concept by way of giving examples. By making use of this comparison, the students can derive definitions or theories. The students are encouraged to give new suitable examples for the concept instead of the examples given in the book to make them think in an innovative manner.

4. Generalization

This step is concerned with arriving at some general ideas or drawing out the necessary conclusions by the students on the basis of the different comparisons, contracts and associated observed in the learning material present by the teacher. As far as possible the task of formulation should be left to students. The teacher at this stage should try to remain in the background for providing only necessary guidance and correction.

5. Application

In this stage, the teacher makes the students to use the understood knowledge in an unfamiliar situation. Unless the knowledge of science is applied in new situations or in our day-to-day life, the study f science will become meaningless. This application off scientific principles will strengthen learning and will make the learning permanent

6. Recapitulation

This stage is meant for the teachers to know whether students have grasped and understood these concepts taught or not. This can be achieved by

reviewing a lesson or by giving assignments to the students. Only through this step achieving closure (in teaching) is possible.

4.6 ASPECTS OF A GOOD LESSON PLAN

Student choice: Best way to make lessons engaging and meaningful is to give students opinions that relate to them.

Cross- Curricular: Teacher should strive to have lessons in cross- sectional competencies.

21st – Century Skills: 21st – century skills are now essential life skills for modern students. Hence the teacher should make digital citizenship instruction

Hands – on instruction: teacher can make a lesson effectively by utilizing hands- on learning experiences.

Multimodal: along with direct lecture model, teacher should utilize visual tools for better learning.

Multiple tasks : Good lesson should provide multiple task to the learner.

Evolving: A good lesson would adjust according to the needs of the society and perfect updated.

4.7 UNIT PLANNING – DEFINITION

Unit plans consist of concepts and learning goals that are taught over a period of time and are woven together, often across subject areas. A unit plan lasts two or three weeks (or longer) and includes several standards, skills, and desired outcomes for interconnected learning.

4.7.1 PURPOSE OF UNIT PLANNING:

The purpose of unit planning is to connect the competencies, language standards, and skills together so that it creates a unified picture for the students. Instructors are able to group language standards across skills to integrate with the competencies at the students' level.

4.7.2 IMPORTANCE OF UNIT PLANNING:

It makes teaching systematic and well organized. It helps teachers in identifying adequate content and its proper sequencing for teaching a lesson. It helps teachers to learn to foresee and tackle learning difficulties of children.

4.7.3 UNIT PLANNING - SALIENT FEATURES

1. Effectively in terms of whole rather than fraction
2. Effective when is an understanding and acceptance of goal to be achieved
3. Developmental and therefore provide for vertical & horizontal organization of learning experience
4. Necessity for providing for individual differences in rates of learning and interests.
5. Unit planning recognizes that true learning renders the learners increasingly skill in self- directions.
6. Unit planning provides sound basis for evaluation

4.7.4 UNIT PLANNING - STEPS

Step 1 – Develop your unit's vision and purpose.

Step 2 - Decide what skills, concepts and terminology will be taught or emphasized.

Step 3 - Plan a summative unit assessment.

Step 4 - Translate your learning goals into lesson objectives.

Step 5 - Sequence your content and scaffold your lesson objectives.

4.7.5 ELEMENTS SHOULD BE CONSIDERED WHEN DEVELOPING A UNIT PLAN:

- A principal purpose
- Main topic or topics (e.g., World War II, reptiles, double-digit multiplication)
- Concepts (e.g., integrity, the Doppler effect) that unite lessons within the unit

- Essential skills to be developed
- Academic goals and desired outcomes
- Academic standards that directly relate to the subject area or areas
- Cross-curricular connections
- Methods to make the learning relevant throughout the unit
- Big ideas that link to additional big ideas to increase understanding
- Past learning that links to present learning and leads to future learning
- An understanding of students' current knowledge
- Questions to guide thinking each day and from day to day
- Questions based on recurring unit ideas or themes
- Clear expectations for learning of all students
- Vocabulary to study and focus on, with multiple exposures over time to engrain learning
- A determination of appropriate level of proficiency to meet desired outcomes
- Assessments for before, during, and after lessons and the overall unit

UNIT 5: METHODS AND TECHNIQUES OF TEACHING PHYSICAL SCIENCE

5.1 LECTURE – CUM - DEMONSTRATION METHOD

Lecture-cum-demonstration is one of Traditional and Teacher centered method. This is also known as Chalk and talk method. This method includes the merits of the lecture as well as demonstration method. It attempts to filter out the disadvantages of both. Demonstration means 'to show'. In Lecture method teacher just tells but in demonstration method teacher shows and illustrates certain fundamental phenomena.

5.1.1 STEPS IN LECTURE-CUM-DEMONSTRATION

1. **Planning and Presentation:** While planning a demonstration, Subject matter, Lesson planning, Rehearsal of experiment, Collection and arrangement of apparatus should be kept in mind.

2. Introduction of lesson: The lesson may be introduced on Student's personal experience, Student's environment, Telling story, simple and interesting experiment.

3. Presentation of the subject matter: The subject should consists of the following things

- The teacher must study the subject matter on broad basis taking into consideration the interest and experience of students
- While demonstration is going on, question should also be asked which help the students to understand the principles
- The teacher should try to illustrate the facts and principles
- Language used by teacher should be simple and clear.

4. Experimentation:

- Demonstration should be properly spaced and striking, clear and convincing
- The demonstration table should have only apparatus

- The experiment should be simple and speedy
- All the apparatus should not be displayed at once

5. Blackboard work

A big blackboard behind the demonstration table is necessary in order to summarize the principles and other matters of demonstration and also to draw necessary diagrams and sketches.

5.1.2 CRITERIA OF A GOOD LECTURE- CUM- DEMONSTRATION METHOD

1. Should be planned and rehearsed well in advance.
2. The teacher should be clear of the purpose of demonstration.
3. Demonstration should be the result of the active participation of pupils and teacher.
4. Teacher helps the students in arranging and fitting and performing the experiment.

5.1.3 ADVANTAGES OF LECTURE- CUM- DEMONSTRATION METHOD

1. It helps in involving various sense to make learning permanent
2. It invites the cooperation of pupils in teaching learning process
3. It develops interest in the learners and motivates them for their active participation
4. It helps in achieving psychomotor objectives
5. Simple or complex skill becomes easy to understand
6. Save time and money.
7. Activity method and Helpful for teacher

5.1.4 DISADVANTAGES OF LECTURE- CUM- DEMONSTRATION METHOD

1. It can be used only for skills subjects
2. Only the attention of the learners is invited towards the activity demonstrated.
3. Students are not free to discuss about it

4. In some schools scarcity of audio-visual aids and equipment and the teachers are not so creative to produce handmade models for demonstration
5. There is a general lack of sincerity and diligence among teachers who wish to complete the syllabus or syllabi at the earliest without putting sincere efforts
6. Visibility is main problem for a teacher because all the students may not be able to see the details and results of a demonstration
7. Speed of experiment, Either too fast or too slow speed of demonstration sometimes may create trouble
8. Ignore individual difference
9. This method somehow hinder the development of laboratory skills among the students
10. Not useful for developing scientific attitude.
11. Ignore maxim of education, 'Learning by Doing' and the principles of psychology of learning has no place in this method.

5.2 HEURISTIC APPROACH

The term "Heuristic" refers to Armstrong who was the exponent of this strategy. Pollion and Dankar (1945) called it "problem solving". It is based on the psychological principles of "trial and error" theory. Logical and imaginative thinking are perquisites for this type of teaching strategy. It is an economical and speedy strategy.

Heuristics are a problem-solving method that uses shortcuts to produce good-enough solutions given a limited time frame or deadline. Heuristics are a flexibility technique for quick decisions, particularly when working with complex data. Decisions made using a heuristic approach may not necessarily be optimal. Heuristic is derived from the Greek word meaning "to discover".

Problem is placed before the learners and they are asked to find the solution of the problem through various literacy means, like library, laboratory, and workshops etc.

Teacher's role in heuristic approach: Teacher's role is to initiate the learning and pupils are active throughout the learning process. By using their creative thinking and imaginative power, they try to find out the relevant solutions based on some logic. They learn by self-experience.

5.2.1 OBJECTIVES OF HEURISTIC APPROACH

- To develop problem solving attitude
- To develop scientific attitudes towards the problem
- To develop power of self-expression
- To teach as little as possible at one time
- To encourage learner to learn himself as much as possible

5.2.2 ADVANTAGES OF HEURISTIC TEACHING METHOD

1. It helps in achieving cognitive, affective and psychomotor objectives
2. It helps in all round development of the child.
3. Provides situation to learn by self-experience.
4. Develops self-confidence and self-reliance in the learners.
5. It helps in developing scientific attitude and creativity in the learners.
6. New knowledge is discovered by students.
7. Interaction between the teacher and the learner takes place in a cooperative, conducive environment.

5.2.3 DISADVANTAGES OF HEURISTIC TEACHING METHOD

1. It cannot be used at primary level of education
2. Higher intelligence and divergent thinking is required in the learners.
3. Few teachers do not have patience for providing individual guidance to the learners.
4. Learners feel hesitation in seeking teachers help.
5. There can be number of solutions for a problem.

5.2.4 SUGGESTIONS TO HEURISTIC TEACHING METHOD

- Problem should be related to the course and curriculum
- A definite time period should be allotted to the learners to finish research work.
- Students' abilities capabilities, interest and choice of the subject should be taken into consideration in allotting the problems.
- There should be eligibility criteria for providing the problems.

5.3 HISTORICAL AND BIOGRAPHICAL APPROACHES

Historical Approach: Interpreting a piece of literature in order to understand the time and culture in which the work was written.

Biographical Approach: Looks into the life of the author through primary sources that reveal the experience, thoughts and feeling that contributed to the creation of a literary work.

5.3.1 HISTORICAL AND BIOGRAPHICAL APPROACHES

The historical approach is usually allied with biographical approach and together they constitute the historical-biographical approach. The historical biographical approach "sees a literary work chiefly, if not exclusively, as a reflection of its author's life and times or the life and times of the characters in the work".

The historical-biographical approach helps us in understanding a work in a better light because if we know the historical circumstances, as well as the real life incidents of the author, then we can analyse and take out interpretations from the work which may have seeped in knowingly or unknowingly. What a person is definitely an outcome of the times he lives in or of his own life experiences.

Moreover, what a person is, his beliefs, his convictions, his thoughts and his philosophy, does get reflected in his work through the characters or situations portrayed therein. Complete alienation between 'the man who suffers' and 'the mind which creates' though desirable may not always be possible.

5.3.2 Advantages of historical-biographical approach

- Students will reinforce their memorizing ability
- Evolves students speaking ability and accustomed to produce correct language
- It values personal experiences and individual voices as relevant and insightful ways of understanding the everyday realities of education.
- Works well for some which are obviously political or biographical in nature

5.3.3 Disadvantages of historical-biographical approach

- At the beginning it will be very confuse for the slow-brain students to follow
- It needs a lot of concentration to focus on what the teacher say in order to repeat it correctly
- It cannot guarantee that the students writing ability will be as good as their speaking ability because this method is more focus on speaking and memorizing skills.
- All the topics cannot be dealt with this method.

5.4 SCIENTIFIC METHOD

The scientific method is defined as a method of research in which a problem is identified, relevant data is gathered, a hypothesis is formulated from this data, and the hypothesis is empirically tested.

Make an observation or observations

5.4.1 STEPS IN SCIENTIFIC METHOD

Step 1: Make an Observation

Almost all scientific inquiry begins with an observation that piques curiosity or raises a question

For example, if you wanted to study the air-resistance problem stated above, you might already have an intuitive sense that a car shaped like a bird would reduce air resistance more effectively than a car shaped like a box. You could use that intuition to help formulate your hypothesis.

For example, when **Charles Darwin** (1809-1882) visited the Galapagos Islands (located in the Pacific Ocean, 950 kilometers west of Ecuador, he observed several species of finches, each uniquely adapted to a very specific habitat. In particular, the beaks of the finches were quite variable and seemed to play important roles in how the birds obtained food. These birds captivated Darwin. He wanted to understand the forces that allowed so many different varieties of finch to coexist successfully in such a small geographic area. His observations caused him to wonder, and his wonderment led him to ask a question that could be tested.

Step 2: Ask a Question

The purpose of the question is to narrow the focus of the inquiry, to identify the problem in specific terms. The question Darwin might have asked after seeing so many different finches was something like this: What caused the diversification of finches on the Galapagos Islands?

Here are some other scientific questions:

- What causes the roots of a plant to grow downward and the stem to grow upward?
- What brand of mouthwash kills the most germs?
- Which car body shape reduces air resistance most effectively?
- What causes coral bleaching?
- Does green tea reduce the effects of oxidation?
- What type of building material absorbs the most sound?


Ask a Question
Do Background Research
Construct a Hypothesis
Test with an Experiment
Procedure Working?
No
Yes
Troubleshoot procedure. Carefully check all steps and set-up.
Analyze Data and Draw Conclusions
Results Align with Hypothesis
Results Align Partially or Not at All with Hypothesis
Experimental data becomes background research for new/future project. Ask new question, form new hypothesis, experiment again!
Communicate Results

.

Step 3: Formulate a Hypothesis

The great thing about a question is that it yearns for an answer, and the next step in the scientific method is to suggest a possible answer in the form of A hypothesis is often defined as an educated guess because it is almost always informed by what you already know about a topic.

Notice that there are two important qualities about a hypothesis expressed as an "if then" statement. First, it is testable; an experiment could be set up to test the validity of the statement. Second, it is falsifiable; an experiment could be devised that might reveal that such an idea is not true. If these two qualities are not met, then the question being asked cannot be addressed Experiment

Many people think of an experiment as something that takes place in a lab. While this can be true, experiments don't have to involve laboratory workbenches, Bunsen burners or test tubes. They do, however, have to be set up to test a specific hypothesis and they must be controlled. Controlling an experiment means controlling all of the variables so that only a single variable is studied. The independent variable is the one that's controlled and manipulated by the experimenter, whereas the dependent variable is not. As the independent variable is manipulated, the dependent variable is measured for variation.

Controlling an experiment also means setting it up so it has a control group and an experimental group. The control group allows the experimenter to compare his test results against a baseline measurement so he can feel confident that those results are not due to chance.

Step 5: Analyze Data and Draw a Conclusion

During an experiment, both quantitative and qualitative data should be collected. Buried in that information, hopefully, is evidence to support or reject the hypothesis. The amount of analysis required to come to a satisfactory conclusion can vary tremendously. Sometimes, sophisticated statistical tools

have to be used to analyze data. Either way, the ultimate goal is to prove or disprove the hypothesis and, in doing so, answer the original question.

5.4.2 ADVANTAGES / IMPORTANCE OF THE SCIENTIFIC METHOD

1. The scientific method is impartial and attempts to minimize the influence of bias or prejudice in the experimenter.
2. It provides an objective, standardized approach to conducting experiments and, in doing so, improves their results.
3. Strengthens confident, stick to the facts and limit the influence of personal, preconceived notions.
4. It is based on empirical evidence
5. It provides proof and subject to verification
6. Found by reasoning and observation
7. Reliable at finding the truth
8. Cautious - with theories that are backed up

5.4.3 LIMITATIONS OF THE SCIENTIFIC METHOD

1. Certain topics beyond the reach of the scientific method
2. Science cannot prove or refute the existence of God or any other supernatural entity.
3. Sometimes, scientific principles are used to try to lend credibility to certain nonscientific ideas, such as intelligent design.
4. Science is also incapable of making value judgments.
5. Occasionally, certain organizations use scientific data to advance their causes. This blurs the line between science and morality and encourages the creation of "pseudo-science," which tries to legitimize a product or idea with a claim that has not been subjected to rigorous testing.
6. Nothing has full knowledge of the world
7. Senses can deceive us - science only provides us with an incomplete picture of the world
8. Scientists can never be completely unbiased
9. Science isn't free from error

5.5 INDUCTIVE AND DEDUCTIVE METHODS

5.5.1. INDUCTIVE APPROACH

An inductive approach is concerned with the generation of new theory emerging from the data. The aim is to generate a new theory based on the data. Inductive reasoning allows you to take an observation and then go forward to apply that to various similar circumstances and at times different scenarios.

5.5.2 ADVANTAGES OF INDUCTIVE APPROACH

1. The learners are more engaged in the teaching-learning process
2. Learning becomes more interesting at the outset because we begin with the experiences of our students
3. Allows flexibility, attends closely to context and supports the generation of new theory
4. Enables to work with probabilities.
5. It is used consciously and naturally by people in all walks of life
6. From friends to peers, we tend to use inductive reasoning to judge people
7. It develops our perceptions and it also influences how we approach tasks
8. It fuels more exploration to test if the judgment or probable inference is right or wrong.

5.5.3 DISADVANTAGES OF INDUCTIVE REASONING

1. Inductive reasoning is very limited and begins with a single observation or an inference drawn from very specific and alike situations.
2. This cannot possibly lead anyone to a fair judgment or accurate inference in a diverse world.
3. It begins with something specific and then tries to generalize, which will go wrong more often than frequent.

5.6 DEDUCTIVE APPROACH

A deductive approach is aimed and testing theory, Deductive reasoning allows you to have a cluster of observations and then you deduce the various scenarios or

break them down to get to a specific observation whereby you get led to a conclusion studying the various possibilities.

It is referred to as top-down thinking or moving from the general to the specific.

5.6.1 ADVANTAGES OF DEDUCTIVE APPROACH

This method is short and time-saving. The solution of the problems by pre-established formulae takes little time.

1. It encourages memory as the students have to memories a considerable number of formulae.
2. Possibility to explain causal relationships between concepts and variables. Possibility to measure concepts quantitatively.
3. Possibility to generalize research findings to a certain extent.
4. This method is advantageous at the "Practice and revision" stage.
5. It enhances speed and efficiency in solving problems.
6. This removes the incompleteness and inadequacy of Inductive method.
7. This method is not suitable for development of thinking, reasoning and discovery.

5.6.2 DISADVANTAGES OF DEDUCTIVE APPROACH

1. The beginners find it very difficult to understand an abstract formulae
2. This method will demand blind memorization of a large number of formulae.
3. This cause an unnecessary and heavy burden on the brain of children.
4. In this method, memory becomes more important than understanding and intelligence and that is educationally unsound.
5. Blind cramming leads very often to forgetting the formulae and the children are at a loss to recollect. This ultimately leads to no learning.

5.6 PROJECT METHOD

Project method is one of the modern method of teaching in which students point of view is given importance in designing the curricula and content of studies. This method is based on the philosophy of pragmatism and the principle of “Learning by Doing” . The idea was thought to have originally been introduced in 1908 as a new method of teaching agriculture, but educator William H. Kilpatrick elaborated the concept and popularized it worldwide in his famous article, "The Project Method

W.H Kilpatrick defines “A project mehod is a wholehearted purposeful activity proceeding in a social environment

A project method is a bit of real life that has been imparted into schools – Ballord

5.6.1 STEPS IN PROJECT METHOD

Step 1: Setting the Stage with Real-Life Examples

With the help of the school's science teacher, student ill set the stage according to their real life back ground

Step 2: Taking on the Role of Project Designers

Students are grouped and work will be assigned.

Step 3: Discussing and Accumulating Necessary Background Information

Students need to collect information of project research to be undergo and collected datas are discussed .

Step 4: Negotiating the Criteria for Evaluation

Students are involved in evaluating criteria , whether clearly defined and the students realized that they might have to be modified in the future.

Step 5: Accumulating the Necessary Materials

Required materials for the project are arranged well in advance

Step 6: Creating the Project

Students in each group worked on until they decided on a final design. During this stage teacher should serve as coach, moving from group to group to guide the students' work.

Teacher can check,

- Do the students have a clear understanding of the task?
- Does each student have *ownership* of her role within the group?
- Are the students *attentive* and working together cooperatively?
- Are the resources that students use geared to their comprehensive level of understanding?
- Are any groups stumbling in a way that is blocking their work due to heightened emotions?

Step 7: Preparing to Present the Project

The students in each group prepared for the final stages, discussing whether or not the presentations needed to be rehearsed.

Step 8: Presenting the Project

During this stage, students become aware of the ways their presentations meet the criteria of assessment. The teacher-coach observes how engaged they are in presenting their projects.

Step 9: Reflecting on the Process and Evaluating the Process

In this simulation, the students discussed what they enjoyed about working in pairs or small groups, and how one student's idea would spawn another student's idea. They discussed what they liked about the materials and what they found to be frustrating. Students shared their reflections to note what they had in common and what was special to each pair or to each individual personally. They reviewed the criteria of assessment and discussed how well they met them.

5.6.2 PRINCIPALS INVOLVED IN PROJECT METHOD

1. Principle of Utility: Choose those projects which are closer to the social life.
2. Principle of readiness: Involve the learners in finding the solution of the problem with their active participation.
3. Principle Learning by Doing: Learner performs certain tasks and experiences new things.
4. Principle of knowledge empowering: This adds to his knowledge and results in learning.
5. Principle of Socialization: It develops the feeling of cooperation and group work.

6. Principle of Inter-disciplinary Approach: It involves the knowledge of different subjects in solving the social problems.
7. Principle of freedom : The desire for an activity must be spontaneous and not forced by a teacher
8. Principle of reality : this method adopts real life situation as a base for doing project

5.6.3 KILPATRIC CLASSIFICATION OF PROJECT METHOD

1. **Constructive:** When learners have to construct some things related to social life. e.g. charts, models, maps, parcels etc.
2. **Artistic:** These projects are generally allotted in the aesthetic fields of life. e.g. in music, drawing, painting art and culture.
3. **Problem-Solving:** These projects are given to solve the problems related to any life-situation or related to any subject e.g. how to operate bank accounts? Or how to send an email or letter. These general problems if solved, will make a child efficient for social-life.
4. **Group-Work:** A team of students is assigned a work to be performed. e.g. to develop a garden in the school

5.6.4 APPLICATIONS OF PROJECT METHOD

1. It helps to develop social skills and values among the students.
2. It gives an opportunity to correlate the subject matter to real life situations.
3. Students are more receptive and learn faster when they work together.
4. It helps in developing social norms and social values among the learners.
5. It provides invaluable opportunities for correlation of various elements of the subject matter and for transfer of training or learning.
6. Students get proper freedom to execute the project in accordance with their interest and abilities
7. Students are permitted to choose projects on their own, as a result of which they make use of their abilities to maximum possible extent.

8. Habit of critical thinking gets developed among the students through this method.
9. Students get the ample chances in which they can develop coordination among their body and mind.
10. Teacher can lead a well balanced development of the students.
11. Science teaching can be done with considerable success
12. Students can able to solve out their own life problems independently and effectively.

5.6.5 SHORTCOMINGS OF PROJECT METHOD

1. This method takes a lot of time to plan and execute a single project.
2. It is not possible to design different projects for different topics and it is also not possible to cover all the topics or content in a single project.
3. For proper execution of a project, large number of financial resources is required
4. Such method can only be prove successful if the teacher is highly knowledgeable
5. Systematic and adequate learning is not provided by this method, as it is a method of incidental learning.
6. Generally it is found that teachers do not possess much information regarding the manner in which this method should be used.

5.7 LABORATORY METHOD

Laboratory Method is a planned learning activity dealing with original or raw data in the solution of problem. It is a procedure involving first hand experiences with materials or facts derived from investigations or experimentation.

This method is one of the important methods of teaching science and it forms an integral part of effective science teaching. Under this method teacher can encourage the students to derive various scientific laws and principles on their own by getting personally involved.

5.7.1 ADVANTAGES OF LABORATORY METHOD

1. Gives training in organizing data gathered from real materials object and how these objects are manipulated to attain the objectives
2. Develops the power of observation and reasoning
3. Develops scientific attitude
4. It enables students in solving problems

5.7.2 DISADVANTAGES OF LABORATORY METHOD

1. Does not give much training in verbal expression
2. Students are aware of experiment, may change behaviour.
3. Artificial environment and low realism.
4. May have low ecological validity and difficult to generalise to other situations.
5. Experimenter effects - bias when experimenter's expectations affect behaviour.

5.8 TEAM TEACHING

Team teaching is a well-defined system in which many teachers provide instructions collectively to the group of students.

It involves a group of instructors working purposefully, regularly, and cooperatively to help a group of students of any age learn. Teachers together set goals for a course, design a syllabus, prepare individual lesson plans, teach students, and evaluate the results.Here the plan of teaching method, time and process is kept flexible. So that it can be modified according to the ability of teachers and students and on objectives of teaching.

5.8.1 TYPES OF TEAM TEACHING

1. A team of teachers of the same department

Such type of classification is done for secondary and secondary classes. It is possible only when more than one teacher is available in the department.

2. A team of teachers of various departments of the same institution

Here a team of teachers of different subjects is made and that team is used in a training institution. Interdisciplinary teaching is encouraged. For example for B.Ed. and M.Ed. training a team of teachers from subjects like psychology, philosophy, sociology etc. are used.

3. A team of teachers of the same department from different institutions

In this type of teaching experts from other institutions are also invited to join the team. Such a team can be arranged at every level. A provision of such team teaching for each topic can be made very conveniently. Use of such team teaching is very beneficial.

5.8.2 STEPS OF TEAM TEACHING

For team teaching, a sequential procedure is followed. Following steps are involved in the process of team teaching.

Step 1: Planning

Step 2: Organization

Step 3: Evaluating team teaching

Step 1: Planning

In this step plan for team-teaching is prepared.The orientation of faculty, Since it is a collaborative activity it is the responsibility of the organizes to provide orientation to the teacher involved about the concept of team teaching, he rationale of implementing it, responsibilities of each team member.

Teachers should also be told about their roles, record making, communication strategies, and scheduling teamwork.

- to write, the objective of team teaching is behavioral terms.
- to make a decision about the topic of teaching.
- to determine evaluation techniques.
- to create teaching material and planning for a favorable environment.

Step 2: Organization

To organize team teaching, the objectives of the organization are kept in mind and problems of students are also kept in mind.

Following activities, one performed for the organization of team teaching.

- Teachers judge the entering behavior of students for making a decision about the level of the instructions.
- After determination of entry behavior of students, communication technique is selected.
- The teacher then delivers the lead lecture and fellow teachers of team listen to him and note points where students face difficulties, which topic head more detailing and which parts of the lecture were not presented properly.
- After this other teachers also deliver the lecture and clarify the different elements by supplementing the lead lecture.
- The activities of students are reinforced.
- During these lectures, some tasks are assigned to the students for better compliance in the classroom.

Step 3: Evaluating team teaching

- This is a very significant step in the entire team teaching process.
- In this step, evaluation is done in the context of the acquisition of objectives on the basis of the performance of students.
- In this step oral, written questions and experimental methods are followed for evaluation. Every question evaluates an objective.
- The drawbacks and difficulties of the students are diagnosed and proper remedies are proposed.
- Results of evaluation act as the reinforcement in pupils and teachers.

5.8.3 ADVANTAGES OF TEAM TEACHING

1. It helps in creating a dynamic and interactive learning environment.
2. It inspires new ideas and sense of partnership amongst teachers.
3. Most/important utility of team teaching is that it can be used to improve the quality of instruction.
4. In team teaching the students to get the opportunity of exposure to more specialists.
5. Teachers learn from the experience and expertise of other teachers and are able to expand the scope of their teaching capacity.

6. It leads to the effective utilization of human resources and effective use of available facilities.
7. Through team teaching, the members and the students get multiple chances to participate in discussions.
8. Team teaching gives professors the opportunity to teach in a different way, and to learn in a different way.
9. It is based on the co-operation of the participating teachers
10. It allows instructors to sharpen their pedagogical skills and develop new topics per research and scholarship.

5.8.4 LIMITATIONS OF TEAM TEACHING

1. Team teaching cannot be a success if teachers do not co-operate and co-ordinate with each other.
2. Group responsibility can actually turn out to be no one's responsibility.
3. Team teaching makes more demands on time and energy. Members must arrange a mutually agreeable time for planning and evaluation.
4. There can be a possibility of conflict between new methods and traditionalism.
5. Some teachers are rigid personality types or may be wedded to a single method. Some simply dislike the other teachers on the team.
6. Some do not want to risk humiliation and discouragement at possible failures
7. Team teaching makes more demands on time and energy

5.9 SUPERVISED STUDY

Supervised study means a shift from mass teaching to individual or group instruction. Supervised study affords a practical method of teaching pupils what to study and how to study and to bring the pupils into intimate contact with the teacher and the learning process.

Study or preparation of lessons by a class or group in the presence of a teacher who maintains order and may assist individual pupils in improving methods and habits of study.

5.9.1 PROS OF SUPERVISED STUDY

1. It enables the teacher to give individuals attention.
2. The pupils get through training in study habits
3. It gives the child training in the effective use of library and gives the opportunity to judge the soundness of statements given in the text books. This method provides an exact idea about the classes in the training data.
4. It saves time and energy of pupils.
5. It makes the students self reliant and responsible
6. Supervised learning is a simple process for understanding
7. Supervised learning can be very helpful in classification problems.

5.9.2 CONS OF SUPERVISED STUDY

1. It requires good library, good laboratory and good reading room
2. Requires additional teachers
3. Limited in a variety of sense so that it can't handle some of the complex tasks
4. This cannot give you unknown information from the training data like unsupervised learning do.
5. It cannot cluster or classify data by discovering its features on its own, unlike unsupervised learning.
6. We can't always give lots of information with supervision.

5.10 ROLE PLAY

Role-play is a technique that allows students to explore realistic situations by interacting with other people in a managed way in order to develop experience and trial different strategies in a supported environment.

Role play will give children the skills to handle problematic social interactions, such as bullying, which may happen as they progress through life. When children engage in role playing it helps to develop their way of thinking and helps them to develop feelings of empathy.

Role play in the classroom is a form of instruction in which you have students take the part of someone else so that they can understand a situation from a different perspective than they normally would.

5.10.1 PROS OF ROLE PLAY

1. Using role playing in the classroom can help teach children in the class about certain situations in a relatable and dramatic fashion
2. In a role playing situation, students get the opportunity to practice skills they might not use on a regular basis.

5.10.2 CONS OF ROLE PLAY

1. Role playing situations might not flesh out quite like you hope because some students are embarrassed and thus tentative about acting out a part in a dramatic fashion.
2. Children may also have a problem with the activity if they cannot fathom how their character might think or behave.
3. This will cause them to become disinterested and stop paying attention.
4. Children sometimes act silly when they feel uncomfortable, which can trigger other inappropriate behaviors such as teasing and snickering.

5.11 PLAY WAY METHOD

Play-way method of learning is a complete package that enables overall development of the child by developing in terms of feelings, intellect and skills parameters.

Ross: “Play is joyful, spontaneous and creative activity in which man finds fullest self-expression.”

"Play is the activity in which a person engages himself when he is free to do what he wants to do." - Crow and Crow:

"Play is the highest phase of child development and the source of all that is good." - Froebel

5.11.1 PRINCIPLES IN PLAY WAY METHOD

- Principle of Learning by Doing
- Principle of individual differences
- Principle of Sympathetic Attitude

5.11.2 PROS OF PLAY WAY METHOD

1. Encourages creativity and imagination
2. Pretend play helps children naturally develop and use their cognitive abilities and skills.
3. Fosters social and emotional development
4. Improves communication and language
5. Develops thinking, learning & problem solving skills
6. Physical Value: The child develops the body through play. ...
7. Intellectual value: Learning is more effective when children are curious to learn.
8. Social Value: In play the students have a chance to live and work with others.
9. Emotional value: Play helps in stabilizing the emotions of children.

5.11.3 CONS OF PLAY WAY METHOD

1. It consumes a lot of time and very tedious for the teacher, especially when the class size is large.
2. It is expensive because it requires the use of teaching aids and equipment
3. It may not lead to Learning
4. It may not be Ideal for Language Development
5. Parents may disagree with Unstructured Play

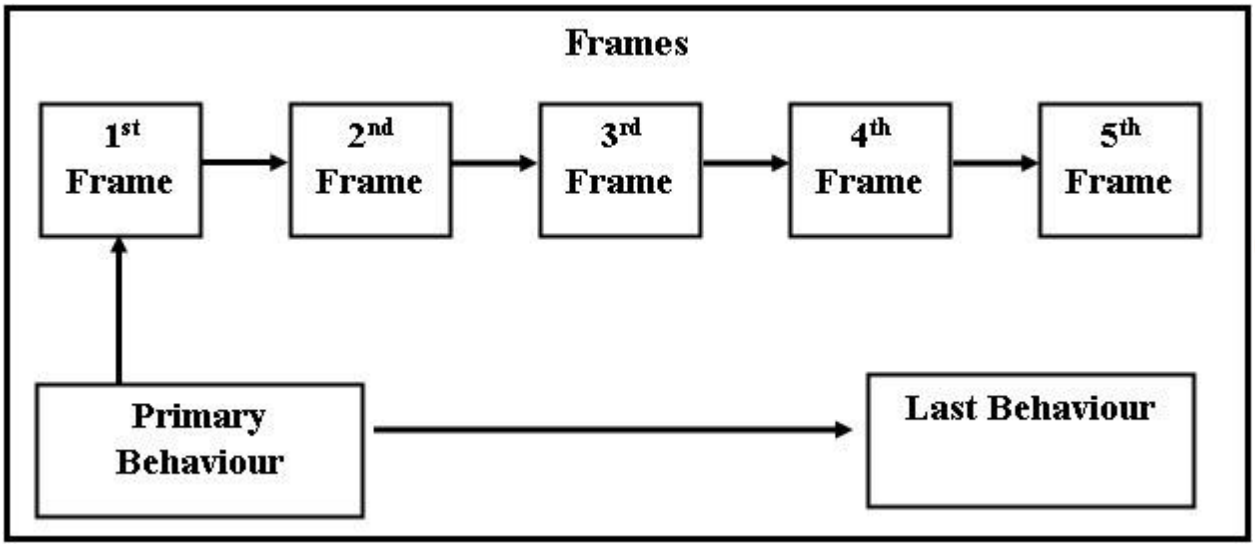
5.12 PROGRAMMEDINSTRUCTION

Programmed learning is the most appropriate example of the latest concept of instructional technology. It is educational innovation and auto-instructional device. It is not only a technique for effective learning but also a successful mechanism of feedback device for the modification of teacher-behaviour.

Programmed instruction is a method of presenting new subject matters to students in a graded sequence of controlled steps. Students work through the programmed material by themselves at their own speed and after each step test their comprehension by answering an examination question or filling in a diagram.

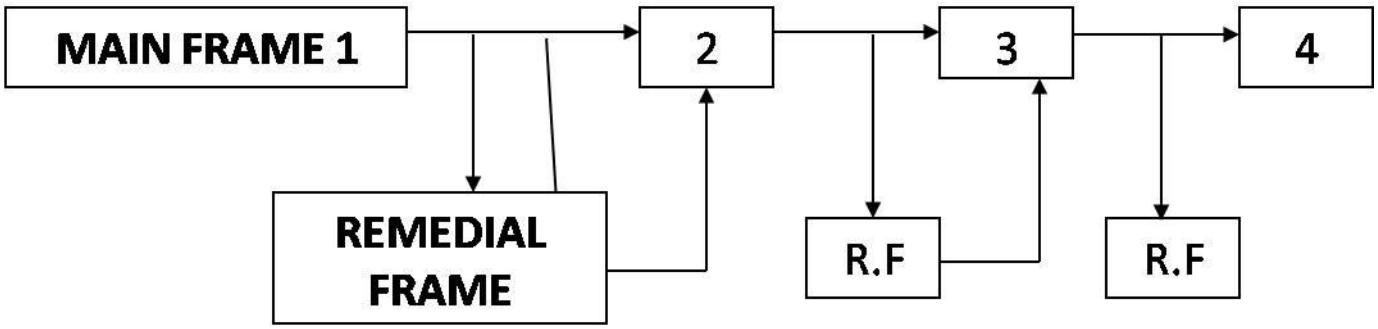
5.12.1 TYPES OF PROGRAMMED INSTRUCTION – LINEAR PROGRAMME

Linear programme is one in which every learner follows the identical sequence, that is, the frames or didules are encountered in a single, pre-arranged order. The proponent of this type of programme style is B.E Skinner (1958).



5.12.2 TYPES OF PROGRAMMED INSTRUCTION – Branching

Branching programme is one where the particular response emitted on a frame or didule determines the alternative frame/ frames, the learner proceeds to next. The proponent of this programme type is Norman Crowder (1960)



Mathetics is one in which there is the systematic application of reinforcement theory to the analysis and construction of complex repertoires. This also represents mastery of subject matter.

5.12.3 STEPS IN PROGRAMMING

1. Topic Selection: The programmes should select the most familiar topic; otherwise he has to take the help of a subject expert.

2. Content Outline: After topic selection, its outline may be prepared which cover all the materials, one plans, to teach. For this programme one has to refer to examine relevant books and materials.

3. Instructional Objectives: Instructional Objectives must be formulated which involve both task description and task analysis. The former is the description of terminal behaviours which the learner is expected to achieve and the latter is the series of component behaviours that he is required to acquire in the process of achieving terminal behaviour.

4. Entry Skill: The learner should have some pre-reqisite ability and skill to understand properly the new programme. This background experience is called the entry skill and a suitable programme cannot ne prepared without proper assessment of the entry skill.

5. Presentation of the Material: Suitable format is to be decided for presenting the material from the educational point of view. Then the programmed material should be presented in a sequence of frames arranged as steps towards terminal behaviour.

6. Student Participation: On analysis of the terminal behaviour one will find the critical responses of the students.

7. Terminal Behaviour Test: The effect of programme can be ascertained by administering the terminal behaviour test. It is also known as performance assessment. This provides feedback to the programme and shows the effectiveness of the instructional materials.

8. Revision: Lastly the programme may be revised on the basis of feedback. The instructional materials may be edited and modified according to the needs and requirements of the target audience.

5.12.4 PRINCIPLES OF PROGRAMMED INSTRUCTION

1. Principle of Small Steps

A program is prepared with large number of small and easy steps. The subject matter is broken down into a sequence of small step. A learner can take a step at a time. He/she has to read a small step by being active. Learning is better when the material is presented in small steps. It also reduces the rate of committing errors and encourages further learning.

2. Principle of Active Responding

Programmed instruction provides the information in the form of small steps and each step is required to be responded by the learner. Hence, the learner should be actively involved in the learning material. The learner does not remain passive because there is a need of active involvement in learning. The learner has to construct the response. It is an integral part of learning. The frames of program should also be designed logically that the learner shows interest in responding the frames.

3. Principle of Immediate Reinforcement

Programmed instruction involves giving immediate reinforcement to the learners. When learners response to the frames, they do not know that these responses are correct or wrong. By providing immediate reinforcement or confirmation to the response, the learner gets confidence. When the learner is reinforced for a correct response, he/she becomes repetitive for further learning. The learner learns best if his/her response is confirmed immediately. The confirmation provides reinforcement to the learner.

4. Principle of Self-Pacing

Programmed instruction rests on the principle of self-pacing. It recognizes the individual differences of the learners. This principle is based on the assumption that each learner can work each step as slowly or as quickly, depending upon his/her pace. Each learner is free to move according to his/her own speed, slowly or quickly as they like. Some can learn things at a quicker speed and may skip one or more frames, whereas others can go on slowly. It satisfies every learner's need.

5. Principles of Continuous Evaluation

The programmed instruction is based on continuous evaluation by recording the response of the learner. The learner leaves the record of his/her study for each step in response sheet. It helps to improve the quality of programmed material through checking the number of errors at each step. Also, the learner's progress can be evaluated by looking into the various types of response produced by the learner.

5.12.5 PROS OF PROGRAMMED INSTRUCTION

1. Following are the advantages of this teaching strategy
2. The main emphasis is on individual differences and students' involvement.
3. There is not fixed time interval for learning. Students may learn at their own pace.
4. Learning by doing maxim of teaching is followed to involve learners in the learning process.
5. Students are exposed only to correct responses, therefore, possibility to commit errors in reduced.

6. Immediate confirmation of the results provides reinforcement to the learners and encourages the learners to proceed further.
7. Feedback is provided to wrong answers, so that learner is able to develop mastery over the content.

5.12.6 CONS OF PROGRAMMED INSTRUCTION

1. It is very difficult to develop an instructional programme
2. Only cognitive objectives can be achieved
3. Due to tight schedule of time table, students cannot be left to learn at their own pace. It would be very difficult to learn the content the subject matter in a limited period of time.
4. There is no chance for students' creativity, their responses are highly structured.
5. Development of programme is not economical in terms of cost and time
6. In absence of the teacher, students may spoil the disciplinary tone of the class, or they will be helpless when any problem arises.
7. It cannot be applied at primary level of education or at higher education

5.13 COMPUTER ASSISTED INSTRUCTION (CAI)

Computer assisted instruction (CAI) is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place. CAI uses a combination of text, graphics, sound and video in enhancing the learning process.

5.13.1 TYPES OF COMPUTER ASSISTED INSTRUCTION

1. Drill-and-practice Drill and practice provide opportunities or students to repeatedly practice the skills that have previously been presented and that further practice is necessary for mastery.

2. Tutorial Tutorial activity includes both the presentation of information and its extension into different forms of work, including drill and practice, games and simulation.

3. Games Game software often creates a contest to achieve the highest score and either beat others or beat the computer.

4. Simulation Simulation software can provide an approximation of reality that does not require the expense of real life or its risks.

5. Discovery Discovery approach provides a large database of information specific to a course or content area and challenges the learner to analyze, compare, infer and evaluate based on their explorations of the data.

6. Problem Solving This approach helps children develop specific problem solving skills and strategies.

5.13.2 MERITS OF COMPUTER-ASSISTED INSTRUCTION (CAI):

1. Immediate feedback: The immediate feedback provided by interactive terminals keeps students interacting and eager to keep trying.
2. Active participation: Even weaker students are obliged to participate actively. They often remain passive in lectures.
3. Immediate feedback: The immediate feedback provided by interactive terminals keeps students interacting and eager to keep trying.
4. No annoyance: The computer will wait patiently for an answer and does not express annoyance with wrong response.
5. Graphics facility: Interactive graphics make it possible to sample many more illustrations that could easily be shown in a textbook.
6. Mathematical calculations: Mathematical calculations can be done as readily for realistic examples as for artificially simple class that can be solved analytically.
7. Accurate data: Large volumes of data can be handled with accuracy and without drudgery.
8. Enrichment of course: The novel technique provides enrichment of course through added variety
9. Privacy helps the shy and slow learner to learns
10. Individual attention
11. Learn more and more rapidly

12. Multimedia helps to understand difficult concepts through multi sensory approach

13. Self directed learning – students can decide when, where, and what to learn

5.13.3 DEMERITS OF COMPUTER-ASSISTED INSTRUCTION CAI

1. Over use of multimedia may divert the attention from the content
2. learning becomes too mechanical
3. Non availability of good CAI packages
4. Lack of infrastructure

UNIT :VI APPROACHES IN LEARNING PHYSICAL SCIENCE

6.1 5E LEARNING MODEL

5E learning model is a constructivist model of teaching–learning. The (five) 5Es are - Engage, Explore, Explain, Elaborate and Evaluate. In this model, conceptual change can be achieved by using five distinct, but interconnected phases. Let us see it using the concept, sound is produced by a vibrating body.

1. Engage: Students need to be engaged and focused on the learning tasks by asking questions, defining a problem and drawing their attention to an interesting event. This is the process of motivating to learn.

The teacher exposes the students to various situations of production of sound by vibrating body and facilitate them to observe carefully. She draws students' attention to following situations.

2. Explore: Students get opportunity to explore through all senses. They are allowed to work together and build a base of common experience which assists them in the process of sharing and communicating. During exploration the students' inquiry process drives the teaching learning.

Students observe and gain some experiences of how sound is produced in different situations

3. Explain: Teacher interacts with students to discover their ideas. The communication among the peers and with the facilitator may be observed to notice their questions, writing, drawing; and their performance of activities and experiments. This can help the teacher to facilitate progress in students' learning and integrating assessment with the teaching-learning process.

The teacher interacts with the students and helps them to explain why they cannot notice the vibration in a table.

4. Elaborate: Students are allowed to expand the concept they have learned, make connections to other related concepts and apply their understanding to

real life situations. The teacher who acts as the facilitator, helps the students to develop their understanding through additional hands-on work and minds-on activities.

Teacher encourages the students to suggest some more activities/ experiments/real life situations where sound is produced and vibration can be felt. Students share their experiences from their daily life about this concept.

5. Evaluate: In this stage the teacher sees if the students have attained understanding of concept and knowledge. During the teaching-learning process the teacher adopts continuous and comprehensive assessment of teaching-learning.

Students' knowledge construction is tested through suitable questions and observation of their inquiry and process skills of science and participation in classroom activities.

6.2 COLLABORATIVE LEARNING APPROACH [CLA]

Collaborative learning approach is the approach where by learners' take responsibilities of their own learning. It promotes self learning skills among learners. Collaborative learning approach develops both academic and social skills in learner in an integrated manner.

5.2.1 Steps of collaborative learning:

Problem identification: Problem, issue or concept is identified to be dealt within a group situation. It may be small or big, simple or complex, depending upon learning environment and teaching-learning process.

Formation of groups: Formation of groups (3 to 6 students) is facilitated by the teacher. Students are also facilitated to take up the task of their choice.

Exchange of ideas: There is exchange of ideas, discussion on the issue at hand orλ performance of activities or experiment to clarify the concept in group situation. Sharing of ideas facilitates visiting and revisiting the concepts.

Facilitating interactions: Teacher facilitates their interactions directed towards the set goal within stipulated time frame.

Assessment and feedback: Learning evidences are assessed throughout the teaching learning process and feedback is provided to all groups of the learners.

6.2.2 Advantages of collaborative learning:

- Collaborative learning Involves social aspect of learning in group
- Provides room for negotiation of meaning, sharing of multiple views and changing the internal representation of ideas to the external reality.
- Learner individually and socially constructs meaning when learns.
- Enhances motivation to learn and increases depth of understanding
- In the group setting, learners develop a positive attitude towards the learning and materials on which they work on, as they contribute to it.
- Learning is more effective as students themselves take care to resolve any conflicting observation and opinion.
- It also gives them opportunity to apply the concepts in real-life situation and to learn to solve a problem through multiple ways.
- Disinterested students readily learn from their peers as their learning problems and issue are better appreciated by the peers.
- Working in a group, students move beyond the caste, creed, region and get opportunity to develop friendship with each other.
- Students learn the qualities of doing collaborative and team work, patience, persistence of effort, completing the task within a set time frame, and sense of belongingness to the group as well as to their learning.
- They get to know who they are in the opinion of others and identify their own social and academic potential.

6.2.3 Ensuring meaningful learning through CLA:

- Ensure that the group is heterogeneous
- Keep grouping pattern flexible and consider the choice of learners
- Every time keep on changing the members of the group. Facilitate them to form group rule.

- Make it a point that group leader will facilitate the work of the group and keep them organised.
- The leader should not dominate over other members.
- Tell one student of the class to pass on the name of group members and group leaders on a piece of paper for your record.
- While assessing, you may give same grade to all members of the group as far as possible.
- It will give you enough time to identify academic and social skills of all the students and help you to facilitate them in forming the group.
- Ensure that members of all groups should be made responsible for their work.
- All members should remain open to each other's idea and get equal opportunities to share their ideas and work
- All members should be given liberty to express their ideas freely and work cohesively towards achieving the goal.

6.2.4 Ways of applying collaborative learning approach: There are various ways in which collaborative learning approach may be applied such as given below.

1. Brainstorming: A problem is identified. Small groups are formed. All members are encouraged to find the solution and express their ideas. No idea is criticised. However, ideas can be modified.

Example: How can we minimise wastage of water?

Skills developed: Generating ideas, creativity.

2. Task group: A task is identified. Small groups are formed. Each group of the class is assigned a specific task to be completed within a time frame. Task of each group is evaluated by other group. Completion of task is responsibility of all.

Example: Prepare models of lever of Classes I, II and III.

Skills developed: Taking responsibility, delegation of work, initiativeness, planning skills, accomplishment, evaluation and emotional skills.

3. Inquiry group: Teacher creates a situation of some discrepant event during teaching-learning process. Students are helped to realise that there exists a problem, solution of which is to be inquired.Different groups work on the same problem and may come up with different hypothesis, solutions and conclusion. In order to get involved in the inquiry, learners may discuss,λ share their ideas, derive the equations, perform an activity, experiments and solve numericals.

Example: How would our life be affected if force of friction suddenly vanishes?

Skills developed: Problem solving skill, inquiry skills, analysis, synthesis and evaluation.

4. Tutorial group: Teacher facilitates formation of group according to students' ability. A concept is identified by the teacher which can be learned in a group setting. A student having good understanding of the concept is identified as group leader by the teacher. Opportunity should be provided to various students in turn. The group leader is assigned the job of facilitating learning to all members of her group. The group leader asks questions with the members and encourages them to discuss their learning difficulties with her.

Example: Determine unknown resistance using a metre bridge.

Skills developed: Basic competencies related to a concept develop in all members.

6.2.5 Limitation of CLA:

- Teacher's dominance is reduced.
- If work of the groups is not properly monitored, misconception and naive concepts may breed in the thinking of learners.
- A few shy students may not participate actively in the group.
- Interaction of all members needs to be continuously monitored.
- It may be difficult to check and recheck the work of all the groups working at one time for an inexperienced teacher.
- Very meticulous planning is required for meaningful learning to take place.

- Various aspects need to be considered- needs, interest and abilities of each student, scope of the activity/concept to be discussed in the group and classroom management, group dynamics of the class, etc

6.3 PROBLEM SOLVING APPROACH[PSA]

Learning experiences that allow independent thinking and multiple ways of approaching the problem, encourage independence and creativity in learners.

PSA is based on the idea of involvement of students in real life problems. It gives students opportunity to actively construct their learning by thinking, questioning, visualising the situation, searching for solution, doing activities and experiments and arriving at conclusion on their own.

Teacher facilitates them in identifying the problem. For this teacher may create a situation, pose a question, perform activity or experiment, elicit inquiry from students to make students realise that a problem exists and help them to identify the problem. Teacher sets up the stage for solving the problem. She helps them pose questions to initiate thinking, listens to their thinking, facilitate them to recall their existing knowledge and reconstruct them as and when it is required, and to use that knowledge to solve problems.

6.3.1 Steps in problem solving approach:

1. **Realizing problem**: Students realize that problem exists. They conceive the situation as problem and provide rationale of the problem. They identify various issues related with problem and separate known and unknown things. Students think, make decision—how, when and where, they can find the unknown issue by applying their existing knowledge and understanding who else can facilitate them in this process; what experiment/activity/ calculation need to be done; what learning resources to be utilised.
2. **Visualizing situation of the problem:** Students visualise the situation of the problem, process of the problem solving and expected solution of the problem. For this he may draw diagram/graph/flowchart/concept map.

3. **Attempt to solve the problem:** Students attempt to solve the problem.
4. **Observation and data collection:** Student make observation and collect data to explore the solution. In this process they apply their understanding to construct their knowledge.
5. **Drawing Conclusion**: Based on the observation students draw conclusion.
6. **Record presenting:** Accordingly students make a record presentation.
7. **Conclusion generalization:** Students generalise the conclusion.

6.3.2 Teacher's role in problem solving approach:

- Facilitate students to define the problem
- Encourage students to plan their method of problem solving.
- Students learn by thinking themselves while working on problem and struggling to find the solution
- Ensure participation of all if problem is being solved in groups.
- Keep moving around the class and observing students' group work.
- Observe that all students are working on the task
- Encourage the group which has completed the task earliest to extend help to the group struggling with the problem, so that they can do it within the given time frame
- Call a few students to share their ideas on the problem when all the students have completed the work.
- They may use the blackboard or perform the critical part of the activity again to explain the phenomenon being studied
- Reflect and discuss explicitly on the problem, acknowledging contribution of students; collect the work of students. learnt the concepts required to solve a problem, they should be trusted to work on the problem. If proper activities and learning environment are planned in a workable and feasible manner, this approach can promote critical and divergent thinking in learners.

6.4 CONCEPT MAPPING

Concept maps are graphical tools for organising and representing knowledge about certain concepts. A concept map represents an understanding of the relationship and hierarchy between important set of concepts. They promote meaningful learning in science. This can be understood by studying the following components of a concept map.

1. Concept: Concept may be thought of as a mental framework of an event or an object. Any event or object is a concept because it has some identifiable properties or ideas associated with it. In addition, a concept also has a label (name).

In a concept map, concepts are usually presented enclosed within a circle or a box. The first step is to identify and enlist various key concepts in the topic. These concepts are then arranged in a two dimensional array hierarchically in descending order, i.e. the more general concepts are placed at the top followed by the less inclusive concepts. Concepts occurring at same level of observation are placed at the same horizontal level.

For example – For transacting the topic Structure of atom, the arrangement of the concepts can look like the

2. Linkages: They are usually represented by arrows or lines. They link two concepts appropriately.

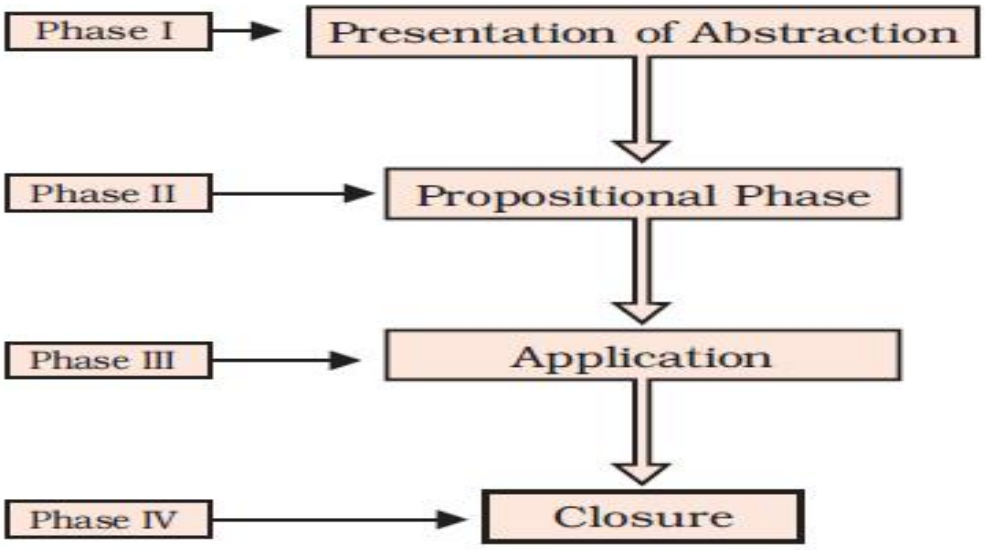
3. Labels for linkages: The label for most linkages is a word/s or a phrase

These labels for linkages are also named as proposition.

Thus, we observe that concepts in a concept map are not isolated collection of the concepts. They are interconnected together through well labeled linkages. Cross-links are particularly powerful connections, which form a 'web' of relevant and interrelated concepts. These links enhance the anchorage and stability in the cognitive structure of concepts rather than just connecting general concepts to specific concepts. They tend to connect different sub conceptual structure. There is no limit on the number of connecting lines. As a matter of fact greater number of connecting lines represents integrative thinking and depth of knowledge of the learner.

Concept mapping (as developed in its standard form by Novak in 1984) is considered to be an offshoot of the Ausubelian approach. Novak himself asserts: "My work and the work of my students on concept mapping has been based upon Ausubel's theory of meaningful learning (1963, 1968). It is this fundamental principle that has led our research group to search for better ways to represent what the learner already knows."

6.4.1 Phases of the concept mapping:



Phase I: Presentation of abstraction

- Students are presented with a definition or generalisation, which is linked to their existing cognitive structure.
- Students are asked to identify various concepts and sub-concepts and enlist them.
- Students' understanding of these concepts is assessed by asking them to provide new and unique examples.

Phase II: Propositional phase

- The teacher uses prompts and cues to guide the learners to arrange the concepts hierarchically with the broader/general concepts at the top and the less inclusive concepts at the bottom, giving the whole structure the look of a pyramid.

- The various concepts are interlinked logically by using (arrowhead) lines
- These lines are supplemented by word/words/phrases, which define them and illustrate meaningful relationships between the various concepts.
- The whole concept map is viewed as a network of concepts.

Phase III: Application

- The learners apply their knowledge to generate new examples and reflect on the existing ones.

Phase IV: Closure

- The learners summarise the major ideas evolved during

6.4.2 Uses of concept maps

The potential of concept maps needs to be explored in our schools as they are of tremendous use for learners, teacher, curriculum developers and evaluators.

1. For learners

- Concept maps can be used by learners for meaningful acquisition of concepts.
- Providing a visual representation helps the students to make better sense of the material, especially when the material is complex.
- Helping learners develop new relationships among concepts in one or more related areas, thereby creating new meaning.
- Motivating learners to think and engage in active learning as they try to construct the most plausible relationships.
- Helping learners identify gaps in their knowledge.
- Making learners aware of the explicit roles that language playsλ in the exchange of information.
- Promoting reflective thinking associated with pushing and pulling of concepts, putting them together and separating them again.
- Allowing learners to exchange view, thereby achieving shared meaning, which is possible, because concept maps are explicit.

- Analysing an activity and an experiment in terms of procedure or content and reduce subsequent burden on working memory.
- Providing practice by using specific concept labels which act as attention catchers especially for students struggling to learn.
- concept mapping as a teaching-learning strategy can be applied to facilitate learners to draw the ray diagrams of the formation of images by the lens and mirrors for different position of the object.
- It provides a holistic view of the phenomena of reflection and refraction of light.

2. For teachers:

- Helping teachers in planning a lesson by identifying key concepts, their prerequisites and relevant examples.
- Serving as a means for providing an overview of some unit.
- Providing an operational definition of a teaching-learning goal by indicating the learning objectives that are to be attained.
- Serving as a remarkably effective tool for helping learners toλ identify their alternative framework (misconceptions and naive concepts).
- Helping in planning interdisciplinary teaching-learning by developing a conceptually coherent programme that integrates concepts from different areas.
- Construction of concept maps may be provided as an activity prior to a lesson to reveal previous knowledge of the learners; as homework; for consolidation; to summarise and review the lesson; in a group discussion; as an individual assignment in evaluation, etc.

3. Concept maps as effective tools in complex laboratory environment

- The connection between theoretical concepts and experimental observations can be considered as criteria for meaningful learning of scientific concepts in complex laboratory environment.

- New experiments can be designed to understand integration and linkages with the theoretical part of the concepts using concept maps. Concept maps can also be created as a part of post-laboratory activity

6.6 Cognitive Conflict

The occurrences of alternative conception which are significantly different from scientific conception give rise to cognitive conflict. Cognitive conflict has a long tradition as a strategy for promoting conceptual change in science learning.

Conceptual Change: Learning is visualised as change in conceptions of a person rather than simply adding new knowledge to already existing one. One of the models of conceptual change is given by Appleton (1997). This model is based on Piaget's theory and gives different possibilities of what happens when a learner is confronted with new experiences/information. When new information is processed the following three possibilities may occur:

1. **Identical fit:** The new information/concept/experience may exactly fit the existing one (schema). This means that the learner is able to make sense of new information on the basis of existing knowledge which may not be scientifically correct.
2. **Approximate fit:** The new information may form an approximate fit with an existing idea. These learners encounter new ideas, but do not give up old ideas. The learners belonging to this category assimilate the new ideas, but cannot accommodate. They do not reach the situation where cognitive conflict can occur.
3. **Incomplete fit:** The new information does not fit any of the existing ideas and cognitive conflict results. When learner experiences an incomplete fit, she tries to resolve the conflict by seeking more information. The main mechanism for change in Appleton's model of conceptual change is cognitive conflict.

- **Generating cognitive conflict:** Cognitive conflict may occur due to the following situations:

- **Encounter with discrepant events:** On encountering a new concept/ event the learner may try to explain it with the alternative concept that learner has developed and may arrive at a solution that is different from what actually happens. Such an event is called a 'discrepant event'. Thus a cognitive conflict is between a learner's cognitive structure related to certain physical reality and actual physical reality.
- **Encounter with mutually conflicting alternative conceptions:** This situation arises when the learner faces a situation where she can explain the same event using two different already existing cognitive structures which are at conflict with each other.
- **Occurrence of identical conflict:** Learners may frame different alternative concepts from the same concept. When learners are allowed to discuss about a concept, then there is a possibility that conflict may occur between learner's different concepts that she has generated.

Techniques to generate cognitive conflict:

- Ask questions that create dilemma.
- Help them to visualise the problem. A specific situation or aλ numerical problem can be set up.
- Demonstrate an activity. A brainstorming session or a group discussion can be arranged.
- Provide computer-simulated situation. Allow the students to ask questions.
- Allow students to interact actively.

6.7 Inquiry Approach

Inquiry is the prominent place of teaching learning process that promotes exploration of ideas, experimentation and critical thinking. The inquiry should relate the real life experiences of the students to their learning process.

In this approach teacher does not give lecture on the types of materials/classification of materials on the basis of their properties.

He created the situation in the class to make them observe, think, classify, record, conclude and communicate about the classification of materials on the basis of their physical properties.

Inquiry approach is not just about asking and answering questions. Learners should be facilitated to engage themselves in using equipments and measuring devices to collect data and pose questions for explanation; using graphs and diagrams for communication and getting clarification of ideas from multiple sources.

Inquiry begins with observation and can be carried out through reasoning, hypothesis, experimentation and activities and communicating ideas effectively to construct argument and generate knowledge.

6.8 Analogy Strategy

Analogy is a process of identifying similarities between two concepts. Learners can be introduced to a new concept by relating it with some familiar concept they already posses. It can help learners in the construction of their ideas. The familiar concept is analogue and unfamiliar science concept is target. Analogy strategy provides a bridge between analogue and target. Effective analogies motivate students, clarify students' thinking, help students overcome alternative conceptions, and facilitate them to visualise abstract concept. Analogy will be effective, if it is familiar to the students and its features and functions are congruent with those of target. Its appropriate use can promote meaningful learning and conceptual development.

Teaching With Analogies (TWA) model as given in includes the following six steps (Glynn, 1995):

(i) Introduce the target concept;
(ii) Review the analogue concept;
(iii) Identify relevant features of the target and analogue;
(iv) Map similarities;
(v) Indicate where analogy breaks down;
(vi) Draw conclusions.

Generally analogies of camera with the structure of the eye (target concept), solar system with atomic model (target concept), electrostatic force with gravitational force, etc. are used in teaching- learning process.

One can draw the following similarities between the solar system and the atom. Analogue Target Solar System (familiar ideas) Rutherford Model of Atom (scientific knowledge)

(i) Sun - Nucleus

(ii) Planets - Electrons

(iii) Sun and planets attract each other - Nucleus and electrons attract each other

(iv) Sun has more mass than all planets - Nucleus is very heavy as compared to electrons.

Thus, analogy strategy is mapping of relations between the analogue and the target. However, use of analogue has its own limitations and if relation is not established clearly and dissimilarities and unlikeness are not highlighted properly, it may lead to formation of alternative conceptions instead of removing them. Care should be taken that students remember the concept, not the analogue.

UNIT VII : TEACHING RESOURCES

7.1 SCIENCE TEXTBOOK

A textbook is a comprehensive compilation of content in a branch of study. Textbooks are produced to meet the needs of educators, usually at educational institutions. School books are textbooks and other books used in schools. Today, many textbooks are published in both print format and digital formats.

In the teaching-learning process, the text-book occupies an important place. There is a saying "As is the text-book, so is the teaching and learning". A good text-book can even replace class-room teaching.

The science text-book should aim at aiding the pupils in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely stuffing their minds with facts.

7.1.1 SCIENCE TEXTBOOK - CHARACTERISTICS

A science text book should have the following features:

The author

A good text-book is judged, at face, by the author, his qualification and experience.

Mechanical features of the text-book:

- The print and paper used and the binding of the text-book should be attractive. It should be hard and durable.
- The printing should be clear, legible and appropriately spaced.
- The book should be well-illustrated with diagrams, sketches and pictures.
- The size of the print, the language and experiments discussed should suit the age of the child and standard of the child.

The subject matter-its nature and organization

- The subject-matter should be developed as far as possible in psychological sequence. Care must be taken of the mental growth and interest of pupils.

- There should be consistency of the subject-matter and the text-book should satisfy the objectives of science teaching.
- Each chapter should begin with a brief introduction and end with a summary.
- Subject-matter should lead to the inculcation of scientific attitudes, disciplinary and cultural values.
- Each chapter should contain assignments at the end.
- During treatment of subject-matter, numerical examples should find place where necessary.
- Headings and sub-headings are given in bold letters.
- Each text-book should contain detailed Table of Contents and an index.
- The language of the book should be simple, clear, lucid, scientific and precise. The English equivalents of the terms should be always given in brackets.
- The text-book should give suggestions for improving scientific apparatus.
- Examples in the text-book should be given from local environment and from life experience.
- During the treatment of science subject in the text-book, care should be taken to see that it is correlated with other subjects like craft, social environment and physical environment.
- Each text-book should be accompanied by a laboratory manual.

UNESCO PLANNING MISSION - PRINCIPLES OF WRITING TEXT-BOOKS

- It should be first of all according to the requirements of the syllabus. It should also help in the improvement of the syllabus.
- The facts, concepts etc., should be modern and within the comprehension of the pupils.
- The contents should contain not only the established facts but also the problems which are being researched and thereby, arousing the interest in the pupils in these problems.

- It should help in linking up science with life and practice. The pupils should be equipped with 'know-how' utilizing the knowledge in everyday life.
- The whole content of the text-book should be aimed at shaping the integrated modern scientific outlook which ensures success in mastering scientific knowledge and solution of the problems of vital issues. The content should be simple, brief, exact, definite and accessible.

7.2 EVALUATION OF A GOOD SCIENCE TEXTBOOK – CRITERIA

The following criteria will have to be kept in mind while evaluating the science text book

Lesson Purpose

Lesson objectives should relate to the curriculum indicators and also enhances students to understand the content that they are going to learn.

Content

For each lesson, prerequisite knowledge is well defined. All of contents, questions and situations in the lesson are appropriate for students' abilities and should also encourage students to express their level of understanding.

Phenomenon and Learning Experience

Phenomena and situations included in the textbooks should be related to the lesson content. In addition, learning activities provide students to learn by working in real or simulated situations. Either direct or indirect phenomena and situations, should be used to encourage students to connect scientific concepts, make reasonable conclusions, and construct their own knowledge.

Communication

Explanation and scientific/technical terms used in the textbook should easy to understand and communicate scientific concepts. These terms also show the relationship among those concepts.

Learning Activity

Learning activities, problems and questions should encourage students to practice scientific processes. Especially, end-of-lesson questions should be given to students to check their understanding after doing activities and help them to apply knowledge in everyday life.

Assessment

Questions, problems and exercises should be aligned with the curriculum indicators and also emphasize on higher-order thinking levels and the application of scientific concepts in everyday life.

7.3 USE OF TEXT BOOK

A textbook is a book used for the study of a subject. People use a textbook to learn facts and methods about a certain subject. Textbooks sometimes have questions to test the knowledge and understanding of the learner.

1. There are many reasons why textbooks have been proven to be a more helpful for students
2. Students will not get as distracted, the information is understood more clearly, and textbooks are more reliable
3. Textbooks are a great source of information and are easy for teachers and students to use.
4. "Good textbooks are excellent teaching aids. They're a resource for both teachers and students."
5. A textbook series provides you with a balanced, chronological presentation of information
6. Textbooks are a detailed sequence of teaching procedures that tell what to do and when to do it.
7. Textbooks provide administrators and teachers with a complete program. The series is typically based on the latest research and teaching
8. Good textbooks are excellent teaching aids. They're a resource for both teacher and students

7.4 MACHINE OPERATED AID

Teaching aids are an integral component in any classroom. The many benefits of teaching aids include helping learners to improve reading comprehension skills, illustrating or reinforcing a skill or concept, differentiating instruction and relieving anxiety or boredom by presenting information in a new and exciting way.

Projected Aids - Projected visual aids are pictures shown upon a screen by the use of a certain type of machines

The importance of diversifying teaching materials enhances learning among students. In particular, machine operated aids for learning can have a huge impact on how students retain information. While words can be abstract and hard to retain, visuals tend to be more concrete and easier to recall.

7.4.1 EPIDIASCOPE

The opaque projector, epidiascope, *epidiascope* or episcope is a device which displays opaque materials by shining a bright lamp onto the object from above. A system of mirrors, prisms and/or imaging lenses is used to focus an image of the material onto a viewing screen.

The epidiascope is an instrument which can project images or printed matter or small opaque objects on a screen or it can project images of a 4″ x 4″ slide. With the help of any epidiascope, any chart, diagram, map, photograph

and picture can be projected on the screen without tearing it off from the book. No slide is needed for this purpose.

Purpose: An epidiascope serves two purposes. It works as epidiascope when it is used to project opaque objects. It works as epidiascope when it is used to project slides (by operating a lever).

Working procedure: It works on the principle of horizontal straight line projection with a lamp, plane mirror and projection lens. A strong light from the lamp falls on the opaque object. A plane mirror placed at an angle of 45″ over the project reflects the light so that it passes through the projection lens forming a magnified image on the screen.

7.4.2 FILMSTRIP-CUM-SLIDE PROJECTOR

A film strip is 35 mm wide and has a series of 12 to 48 picture frames arranged in a sequence so that they develop a theme. A film strip can be prepared by taking a series of photographs using a 35 mm camera and then by taking a positive print of the negative film on another 35 mm film.

A slide projector is a device that is used to view photographic slides by using optical and mechanical methods. It contains an electric light bulb. Focusing lenses. Reflector and condensing lenses.

A *slide projector* is an opto-mechanical device for showing photographic slides. 35 mm *slide projectors*, direct descendants of the larger-format magic lantern

7.4.3 OVER HEAD PROJECTOR - OHP

An *overhead projector* is a machine that causes an image from a transparent sheet to be projected onto a viewing screen. It has a light inside it and can be used to make the writing or pictures on a sheet of plastic appear on a screen or wall.

A *transparency*, also known variously as a view foil, foil, or viewgraph, is a thin sheet of transparent flexible material, normally about letter size (A4), on which you can write your information, typically cellulose acetate, onto which figures can be drawn. These are then placed on an *overhead projector* for display to an audience.

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USES OR PROS OF OHP

1. The overhead projector is a very useful adjunct to other teaching aids. It is easy to operate, flexible, and the lecturer can work it himself while facing the audience.
2. Transparencies can be produced quickly and simply, and since they are large enough to be studied without viewing equipment
3. Sets of transparencies can be kept in libraries for the benefit of students revising particular subjects.

4. Lecture can use it again and again.
5. Serves both as an outward non-verbal communication channel for the teacher
6. As a means of obtaining feedback from the class on how a session is going.
7. Used to show pre prepared material.

7.4.4 DIGITAL PROJECTOR

A **digital projector** is an electronic device that is capable of connecting to a computer or other device and projecting the video output onto a screen or wall. Digital projectors can be either fixed onto the ceiling, placed on a stand or can even be portable. Digital projectors are used in situations such as office training or presentation sessions, classroom teaching and home cinemas.

A digital projector, also called a digital projection display system, The light transmittivity of each pixel varies depending on the image data received from the computer.

The term digital projector is sometimes used for a program that facilitates the viewing of three-dimensional (3D), interactive, full-motion audio-visual files on a personal computer.

7.4.5 INTER-ACTIVE WHITE BOARD (IWB)

An **interactive whiteboard** (**IWB**) also commonly known as Interactive board or Smart boards is a large interactive display in the form factor of a whiteboard. It can either be a standalone touch screen computer used independently to perform tasks and operations, or a connectable apparatus used as a touchpad to control computers from a projector. They are used in a variety of settings, including classrooms at all levels of education, in corporate board rooms and work groups, in training rooms for professional sports coaching, in broadcasting studios, and others.

PROS OF IWB

Running software that is loaded onto the connected PC, such as a web browsers or other software used in the classroom. Capturing and saving notes written on a whiteboard to the connected PC. Capturing notes written on a graphics tablet connected to the whiteboard.

7.5 NON– MACHINE OPERATED AIDS

Non-machine operated aids are those aids which are used in class room teaching without any machines. So they translate abstract ideas into a more realistic

format. They allow instruction to move from verbal representation to a more concrete level.

7.5.1 GRAPHICAL AIDS

Graphical aids are charts, diagrams, graphs, maps, flashcards, posters, pictures, photographs, leaflets, folders, pamphlets, cartoons and comics. They are two-dimensional materials having no depth which communicate facts, ideas and relationships clearly through words, lines, drawings, symbols and pictures

This would give a better learning experience to the audience. With the use of visual aids, it is easier for the audience to understand and remember the information you provide. Seeing text with relevant image is easier to understand than a simple text. People remember more of what they see than what they hear

7.5.2 FLASH CARDS

A simple flash card may be prepared by writing, printing or drawing on a plain sheet of cardboard. Plain thick wrapping paper, cardboard, etc. also make good flash card material.

The flash cards and the pictures therein should be large enough for a group of 30 to 50 to see (size is 22" x 2%" and 11" x 14" for large and small groups respectively). Use colour to make it attractive. The wording should be brief. The lettering should be large enough for the group to read. The number of cards should be 10 to 12 in a set.

7.5.3 CHARTS

A *chart* is a good means or *aid* of *teaching*. It brings environment to the process of *teaching* inside the class indirectly. *I*nstead of visiting the actual fields of a lesson in real life, the chart can bring such scene into class to be seen by learners. The purpose is to give life to the theoretical learning. It facilitates the process of presentation in class.

ADVANTAGES OF CHART

1. Using charts can help the audience grasp visually the message that has to be conveyed
2. Display a lot of information is an easy to understand format
3. Enable people to take in the "big picture" quickly
4. Charts can communicate difficult, often dull subject matter in interesting and effective ways
5. Make facts and figures clear and interesting
6. They show or compare changes, size and placement of parts
7. Help to develop an idea and to improve the understanding of the topic

7.5.4 FLIP CHART

A chart that consists of a series of large pieces of paper which are attached at the top and which are used to present information to an audience by turning over one piece of paper at a time.

Over-lay chart - It consists of a number of sheets which can be placed one over the other conveniently. On each individual sheet a part of the whole picture is drawn. This enables the viewer to see not only the different parts, but also how they appear when one is placed over the other. After the final over-lay is placed, it shows the whole picture. This type of presentation is dramatic and effective.

7.5.5 GRAPHS

A Graph is a non-linear data structure consisting of nodes and edges. The nodes are sometimes also referred to as vertices and the edges are lines or arcs that connect any two nodes in the graph.

The four most common are probably line graphs, bar graphs and histograms, pie charts, and Cartesian graphs. They are generally used for, and best for, quite different things. You would use: Bar graphs to show numbers that are independent of each other.

The four most common are probably line graphs, bar graphs and histograms, pie charts, and Cartesian graphs. They are generally used for, and best for, quite different things.

7.5.6 PICTURES

A picture, also called an image, is a group of coloured points on a flat surface that looks the same as something else. For example, a picture can look the same as an object or a person. Pictures can also be drawings, paintings or photographs. People who make such pictures are called artists, photographers or painters. Visuals are one way of grabbing your audience's attention and gaining interaction,.

7.5.7 POSTER

A poster is a temporary promotion of an idea, product, or event put up in a public space for mass consumption. Posters may be used for many purposes. They are a frequent tool of advertisers (particularly of events, musicians, and films), propagandists, protestors, and other groups trying to communicate a message.

7.5.8 CUT-OUTS

Cut- out models are the teaching learning aids which are prepared by cutting a card board or hard paper which seems to be the real object. Cut-out models maximize the visibility in the class room. For example thermometer, pipette, measuring jar or picture of eminent scientist pasted on card board may be cut and used in teaching.

7.6 DISPLAY BOARD

A display board is a board-shaped material that is rigid and strong enough to stand on its own, and generally used paper or other materials affixed to it. Display board may also be referred to as poster board.

The purpose of the display board in that context is to catch the viewer's attention and explain what was performed and what was learned.

7.6.1 CHALKBOARD

A blackboard, also called a chalkboard, is a surface on which chalk is visible. It is used as a surface to write on. It is painted black to reflect the white chalks. The

high-grade blackboards are made of porcelain enameled steel. Blackboards are often used to help in teaching in school.

"Blackboard" is the soul of a classroom. Effective teaching- learning process takes place through blackboard. Blackboard is like mirror. It takes care of all without making a distinction among gifted, brilliant, average and slow learners.

The board provides the teacher with an inexpensive and adaptable visual aid. It can provide the teacher to record the suggestions from the students as they develop main points in a lesson. It provides a space for hand drawn charts, maps, and graphs. It can also be used as a sheet on which to list questions to be asked.

Chalkboards used to be black in colour and hence the name blackboard. This was so because the black surface would provide the perfect contrast to the white chalk.

Green boards However, due to functional reasons one now finds the chalkboards to be made up of green ground glass painted from behind and called the 'green board'. The glass green board, unlike the blackboard, which is wooden, is also found in shades of green, yellow and grey.

White board A third type of board is the white board which is made of mica or hard plastic. Since the board is white in colour, you would know that the white chalk cannot be used for effective presentation. With such boards one uses ink and marker pens. Writings by these pens can be wiped out and are user friendly as they do not create chalk dust to which some people are allergic.

Advantages of Using Black Board

1. Writing information on a chalkboard helps teachers take visible cues from students.
2. Teachers can immediately address students' body language and facial expressions that suggest confusion about the material.
3. Teaching with chalk is especially an advantage for teachers of students with mixed learning abilities

7.6.2 BULLETIN BOARD

Bulletin board is a board which is usually attached to a wall in order to display notices giving information about something. A bulletin board is a system that enables users to send and receive messages of general interest.

A *bulletin board* is a surface intended for the posting of public messages, for example, to advertise items wanted or for sale and announce events

7.6.3 FLANNEL BOARD

A *Flannel board* is a display *board* made of wood, cardboard or straw *board* covered with colored *flannel* or woolen cloth. Display material like the cut outs, pictures, drawings and light objects backed with rough surface like sand paper strips, etc. will stick to the *flannel board* temporarily.

It is Covered in colored cloth, a flannel board is a beautiful way to teach very young children about the alphabet, allegorical tales and more. A flannel board, or felt board, helps a child explore stories, use their imagination, improve fine motor skills and open up their creativity with shapes, colors and objects

7.6.4 MAGNETIC BOARD

Sheets of ferromagnetic material with specially-painted light surfaces on which material can be written or drawn using suitable markers or pens. They can be mounted on the wall, placed on an easel, or just propped up against the wall. They are easy to clean and need minimal maintenance.

Magnetic boards serve a variety of purposes; they can be used for presentations, used as bulletin boards, as teaching aids, or even as personal organizers.

7.6.5 PEG BOARD

Peg board is a display board with multiple small holes into which pegs can be inserted in different arrays so as to form hooks from which to hang tools or other objects for convenient access. It is used for playing certain games or keeping a score or for enlisting the name list.

7.7 3D AIDS

Three dimensional aids are nearest to living experiences. A simple classification of these aids is models, specimens, mockup, objects and dioramas.

Three-dimensional materials are very useful in the event that real-life materials are impossible to be brought in the classroom to provide students with certain amount of direct, purposeful, rich, and meaningful learning experience in accordance with Dale's “Cone of Experience”.

7.7.1 OBJECTS

Object is a thing that has physical existence of a real thing, which have been removed as units from their natural setting. Objects are useful for teaching and learning in the classroom for better understanding of students. An object is something that is a visible entity, something that can be perceived by the senses.

7.7.2 SPECIMENS

A specimen is a sample of something, like a specimen of blood or body tissue that is taken for medical testing. The noun specimen comes from the Latin word specere, meaning “to look.” Biologists collect specimens so they can get a better look at something to study it.

7.7.3 MODELS

A model is a three-dimensional, recognisable imitation of an object. A model may be the same size as the object it represents or it can be smaller or larger.

Types of models

Scale model: It represents the external form and shape of original object and is prepared to scale-smaller or larger such as Taj Mahal, insect, heart etc.

Cross-sectional model: It reveals internal structure of real objects such as heart, eye, etc.

Working model: It shows operation of essential parts of real object for example. T.V., Telephone, etc.

Simplified model: It shows simple features of the external form of the real object without reproducing the original in precise proportion.

UNIT VIII : TEACHING SKILLS

8.1 TEACHING SKILLS – MEANING

Teaching skills can be defined as discrete and coherent activities by teachers which foster pupil learning. For a teacher three important elements of skills are discernible.

Knowledge - Comprising the teacher's knowledge about the subject, pupils, curriculum, teaching methods, the influence on teaching and learning of other factors, and knowledge about one's own teaching skills.

Decision-making - Comprising the thinking and decision-making that occurs before, during and after a lesson, concerning how best to achieve the educational outcomes intended.

Action - Comprising the overt behaviour by teachers undertaken to foster pupil learning.

Essential teaching skills involved in contributing to successful classroom practice

Planning and preparation: Skills involved in selecting the educational aims and learning outcomes intended for a lesson and how best to achieve these.

Lesson presentation: Skills involved in successfully engaging pupils in the learning experience, particularly in relation to the quality of instruction.

Lesson management: Skills involved in managing and organising the learning activities taking place during the lesson to maintain pupils' attention, interest and involvement.

Classroom climate: Skills involved in establishing and maintaining positive attitudes and motivation by pupils towards the lesson.

Discipline: Skills involved in maintaining good order and dealing with any pupil misbehavior that occurs.

Assessing pupils' progress: Skills involved in assessing pupils' progress, covering both formative (i.e. intended to aid pupils' further development) and summative (i.e. providing a record of attainment) purposes of assessment.

Reflection and evaluation: Skills involved in evaluating one's own current teaching practice in order to improve future practice. These seven sets of essential teaching skills are further

8.2 MICRO-TEACHING DEFINITION

Micro-teaching is defined as a system of controlled practice that makes it possible to concentrate on specified teaching behaviour and to practices teaching under controlled conditions- **Allen D.W and Eve A.W**

Micro-teaching is a scaled down teaching encounter in class size and class time - **Allen D.W**

Micro-teaching is a teacher education technique which allows teachers to apply clearly defined teaching skills to carefully prepared lessons in a planned series of 5-10 minutes encounter with a small group of real students, often with an opportunity to observe the result on video-tape - **Buch M.B**

8.2.1 PURPOSES OF MICROTEACHING

- For student- teachers to develop teaching skills under controlled conditions without risking the learning of the pupils, and
- For experienced teachers to examine and refine their techniques

8.2.3 OBJECTIVES OF MICROTEACHING

- To enable teacher trainees to learn and assimilate new teaching skills under controlled conditions.
- To enable teacher trainees to master a number of teaching skills.
- To enable teacher trainees to gain confidence in teaching.
- Development of new skills in learners.

8.2.3 PRINCIPLES OF MICROTEACHING

Principle of One skill at a time -Skills in microteaching are targeted one at a time. Training on particular skills are given until it is mastered. Once mastered another skill is targeted next. Thus, micro teaching aims for one skill at a time.

Principle of micro content- Limiting the content gives more freedom and ease to the trainees. Thus, micro teaching is based upon the principle of limited content. Teachers are to prepare their lessons within the given content, therefore, it becomes easier for them to conduct their lessons.

Principle of mastering skills - Mastering skills require practice. While focusing on one skill at a time, micro teaching program also gives an opportunity to practice those skills.

Principle of self confidence - Lots of practice can boost the self-confidence and promote in development of teaching skills.

Principle of simulated condition - These skills are tested under controlled condition.

Principle of immediate feedbacks - Micro teaching consists of teacher-pupil and supervisor as students. Once a session ends, teacher-pupil and supervisors come up with their feedback. This feedback is given instantly after the lesson plan ends. Thus, it helps in rectifying the drawbacks.

Principle of Self-evaluation - In micro-teaching, supervisors conducts various tests and thus there are several chances to analyze mistakes.

This program includes a session where drawbacks are pointed out along with their solution. Thus, overall improvement becomes an easier target.

Principle of Continuous efforts - Acquiring and mastering skills is a slow and ongoing process. Even after mastering a previous skill, one should continually strive for betterment. Continuous efforts make it easier to attain overall development.

8.2.4 PHASES OF MICRO TEACHING- There are three phases in micro teaching,

1. Knowledge acquisition phase (Pre-active phase)

In this phase, the student teacher attempt to acquire knowledge about the skill- it's rational, its role in class room and its component behaviours. For this he reads relevant literature. He also observes demonstration lesson-mode of presentation of the skill. The student teacher gets theoretical as well as practical knowledge of the skill.

2. Skill acquisition phase (Inter-active phase)

On the basis of the model presented to the student-teacher, he prepares a micro-lesson and practices the skill and carries out the micro-teaching cycle. There are two components of this phase

1. Feedback

2. Micro teaching settings - include conditions like the size of the micro-class, duration of the micro-lesson, supervisor, types of students etc.

3. Transfer phase (Post-active phase)

Here the student-teacher integrates the different skills. In place of artificial situation, he teaches in the real classroom and tries to integrate all the skills.

8.2.5 STEPS IN MICRO TEACHING

Step-1 *Particular skill to be practiced is explained to the teacher trainees in terms of the purpose and components of the skill with suitable examples.*

Step-2 *The teacher trainer gives the demonstration of the skill in Micro teaching in simulated conditions to the teacher trainees*

Step-3 *The teacher trainee plans a short lesson plan on the basis of the demonstrated skill for his/her practice.*

Step-4 *The teacher trainee teaches the lesson to a small group of pupils. His lesson is supervised by the supervisor and peers.*

Step-5 *On the basis of the observation of a lesson, the supervisor gives feedback to the teacher trainee. The supervisor reinforces the instances of effective use of the skill and draws attention of the teacher trainee to the points where he could not do well.*

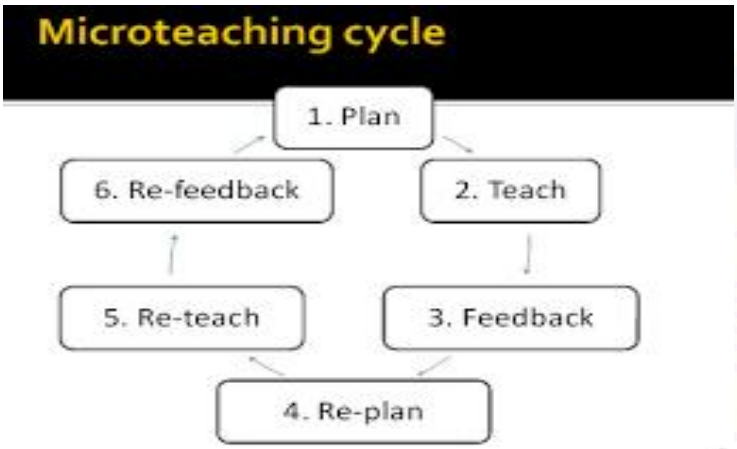
Step-6 *In the light of the feed-back given by the supervisor, the teacher trainee replans the lesson plan in order to use the skill in more effective manner in the second trial.*

Step-7 *The revised lesson is taught to another comparable group of pupils.*

Step-8 *The supervisor observes the re-teach lesson and gives re-feed back to the teacher trainee with convincing arguments and reasons.*

Step-9 *The 'teach – re-teach' cycle may be repeated several times till adequate mastery level is achieved.*

8.2.6 MICROTEACHING CYCLE



1. Plan

This involves the selection of the topic and related content of such a nature in which the use of components of the skill under practice may be made easily and conveniently. The topic is analyzed into different activities of the teacher and the audiences (students). The activities are planned in such a logical sequence where maximum application of the components of a skill is possible.

2. Teach

This involves the attempts of the teacher to use the components of the skill in suitable situations coming up in the process of teaching-learning as per his/her planning of activities. If the situation is different and not as visualized(in the planning of the activities, the teacher should modify his/her behavior according to the demand of the situation. He should have the courage and confidence to handle the situation arising in the class effectively

3. Feedback

This term refers to giving information to the teacher about his performance. It includes the points of strength as well as weakness relating to his/her performance. This helps the teacher to improve his performance in the desired direction

4. Re-plan

The teacher re-plans his lesson incorporating the points of strength and removing the points not skillfully handled during teaching.

5. Re-teach

This involves teaching to the same group of students if topic is changed or to a different group of students.

6. Re-feedback

This is the most important component of Micro-teaching for behavior modification of the teacher.

Duration

In the Indian model of Micro-Teaching developed by NCERT the duration of Micro Teaching is as under:

Teach : 6 Minutes

Feedback : 6 Minutes

Re-plan :12 Minutes

Re-teach : 6 Minutes

Re-feedback : 6 Minutes

Total : 36 Minutes

8.2.7 ADVANTAGES OF MICRO-TEACHING

1. Micro Teaching is a training tool for improving teaching practice and to prepare effective teachers.
2. It simplifies teaching so as to make it suitable for the beginners.
3. Develops the feeling of confidence among the teachers.
4. Micro Teaching can be done either i a real classroom or simulated conditions.
5. It focuses on training for the accomplishment of special tasks such as mastery of instructional skills, curricular materials, and techniques of teaching.
6. It allows increased control and regulates teaching practice.

7. It enables the trainee to make progress in developing teaching skills at his/ her own rating depending upon ability.
8. Micro Teaching is an effective feedback tool for the behavior modification of teacher.
9. It is a highly individualized type of teacher training.
10. It is essential for developing teaching efficiency in pre and in-service teacher training programme.
11. It is useful in systematic and objective observation by providing particular observation duration.
12. It is useful in acquiring various types of skills which ultimately form the basis of a successful teacher.
13. It reduces the complexities of normal classroom teaching such as class size, class time and problem of discipline.

8.3 RELEVANT TEACHING SKILLS IN TEACHING OF PHYSICAL SCIENCE

Physical science subject includes both physics and chemistry. Hence the student- teacher needs to mastery over certain relevant skills like set induction, questioning, black board writing, demonstration, explaining, reinforcement, stimulus variation skills while practicing micro teaching.

8.4 CORE TEACHING SKILLS- MEANING

Teaching skills that are extensively used in routine teaching by all teachers are known as core teaching skills

N.C.E.R.T has laid stress on many core teaching skills which include introducing lesson illustration with example, questioning, using teaching aids, use of blackboard, evaluation and management of class. Most of the trained teachers whether regular or distance mode use core teaching skills in the classroom.

8.5 SET INDUCTION

Set induction is also called anticipatory set Steps taken by a teacher to begin a lesson. To introduce topic and get students focused and interested in the days or other classroom activity.

Components of skill of set induction

1. Utilization of previous knowledge
2. Use of appropriate devices and techniques

   Questioning, narration, storytelling, demonstration, using audio visual aids, dramatization, use of examples
3. Maintenance of continuity in the ideas and information
4. Relevancy of verbal or non-verbal behavior

8.6 SKILL OF EXPLAINING

Skills of Explaining - To present the subject matter in a simplified form before the learners and making it acquirable is known as explanation skill. It involves ability of the teacher to describe logically' how', 'why' and 'when' concept etc. It is the introductory statement to begin explanation.

Components of skill of explaining

1. Beginning statement
2. Clarity of concept
3. Fluency of explanation
4. Use of linking words
5. Questions testing pupils understanding
6. Planned repetition
7. Summarizing the main points

8.7 SKILL OF BLACKBOARD WRITING

Blackboard is an important visual aid used by teachers for effective teaching. A teacher makes extensive use of blackboard in his or her daily classroom teaching for working our problems, deriving formulae, proving theorems, drawing figures, constructing geometrical figures and so on.

Components of skill of blackboard writing

1. Legibility
2. Neatness

3. Appropriateness

8.8 SKILL OF STIMULUS VARIATION

The skill of stimulus variation involves deliberate change in attention drawing behavior of the teacher in order to secure and sustain students' attention to what is being taught. The skill of stimulus variation implies attracting and focusing students' attention by changing stimuli in the environment.

Components of skill of stimulus variation

1. Teacher movement
2. Gesture
3. Change in interaction style
4. Pausing
5. Change in sensory focus
6. Change in speech pattern

8.9 SKILL OF REINFORCEMENT

Reinforcement is strengthening the connection between a stimulus and a response. The skills of reinforcement involve the teacher to use more and more positive reinforcement and to decrease the use of negative reinforcement so that the pupils' participation is maximized.

Components of skill of reinforcement

1. Verbal reinforcement – good, well-done
2. Non-Verbal reinforcement
    1) Gestural reinforcement – facial expression, smile
    2) Proximity reinforcement – teacher moving nearer to students evincing interest
    3) Contact reinforcement- patting head, back
    4) Activity reinforcement – project

5) Token reinforcement – awarding marks, merit cards, writing comments

8.10 SKILL OF PROBING QUESTIONING

Probing is the skill of asking penetrating questions in response to a student's initial answer. Probing leads a student to discover the relationships, similarities and differences that distinguish new concepts from old.

Components of skill of probing questions

1. Probing
2. Prompting
3. Focusing
4. Pausing
5. Directing and redirecting
6. Phrasing and rephrasing
7. Distribution

8.11 SKILL OF DEMONSTRATION

A Demonstration is showing someone else how to do something. It is a show and tell method. Demonstration means showing examples or proofs about or demonstrating experiments in a class room.

Components of skill of demonstration

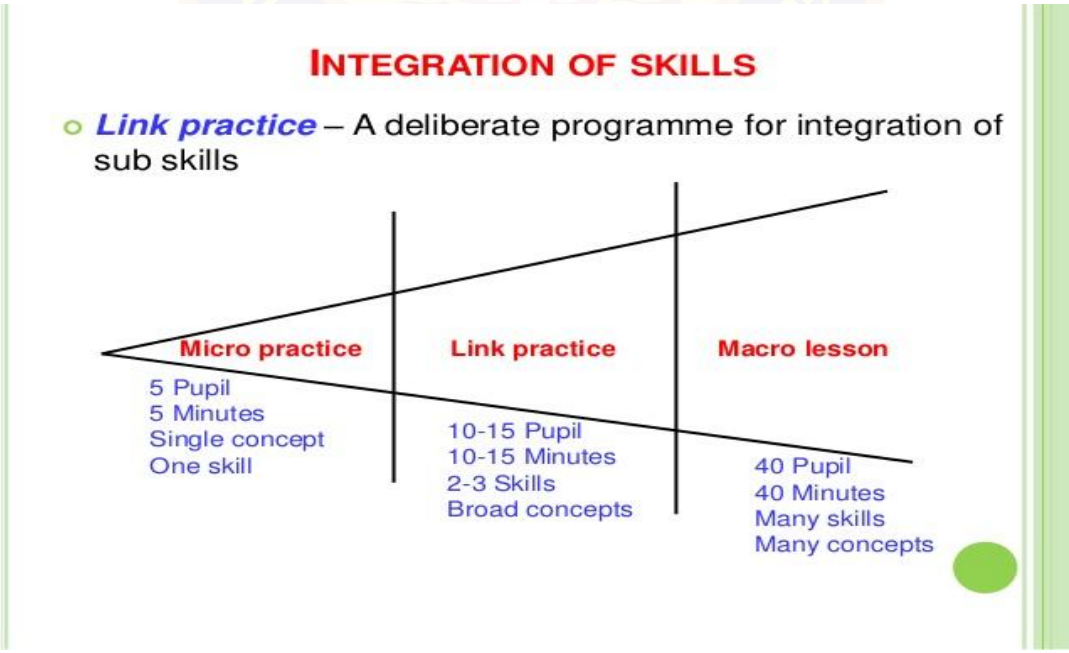
1. Clear objective
2. Relevant equipments
3. Apparatus handling techniques
4. Techniques in arranging apparatus
5. Students participation
6. Blackboard usage
7. Giving explanation

8.12 MICRO TEACHING AS A TECHNIQUE FOR ACQUIRING TEACHING SKILLS

Microteaching is a teacher training technique for learning teaching skills. It employs real teaching situation for developing skills and helps to get deeper knowledge regarding the art of teaching. Microteaching can be practiced with a very small lesson or a single concept and a less number of students.

8.14 LINK PRACTICE

Link practice is bridge between micro and macro teaching. It is a deliberate programme of integration of more than one skill. A link lesson comprising of selected skills to be practiced for ten to twenty minutes, with 10 to 20 peer students will be prepared.



8.15 NEEDS AND IMPORTANCE

Need

Link practice is very much essential for a trainee because in micro teaching individual skills are practiced without integration of skills. Moreover it is a simulated artificial practicing technique. A trainee cannot be possible to jump directly to the real class teaching. Hence link practice is needed for a trainee before going for macro teaching.

Importance

1. It may help pre service teachers to develop decision-making skills crucial for effective teaching
2. Certain skills that are not at all practiced in micro teaching will be practiced in micro teaching
3. Link practice acts as a bridge and connects micro and macro teaching
4. It sets a safe stage for a teacher before going for macro teaching.
5. It helps to raise awareness of the relevance of certain theories and principles that can be applied to help them understand and solve complex and conflicting issues in the classroom or schools.
6. It helps in proper sequencing of skills
7. It enables a teacher in coordination of different elements involved in teaching

UNIT – IX BASIC PHYSICS

9.1 MATTER AND MEASUREMENT

Matter

Matter can be described with both physical properties and chemical properties. Matter can be identified as an element, a compound, or a mixture.

Measurement

Measurement is the act of determining size, capacity, or quantity. *It* is the assignment of a number to a characteristic of an object or event, which can be compared with other objects or events. Essentially, there are four different types of measurement scales: nominal (or categorical), ordinal, interval, and ratio.

Measuring Instrument

Measuring Instrument is a device for measuring a physical quantity. In the physical sciences, quality assurance, and engineering, measurement is the activity.

Measuring Instruments measure various parameters of ranging from Distance measurement, Environmental parameters, etc. to monitor the Process conditions and help make decisions in real time

9.2 FORCES AND MOVEMENT

Motion

Motion is the change in position of an object with respect to its surroundings in a given interval of time. Motion is mathematically described in terms of displacement, distance, velocity, acceleration, and speed. In the world of mechanics, there are four basic types of motion. These four are rotary, oscillating, linear and reciprocating motion.

Force

Force is the effect caused by the interaction of two objects which tries to change the state of the object.

Pressure

Pressure is the force acting on object in perpendicular direction to the surface of the object which results in spreading of force over a certain area.

Motion and liquid

Liquid vibrate, move about, and slide past each other.

Brownian motion is the continuous random movement of small particles suspended in a fluid, which arise from collisions with the fluid molecules.

Laws of motion and gravitation

1. Newton's First Law states that an object will remain at rest or in uniform motion in a straight line unless acted upon by an external force. It may be seen as a statement about inertia, that objects will remain in their state of motion unless a force acts to change the motion.
2. Newton's second law states that the acceleration of an object is dependent upon two variables, the net force acting upon the object and the mass of the object.
3. Newton's third law states that for every action there is an equal and opposite reaction.

Gravitation

The gravitational force is a force that attracts any objects with mass.

The acceleration due to gravity on the surface of the earth is about 9.8 m/s^2 and the acceleration due to gravity on the surface of the Moon is about 1.625 m/s^2

9.3 EXPLORING ENERGY

Energy

Energy is the quantitative property that must be transferred to an object in order to perform work on, or to heat, the object. Energy is a conserved quantity; the law of conservation of energy states that energy can be converted in form, but not created or destroyed.

Types of Energy

Types of Energy - Basic forms of energy include: potential and Kinetic energy

The different types of energy include thermal energy, radiant energy, chemical energy, nuclear energy, electrical energy, motion energy, sound energy, elastic energy and gravitational energy.

Electricity

Electricity is the presence and flow of electric charge (electrons) in one direction. Its best-known form is the flow of electrons through conductors such as copper wires. The word "electricity" is sometimes used to mean "electrical energy".

Heat

Heat is the energy and defined as a spontaneous flow of energy (energy in transit) from one object to another, caused by a difference in temperature between two objects; so objects do not possess heat.

Work

Work is the product of force and displacement. A force is said to do work if, when acting, there is a displacement of the point of application in the direction of the force. **W = F. d**

Power

Power is the rate of doing work or of transferring heat, i.e. the amount of energy transferred or converted per unit time. In the International System of Units, the unit of power is the watt, equal to one joule per second

9.4 EXPLORING PHENOMENA

Scientific phenomena are occurrences in the natural and human-made world that can be observed and cause one to wonder and ask questions.

Magnetism

Magnetism is a class of physical phenomena that are mediated by magnetic fields. Electric currents and the magnetic moments of elementary particles give rise to a magnetic field, which acts on other currents and magnetic moments. Magnetism is one aspect of the combined phenomenon of electromagnetism.

Light

Light refers to electromagnetic radiation of any wavelength, whether visible or not. The energy imparted by the waves is absorbed at single locations the way particles are absorbed.

Laws of light

1. **Law of reflection** States that the angle made by the incident light ray with the normal to the surface at the point of incidence is equal to angle made by the reflected light ray with the normal
2. **Law of refraction** states that the incident ray, the refracted ray, and the normal to the interface, all lie in the same plane.

Sound

Sound is the term to describe what is heard when sound waves pass through a medium to the ear. All sounds are made by vibrations of molecules through which the sound travels. For instance, when a drum or a cymbal is struck, the object vibrates. These vibrations make air molecules move.

Magnetic Effect of Electric Current

Magnetic Effect of Electric Current is known as electromagnetic effect. It is observed that when a compass is brought near a current carrying conductor the needle of compass gets deflected because of flow of electricity. This shows that electric current produces a magnetic effect. Electrical appliances such as the electric doorbell, electric fan, and electric motors work on the principle of electromagnets. They are used in lifting heavy iron loads and iron scrap.

UNIT X: BASICS CHEMISTRY

10.1 CHEMISTRY

Chemistry is the science and study of matter, including its properties, composition as well as reactivity. Chemistry relates to everything that can be sensed from the minute elements to complex structures. The atom and molecules are the basic unit or components of Chemistry.

10.1.1 MATTER

Matter is anything which occupies space and has mass is called matter. Matter is made up of very small tiny particles. Particles of matter have space between them they attract each other.

Elements, Compounds

Matter:

10.2 SEPARATION OF SUBSTANCES

A separation process is a method that converts a mixture or solution of chemical substances into two or more distinct product mixtures.Separations exploit differences in chemical properties or physical properties (such as size, shape, mass, density, or chemical affinity) between the constituents of a mixture. Some of the separation methods are as follows,

1. Hand Picking
2. Threshing
3. Winnowing
4. Sieving
5. Evaporation
6. Sedimentation and decantation
7. Filtration
8. sublimation

Hand Picking - The method in which substances in a mixture can be separated by just picking them out with the help of hand from the mixture is known as handpicking method

Threshing is the process of loosening the edible part of grain (or other crop) from the chaff to which it is attached. It is the step in grain preparation after reaping.Threshing may be done by beating the grain using a flail on a threshing floor.

Winnowing- The process of separating heavier and lighter components of a mixture by wind or by blowing air is called winnowing.

Sieving - The process of separating fine particles from the larger particles by using a sieve, is called sieving.

Separation by **Evaporation** - The changing of liquid into vapours is called **evaporation**. **Evaporation** is used to separate a solid substance that has dissolved in water (or any other liquid). The dissolved substance is left as a solid residue when all the water (or liquid) has **evaporated**.

Sedimentation and decantation - Mixture is kept undisturbed for some time. After some time, sand being heavier and insoluble in water, settles down at the bottom of container. Now, water is poured into another container to separate it from sand.

Filtration - Mixture of sand and water is passed through a filter paper (a filter with very fine pores). Sand particles being larger in size are retained by the filter paper and get separated from water.

Sublimation is a process to separate a sublimable component from a non-sublimable component

q MATTER IN OUR SURROUNDINGS

We all live in surrounding which includes living things and natural forces. Living things not only live in the surrounding but interact with it as well. They affect the surrounding and are affected by the surrounding.

A **compound** contains atoms of different elements chemically combined together in a fixed ratio. An element is a pure chemical substance made of same type of atom. Compounds contain different elements in a fixed ratio arranged in a defined manner through chemical bonds.

Examples of elements include oxygen, hydrogen, sodium, chlorine, lead, iron. Examples of compounds include water (or hydrogen oxide) H2O; and Sodium Chloride, NaCl. ... The word compound simply means that the molecule is made up of at least two different elements. The element oxygen ordinarily exists as the molecule O2.

10.4 EXPLORING CHEMICAL CHANGES AND FORMULATION

Changes around us

Any alteration of a substance from its original shape, size and state is known as a change. But the changes occurring around us can sometimes be reversed and sometimes cannot. Those changes which can be reversed are termed as reversible changes like melting of ice, melting of wax.

A chemical change occurs when a new substance is formed through a chemical reaction like when fruit ripens or rots. When something undergoes a "chemical reaction" and a new substance is formed as a result, we call this chemical change. The iron reacts with water and oxygen to create a new substance -rust.

Matter and Its Nature

Anything which has mass and occupies some space is called matter. Each and everything which we see around us is matter.

Matter is classified at microscopic and macroscopic levels.

At microscopic level, it can be classified as solid, liquid and gas. These are the three physical states of matter. These three states of matter and interconvertable by changing the conditions of temperature and pressure

At macroscopic level, matter can be classified as pure substances and mixtures. This classification of matter is based upon chemical composition of various substances. Pure substances can further be classified into elements and compounds

10.5 CHEMICAL EQUATION

A chemical equation is the symbolic representation of a chemical reaction in the form of symbols and formulae, wherein the reactant entities are given on the left-hand side and the product entities on the right-hand side

qAn example of a chemical equation may be seen in the combustion of methane: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$.

10.6 CHEMICAL REACTIONS

Chemical reaction, a process in which one or more substances, the reactants, are converted to one or more different substances, the products. Substances are either *chemical* elements or compounds. A *chemical reaction* rearranges the constituent atoms of the reactants to create different substances as products.

Oxidation-Reduction or Redox Reaction

In a redox reaction, the oxidation numbers of atoms are changed. Redox reactions may involve the transfer of electrons between chemical species. The reaction that occurs when In which I_2 is reduced to I^- and $S_2O_3^{2-}$ (thiosulfate anion) is oxidized to $S_4O_6^{2-}$ provides an example of a redox reaction:

$2\ S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2\ I^-(aq)$

Direct Combination or Synthesis Reaction

In a synthesis reaction, two or more chemical species combine to form a more complex product. $A+B \rightarrow AB$

The combination of iron and sulfur to form iron (II) sulfide is an example of a synthesis reaction:

$8\ Fe + S_8 \rightarrow 8\ FeS$

Chemical Decomposition or Analysis Reaction

In a decomposition reaction, a compound is broken into smaller chemical species.

$AB \rightarrow A+B$

The electrolysis of water into oxygen and hydrogen gas is an example of a decomposition reaction:

$2\ H_2O \rightarrow 2\ H_2 + O_2$

Single Displacement or Substitution Reaction

A substitution or single displacement reaction is characterized by one element being displaced from a compound by another element.

$A+BC \rightarrow AC+B$

An example of a substitution reaction occurs when zinc combines with hydrochloric acid. The zinc replaces the hydrogen.

$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$

Metathesis or Double Displacement Reaction

In a double displacement or metathesis reaction two compounds exchange bonds or ions in order to form different compounds.

$AB+CD \rightarrow AD+CB$

An example of a double displacement reaction occurs between sodium chloride and silver nitrate to form sodium nitrate and silver chloride.

$NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

Acid-Base Reaction

An acid-base reaction is a type of double displacement reaction that occurs between an acid and a base. The H^+ ion in the acid reacts with the OH^- ion in the base to form water and an ionic salt:

$HA+BOH \rightarrow H_2O+BA$

The reaction between hydrobromic acid (HBr) and sodium hydroxide is an example of an acid-base reaction:

$HBr + NaOH \rightarrow NaBr + H_2O$

Combustion

A combustion reaction is a type of redox reaction in which a combustible material combines with an oxidizer to form oxidized products and generate heat (exothermic reaction). Usually, in a combustion reaction oxygen combines with another compound to form carbon dioxide and water. An example of a combustion reaction is the burning of naphthalene:
$C_{10}H_8 + 12\ O_2 \rightarrow 10\ CO_2 + 4\ H_2O$

Isomerization

In an isomerization reaction, the structural arrangement of a compound is changed but its net atomic composition remains the same.

Hydrolysis Reaction

A hydrolysis reaction involves water. The general form for a hydrolysis reaction is:
$X^-(aq) + H_2O(l) \leftrightarrow HX(aq) + OH^-(aq$

10.7 EXPLORING CHEMICAL FAMILIES: PERIODIC CLASSIFICATION OF ELEMENTS

Lavoisier divided elements into two main types known as metals and non-metals.

Doberiner's Law of Triads

According to this law, "in certain triads (grout) of three elements) the atomic mass of the central element was the arithmetic mean of the atomic masses of the other two elements." But in some triads all the threc elements possessed nearly the same atomic masses, therefore the law was rejected.

e.g., atomic masses of Li, Na and K are respectively 7, 23 and 39, thus the mean of atomic masses of I St and 3rd element is

Limitations of Doberiner's Triads: He could identify only a few such triads and so the law could not gain importance. In the triad ofFe, Co, Ni, all the three elements have a nearly equal atomic mass and thus does not follow the above law

Newland's Law of Octaves

According to this law "the elements are arranged in such a way that the eighth element starting from a given one has properties which are a repetition of those of the first if arranged in order of increasing atomic weight like the. eight note of musical scale."

Drawback of Newland's law of Octaves

(i) According to Newland only 56 elements exists in nature and no more elements would be discovered in the future. But later on several new element were discovered whose properties did not fit into law of octaves.

(ii) In order to fit new elements into his table Newland adjust two elements in the same column, but put some unlike elements under the same column.

Thus, Newland's classification was not accepted.

Mendeleev's Periodic Table

Mendeleev arranged 63 elements known at that time in the periodic table. According to Mendeleev "the properties of the elements are a periodic function of their atomic masses." The table consists of eight vertical column called 'groups' and horizontal rows called 'periods'.

Modern Periodic Classification.

Law of Modern Periodic Table states that properties of elements are the periodic function of their atomic numbers. In the modern periodic table, elements are arranged in order of their increasing atomic numbers. Elements are arranged in order of their increasing atomic numbers. Elements in the modern periodic table are arranged in 7 periods and 18 groups. Horizontal rows are called periods and vertical columns are called groups.

10.8 EXPLORING THE WORLD:

Chemistry in Everyday Life

Chemistry is a big part of our everyday life. We start the day with Chemistry. One can find chemistry in daily life in the foods we eat, the air we breathe, cleaning chemicals, our emotions and literally every object we can see or touch. Love, jealousy, envy, infatuation and infidelity all share a basis in chemistry.

Combustion and Flame

Combustion

Combustion is a chemical process in which a substance reacts rapidly with oxygen and gives off heat. The original substance is called the fuel, and the source of oxygen is called the oxidizer. The fuel can be a solid, liquid, or gas, although for airplane propulsion the fuel is usually a liquid.

A flame

A flame is a hot bright stream of burning gas that comes from something that is burning. The heat from the flames was so intense that roads melted.

There are three types of flames natural flame, carburizing flame and oxidizing flame. Natural flame has synchronized mixture of fuel and oxygen, carburizing flame has more fuel and oxidizing flame has more oxygen. Different material used different flames according to weld condition.

Coal and Petroleum

Coal and Petroleum, Carbon and its Compounds., coal, natural gas, and petroleum are all fossil fuels that formed under similar conditions. Today, petroleum is found in vast underground reservoirs where ancient seas were located. Petroleum reservoirs can be found beneath land or the ocean floor. Their crude oil is extracted with giant drilling machines.

Chemical Bonds

Chemical bond

A chemical bond is an attractive force between atoms that cause multiple atoms to come together in a specific pattern to form compounds, involves a transfer of an electron, so one atom gains an electron while one atom loses an

electron. One of the resulting ions carries a negative charge (anion), and the other ion carries a positive charge (cation). Because opposite charges attract, the atoms bond together to form a molecule.

The most common bond in organic molecules, a covalent bond involves the sharing of electrons between two atoms. The pair of shared electrons forms a new orbit that extends around the nuclei of both atoms, producing a molecule.

Carbon and its compound

Compounds of carbon are defined as chemical substances containing carbon. More compounds of carbon exist than any other chemical element except for hydrogen. Organic carbon compounds are far more numerous than inorganic carbon compounds. In general bonds of carbon with other elements are covalent bonds.

The four major categories of organic compounds that are present in all living things are carbohydrates, lipids, proteins and nucleic acid.

Examples include carbon oxides (CO and CO_2), carbonates (e.g., $CaCO_3$), oxalates (e.g., BaC_2O_4), carbon sulfides (e.g., carbon disulfide, CS_2), carbon-nitrogen compounds (e.g., hydrogen cyanide, HCN), carbon halides, and carbonates.