LEARNING RESOURCES
ON

BED P 101 : PHYSICAL SCIENCE UNDERSTANDING THE DISCIPLINE AND SUBJECT

EDITOR
DR. PRASANTH MATHEW

Department of Physical Science
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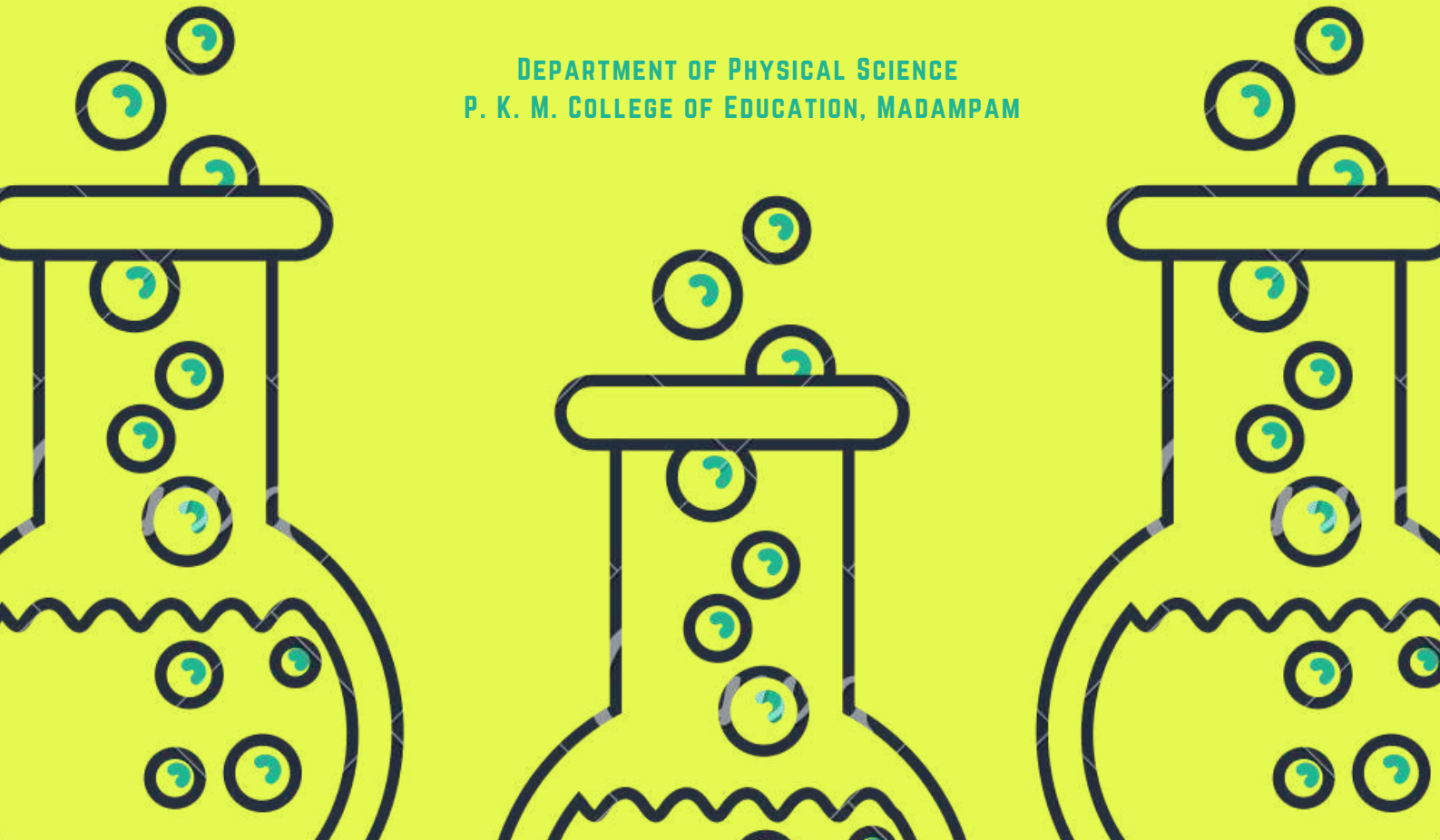

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Title	:	**LEARNING RESOURCES ON B.Ed P 101 : PHYSICAL SCIENCE - UNDERSTANDING THE DISCIPLINE AND SUBJECT**
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PREFACE

Learning resources on B.Ed P 101 : Physical Science - Understanding the Discipline and Subject published by Department of Physical Science , P.K.M College of Education, Madampam. This collaborative effort between faculty and students signifies our commitment to providing a robust learning resource for aspiring educators in physical science. As an essential component of the B.Ed program at Kannur University, this book offers a comprehensive exploration of physics and chemistry. Through this work, we aim to foster intellectual curiosity and inspire a passion for the sciences among future teachers. We extend our heartfelt appreciation to all contributors whose dedication has shaped this publication. May this book serve as a beacon of knowledge, empowering students to excel in their academic pursuits and become catalysts for transformative education. With gratitude and optimism, we embark on this educational journey together, embracing the challenges and opportunities that lie ahead in the pursuit of excellence in teaching and learning.

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4.2	Learner as little scientist Encouraging learners to raise questions.
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BED P 101 : PHYSICAL SCIENCE

UNDERSTANDING THE DISCIPLINE AND SUBJECT

UNIT I

NATURE OF PHYSICAL SCIENCE

1.1 Science – as a domain of enquiry – as a dynamic and expanding body of knowledge – as a process of constructing knowledge – as interdisciplinary area of learning. Process skills in science at secondary stage.

1.2 Facts, concepts, principles, theories and laws – their characteristics in context of physical science.

1.3 Physical science for environment, health, peace, equity.

1.4 Contribution of eminent scientists.

1.5 Scientific attitude, scientific aptitude, scientific creativity, scientific sensitivity.

1.1 Science

The word science comes from the Latin word ***scientia*** which means knowledge. Science is an intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment. Generally science is the study of things and phenomena. An understanding of science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society.

3 dimensions of science

1. Science is a body of knowledge

2. Science is a way of investigation

3. Science is an attitude towards life

1.1.1 Science as a domain of enquiry

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry includes the traditional science processes, but also refers to the combining of these processes with scientific knowledge, critical thinking and scientific reasoning to develop scientific knowledge.

Courses in the scientific inquiry domain are designed to provide students with an opportunity to learn the methods of modern science and its impact in understanding the world around us.

Students who use inquiry to learn science engage in many of the same activities and thinking processes as scientists who are seeking to expand human knowledge of the natural world. By describing inquiry in both science and in classrooms, this volume explores the many facets of inquiry in science education. Through examples and discussion, it shows how students and teachers can use inquiry to learn how to do science, learn about the nature of science, and learn science content.

1.1.2 Science as a dynamic and expanding body of knowledge

While the scientific method provides a stable framework for investigation, science itself is dynamic because there is always the chance for new discoveries and finding new data that changes the nature of previous discoveries.

Science is a process for producing knowledge. The process depends both on making careful observations of phenomena and on inventing theories or making sense out of these observation. Change in knowledge is inevitable because new observation may challenge prevailing theories. In science, the testing, improving and occasional discarding of theories, whether new or old go on all the time. Scientists assume that even if there is no way to secure complete and absolute truth, increasing accurate approximations can be made to account for the world and how it works.

Scientific knowledge is durable although scientists reject the notion of attaining absolute truth and accept some uncertainty as part of nature, most scientific knowledge is durable. The modification of ideas rather than their outright rejection is the norm in science.

Scientific Knowledge refers to the product of science, such as the concepts, facts, principles, theories and laws. Research being carried out in the field of science resulted in developing more knowledge at a faster pace sometimes by replacing old concepts, ideas or principles. The technological developments that took place in recent times enhanced the acceleration of knowledge.

1.1.3 Science as a process of constructing knowledge

Science consists of a body of knowledge and the process by which that knowledge is developed. The core of the process of science is generating testable explanations, and the methods and approaches to generating knowledge are shared publicly so that they can be evaluated by the community of scientists. Scientists build on the work of others to create scientific knowledge. Scientific knowledge is subject to revision and refinement as new data, or new ways to interpret existing data, are found.

1.1.4 Science as interdisciplinary area of learning

In the last two decades there have been studies claiming that science is becoming even more an interdisciplinary area of learning. Science cannot be taught in isolation. All the branches of science are interdependent upon all other and there are a number of facts and principles which are common to various science subjects. Knowledge started expanding day by day; scientists started specialising in certain areas. Hence the knowledge has been organized for convenience into different disciplines. For example environmental science is an interdisciplinary academic field that integrates physics, biological and information sciences (including ecology, biology, physics, chemistry, zoology, mineralogy, oceanology, limnology, soil science, geology of atmospheric science and geodesy).

1.1.5 Process skills in science at secondary stage

A number of process skills are involved in the case of problem solving or scientific method. American Association for Advancement of Science (AAAS) has identified eight basic skills and five integrated processes.

1.1.5.1 Basic Skills

They are primary ways of obtaining knowledge.

1. Observing - This is the most fundamental of all of the processes. Observation may be defined as the gathering of information through the use of any one, or combination of the five basic senses; sight, hearing, touch, taste, and smell. The term observation may also be used to express the result of observing. In other words one might observe and, as a result, gather observations. These observations can also be called data or facts.

2. Measuring - Measurement is an observation made more specific by comparing some attribute of a system to a standard of reference. An example is when the length of an object is expressed in terms of the length of a meter or when the mass of an object is expressed by referring to a standard such as a gram. Measurement and observation are the only process skills that are actually two forms of the same thing.

3. Using space time relationship – It refers to observation of forms, distance, motion, speed, direction and time. This skill originated from the ability to identify shapes of the bodies, their motion, speed and direction.

4. Communication - This process actually refers to a group of skills, all of which represent some form of systematic reporting of data. The most common examples include data display tables, charts and graphs.

5. Classifying - Classification is the process of grouping objects on the basis of observable traits. Objects that share a given characteristic can be said to belong to the same set.

6. Predicting - This process deals with projecting events based upon a body of information. One might project in a future tense, a sort of trend analysis, or one might look for an historical precedent to a current circumstance. In either case, the prediction emerges for a data base rather than being just a guess. A guess is not a prediction. By definition, predictions must also be testable. This means that predictions are accepted or rejected based upon observed criteria. If they are not testable they are not predictions.

7. Using numbers – Applying number and mathematical relationship to make decisions. Numbers are basic to science. Mathematical knowledge is applied here.

8. Inferring - Inferring is an inventive process in which an assumption of cause is generated to explain an observed event. This is a very common function and is influenced by culture and personal theories of nature.

1.1.5.2 Integrated process skills

1. Defining operationally - stating how to measure a variable in an experiment.

2. Formulating hypothesis - stating the expected outcome of an experiment.

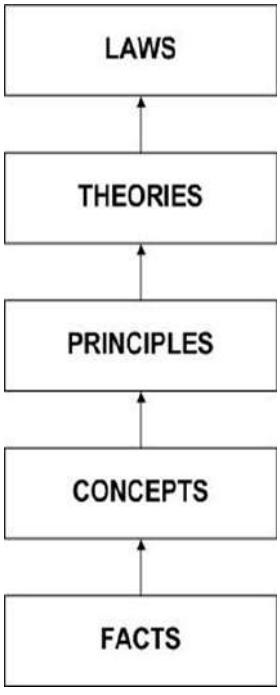
3. Controlling variables - being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable.

4. Experimenting - being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a "fair" experiment, conducting the experiment, and interpreting the results of the experiment.

5. Interpreting data - organizing data and drawing conclusions from it.

1.2 FACTS, CONCEPTS, PRINCIPLES, THEORIES AND LAWS

Their characteristics in context of Physical science



Product of Science

1.2.1 Scientific facts

- Scientific facts are objectively conformed statements about things that are really exist or events that have actually occurred or been observed.

- Scientific facts are obtained as a product of empirical process by asking empirical questions.
- Scientific facts exist in the reality.
- Example
    1. The rainbow is always seen in a direction opposite to that of sun.
    2. The reaction of copper sulphate with zinc resulting in the production of zinc sulphate and copper.

1.2.2 Scientific concepts

- Scientific concepts are mental organizations about the world that are based on similarities among objects or observations or events.
- Scientific concepts are generalized ideas.
- Scientific concepts are the product of logical or analytical process.
- Scientific concepts are formed from scientific facts through analyzing and organizing by the method of reasoning.
- Examples
    1. Solid, Liquid, Gas
    2. Acids

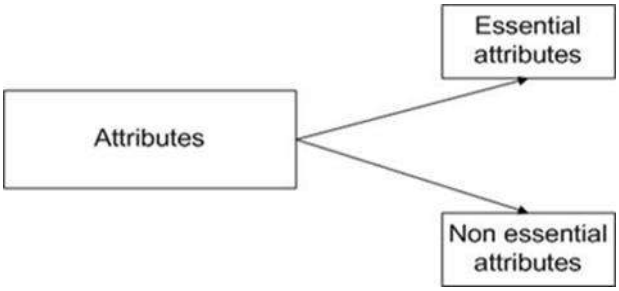
1.2.2.1 Elements of a concept:

1. Name of the concept

    These are the symbolic representation of the concept.
2. Definition of the concept

    These are the generalised statement developed from the attributes
3. Attributes of the concept

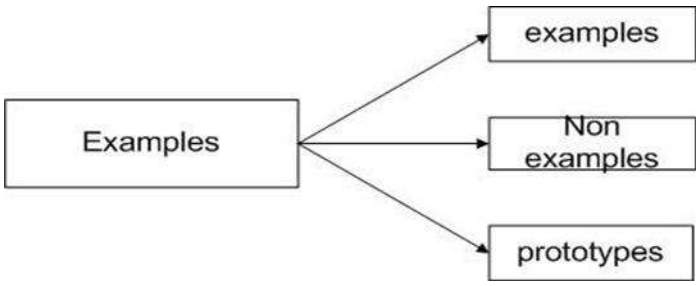
    These are the features or characteristics of the concept.



Essential attributes are the fundamental or absolute features of a concept. Whereas non-essential attributes contains the features that may be present but are not fundamental.

4. Examples of the concept

   These are the instances that could be observed and studied and which exist in the reality.



Examples can be classified as examples, non-examples and prototypes. A prototype is a best example or a model of a concept exists in the reality.

1.2.2.2 Elements of a scientific Concept

1. Scientific term
2. Scientific definition
3. Scientific attributes
4. Scientific facts

The scientific process through which a scientific concept is attained from the scientific facts is known as inductive reasoning. It is a processof moving from specific observations to broader generalizations. Where as deductive reasoning is a top-down approach in which proceeds from general to specific aspects. That is from scientific concepts to scientific facts.

Example:

Scientific concept: Metals

Scientific term - Metals

Scientific definition - a type of solid mineral substance that is usually hard and shiny and that heat and electricity can travel through.

Scientific attributes - malleability, ductility, conductor of heat and electricity, high density, sonority, high melting point

Scientific fact - gold, silver, copper, iron

1.2.3 Scientific principles

- Many concepts can be combined in a way to convey meaning which can be tested and verified universally. Then they become a principle.
- Scientific principles are the relationship between scientific concepts.
- A principle is a comprehensive generalization describing a property related to a natural phenomenon.
- The principle is based on concepts which are formed through concrete examples.
- People apply principles to understand realities around them, to explain the phenomena they have observed, and to test their hypothesis on laboratories.
- Example
    1. Heisenberg's uncertainty principle
    2. Pauli's exclusion principle

1.2.4 Scientific theories

- Scientific theories are the tentative model by scientists about mysteries of nature.
- A scientific theory is a set of statements that when taken together attempt to explain a broad class of related phenomena.
- A scientific theory is based on evidences and tested against a wide range of phenomena.
- Scientific theories are often expressed in terms of a few concepts and equations.
- A theory is a set of interconnected concepts, assumptions and principles giving an explanation of natural phenomena.
- A theory should predict new phenomena which are verifiable by experimentation.
- Examples
    1. Big bang theory
    2. Kinetic theory of gases

1.2.5 Scientific laws

- Scientific laws are universally accepted, tested and proved statements.

- They have durability as long as testing support them.
- Scientific laws are concise verbal statements or mathematical expressions
- A law may describe a single action or a phenomenon where as a theory explains a set of phenomena.
- Examples
    1. Boyle's law
    2. Charles's law

1.3 PHYSICAL SCIENCE FOR EQUITY, PEACE AND ENVIRONMENT

1.3.1 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. 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. Diversity should be valued in school and each individual should be respected. Researchers have shown that the boys and girls perform equally well in science learning. Therefore, no gender bias should be practised in the classroom and in allotting scientific work to the students. All attempts should be made to motivate the parents to encourage their girl children to opt for science. Teachers, teacher educators, textbook writers and educational administrators must be made sensitive and responsive to gender-related issues.

For using science as a tool to foster equity the following actions and options should be adopted.

- Use science curriculum as an instrument of social change to reduce the socio-economic divide.
- Content of the curriculum should promote respect for diverse lifestyles.
- Use Information and Communication Technology (ICT) as a powerful tool for bridging the social divide in education.

- Using an inclusive language which is simple and which uses words from both the rural and urban areas.

1.3.2 PHYSICAL SCIENCE FOR PEACE

Science has brought about an overall betterment of life of humankinds. The scientific knowledge is universal and it has no boundaries. One of the indicators of peace is absence of violence. Students need to be encouraged to visualise future of our nation to become sensitive and responsible citizens. It is important to develop critical thinking in them to maintain a healthy and sustainable society. Children need to be encouraged to appreciate and participate in the responsible use of science and technology for the benefit of society. Students should be made aware about interrelationship and interdependence of various scientific issues in the global and economic contexts so that they can form a wider perspective of justice, peace and non-violence. Scientific knowledge and its developmental enterprises must be used for the welfare of humankinds which in turn would bring peace in the society.

1.3.3 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.

In science we deal with facts, concepts, principles and events that take place in nature. The study of the effects of contaminants (physical, chemical, biological) on the environment has also become part of science. Scientists started working on the prevention of pollution of water, air, soil, noise, and that caused by radioactivity. For example, the use of compressed natural gas (CNG) as fuel in preference to petroleum and diesel helps in reducing the level of carbon dioxide in the air. Thus science is essential for the study of environment and its improvement.

1.3.4 PHYSICAL SCIENCE FOR HEALTH

One indication that the progress of a society has taken place is that its members are healthy. In fact, the disease and poverty form a vicious circle. People are poor, because they are suffering from various diseases; people are suffering from various diseases, because they are poor. Science has served humankinds to a great extent for making its members healthy

and free from diseases. It has formalised the consumption of various nutrients such as proteins, carbohydrates, vitamins, fats, minerals, etc. in requisite amounts for a person to remain healthy. Science has also generated preventive measures so that people do not fall prey to diseases like malaria, tuberculosis and hepatitis B.

Physical science has contributed a lot in reducing human suffering by the discovery of anaesthesia and antisepsis to be used for surgery and various medicines such as painkillers, antibiotics, sedatives, etc. to relieve pain and sufferings. One of the humming issues facing the society today is to provide health care to all its members. Scientific vision of health care and understanding the intricacies of modern medicines can enable the society to choose the right path to follow.

1.4 CONTRIBUTION OF EMINENT SCIENTISTS

1.4.1 ANCIENT SCIENTIST

1. **Anaximander c.610BC–c.546BC.**

   An ancient scientific revolution: the first person in history to recognize that we live on a planet that is free in space and does not need to sit on something

2. **Archimedes c. 287 BC – 212 BC.**

Founded the sciences of mechanics and hydrostatics, calculated pi precisely, devised the law of exponents, created new geometrical proofs, invented numerous ingenious mechanical devices and more.

3. **Aristarchus c. 310 BC – c. 230 BC.**

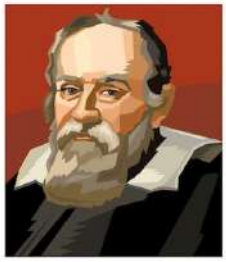
Promoted the idea that the earth follows a circular orbit around the sun eighteen centuries before Nicolaus Copernicus resurrected the idea.

4. **Aristotle 384 BC – 322 BC.**

A genius whose philosophical ideas are still taught, but hiscontributions to physics retarded progress for almost two millennia.

1.4.2 FOREIGN SCIENTISTS

5. Galileo Galilei : Discoverer of the Cosmos

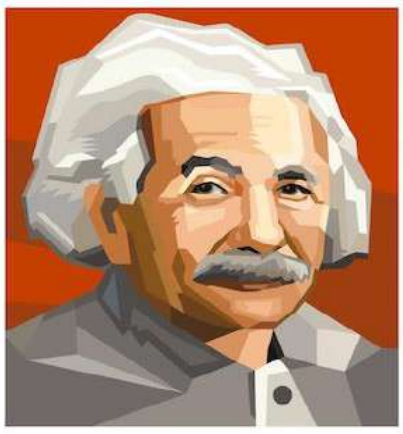


An Italian mathematician, scientist, and philosopher born in 1564.

Contributions :

- Around Dec. 1, 1609, Italian mathematician Galileo Galilei pointed a telescope at the moon and created modern astronomy. His subsequent observations turned up four satellites — massive moons — orbiting Jupiter, and showed that the Milky Way's murky light shines from many dim stars. Galileo also found sunspots upon the surface of our star and discovered the phases of Venus, which confirmed that the planet circles the sun inside Earth's own orbit.
- Galileo invented an early type of thermometer.
- In Galileo discovered the rings of Saturn
- he found proof for the theories of Polish astronomer Nicolaus Copernicus (1473-1543), who had launched the Scientific Revolution with his sun-centered solar system model.
- Ecognized that in a vacuum, all falling objects would accelerate at the same rate regardless of their size, shape, or mass

6. Albert Einstein : the whole package



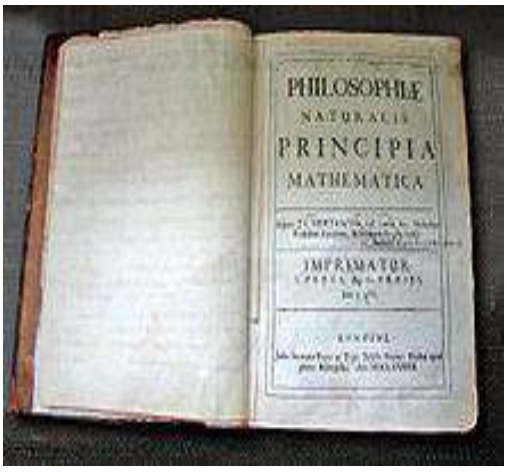
Albert Einstein (14 March 1879 – 18 April 1955) was a German-born theoretical physicist, universally acknowledged to be one of the two greatest physicists of all time, the other being Isaac Newton. Einstein developed the theory of relativity, one of the two pillars of modern physics (alongside quantum mechanics).His mass–energy equivalence

formula $E = mc^2$ has been dubbed "the world's most famous equation". His work is also known for its influence on the philosophy of science. He received the 1921 Nobel Prize in Physics "for his services to theoretical physics, and especially for his discovery of the law of the photoelectric effect, a pivotal step in the development of quantum theory. His intellectual achievements and originality resulted in "Einstein" becoming synonymous with "genius".

Contributions:

- In 1915 Einstein published his general relativity theory. According to it, the observed gravitational attraction between masses results from the warping of space and time by those masses.
- In 1916, he predicted gravitational waves, which has been recently confirmed by experiments in 2016.
- Special Theory of relativity,which revolutionalized our thought related to space ,time and gravity
- His equation $E = mc^2$, it also foreshadowed the creation of the atomic bomb.
- Einstein's understanding of light as something which can function both as a wave and as a stream of particle(Photoelectric effect) became the basis for what is known today as quantum mechanics .
- Brownian motion – evidence for atomic theory.

7. Isaac Newton : the man who defined science on a bet



Sir Isaac Newton (25 December 1642 – 20 March 1726) was an English mathematician, physicist, astronomer, theologian, and author (described in his time

as a "natural philosopher") who is widely recognised as one of the most influential scientists of all time and as a key figure in the scientific revolution. His book Philosophiæ Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy), first published in 1687, established classical mechanics. Newton also made seminal contributions to optics , and shares credit with Gottfried Wilhelm Leibniz for developing the infinitesimal calculus.

In *Principia*, Newton formulated the laws of motion and universal gravitation that formed the dominant scientific viewpoint until it was superseded by the theory of relativity.

Contributions :

- He invented calculus and provided a clear understanding of optics.
- Universal law of gravity
- Newton's laws of motion
- Reflecting Telescope - In 1668 **Newton** invented the reflecting telescope. This type of telescope **uses** mirrors to reflect light and form an image. Nearly all of the major telescopes **used** in astronomy **today** are reflecting telescopes.

8. Nikola Tesla: Wizard of the Industrial Revolution

Nikola Tesla grips his hat in his hand. He points his cane toward Niagara Falls and beckons bystanders to turn their gaze to the future. This bronze Tesla — a statue on the Canadian side — stands atop an induction motor, the type of engine that drove the first hydroelectric power plant.

We owe much of our modern electrified life to the lab experiments of the Serbian-American engineer, born in 1856 in what's now Croatia.

Contributions :

- His designs advanced alternating current at the start of the electric age and allowed utilities to send current over vast distances, powering American homes across the country.
- He developed the Tesla coil — a high-voltage transformer — and techniques to transmit power wirelessly. Cellphone makers (and others) are just now utilizing the potential of this idea.

9. Stephen hawking : a legacy of paradox

Stephen William Hawking (8 January 1942 – 14 March 2018) was an English theoretical physicist, cosmologist, and author who was director of research at the Centre for Theoretical Cosmology at the University of Cambridge at the time of his death. He was the Lucasian Professor of Mathematics at the University of Cambridge between 1979 and 2009.

Contributions :

- **Hawking's** arguably greatest **contribution** was the discovery of the **Hawking** Radiation, which is one of the biggest breakthroughs in the 20th century. It detailed an unprecedented understanding of black holes, as well as, the interplay between quantum effects and general relativity. **He** proposed that black holes would emit subatomic particles until they eventually exploded.

1.4.3 FOREIGN WOMEN SCIENTISTS

10. Marie Curie: She Went Her Own Way

- Despite her French name, Marie Curie's story didn't start in France. Her road to Paris and success was a hard one, as equally worthy of admiration as her scientific accomplishments.
- Born Maria Salomea Sklodowska in 1867 in Warsaw, Poland, she faced some daunting hurdles, both because of her gender and her family's poverty, which stemmed from the political turmoil at the time. Her parents, deeply patriotic Poles, lost most of their money supporting their homeland in its struggle for independence from Russian, Austrian and Prussian regimes. Her father, a math and physics professor, and her mother, headmistress of a respected boarding school in Russian-occupied Warsaw, instilled in their five kids a love of learning. They also imbued them with an appreciation of Polish culture, which the Russian government discouraged.

Contributions :

- Marie Sklodowska Curie (1867–1934) was the first person ever to receive two Nobel Prizes: the first in 1903 in physics, shared with Pierre Curie (her husband) and Henri Becquerel for the discovery of the phenomenon of radioactivity, and the second in 1911 in chemistry for the discovery of the radioactive elements polonium and radium.
- Just before World War I radium institutes were established for her in France and in Poland to pursue the scientific and medical uses of radioactivity. During the war Curie organized a field system of portable X-ray machines to help in treating wounded French soldiers.

11. Rachel Carson *(1907–1964)*

With her 1962 book *Silent Spring*, the biologist energized a nascent environmental movement. In 2006, *Discover* named *Silent Spring* among the top 25 science books of all time.

12. Sophie Germain

1816: French mathematician and physicist who became the first woman to win a prize from the Paris Academy of Sciences for her work on elasticity theory.

13. Henrietta Swan Leavitt

1912: American astronomer , studied the bright-dim cycle periods of Cepheid stars, then found a way to calculate the distance from such stars to Earth.

1.4.4 INDIAN SCIENTISTS

14. **C V Raman**

Chandrasekhara Venkata Raman won the Nobel Prize for Physics in 1930 for his pioneering work on scattering of light. Born in Tiruchirapalli on November 7, 1888, he was the first Asian and first non-White to receive any Nobel Prize in the sciences..

Contributions :

- He discovered that, when light traverses a transparent material, some of the deflected light changes in wavelength. This phenomenon is now called the Raman scattering and is the result of the Raman effect.

- Raman spectroscopy

- Raman also worked on the acoustics of musical instruments. He was the first to investigate the harmonic nature of the sound of the Indian drums such as the tabla and the mridangam

15. Homi J. Bhabha

Born on October 30, 1909 in Bombay, Homi Jehangir Bhabha played an important role in the Quantum Theory.

He was the first person to become the Chairman of the Atomic Energy Commission of India. Having started his scientific career in nuclear physics from Great Britain, Bhabha returned to India and played a key role in convincing the Congress Party's senior leaders, most notably Jawaharlal Nehru, to start the ambitious nuclear programme.

Contributions:

Bhabha is generally acknowledged as the father of Indian nuclear power. But few people know that he was absolutely against India manufacturing atomic bombs, even if the country had enough resources to do so. Instead he suggested that the production of an atomic reactor should be used to lessen India's misery and poverty.

16. Visvesvaraya

Born on 15 September 1860, Sir Mokshagundam Visvesvaraya was a notable Indian engineer, scholar, statesman and the Diwan of Mysore during 1912 to 1918. He was a recipient of the Indian Republic's highest honour, the Bharat Ratna.

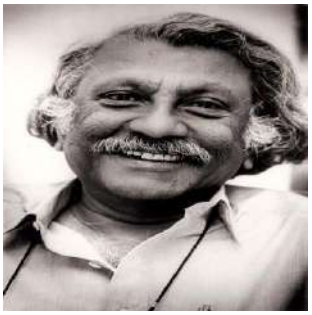
Contributions:

- He has the credit of inventing 'automatic sluice gates' and 'block irrigation system' which are still considered to be marvels in engineering. Each year, his birthday 15 September is celebrated as Engineer's Day in India.

- Since river beds were costly, he came up with an efficient way of filtering water through 'Collector Wells' in 1895 which was rarely seen anywhere in the world.

17. Venkatraman Radhakrishnan

Venkatraman Radhakrishnan was born on May 18, 1929 in Tondaripet, a suburb of Chennai. He died at the age of 81 in Bangalore



Contributions:

- Venkataraman was a globally renowned space scientist and a member of the Royal Swedish Academy of Sciences.

- He was an internationally acclaimed Astrophysicist and also known for his design and fabrication of ultralight aircraft and sailboats.

- His observations and theoretical insights helped the community in unraveling many mysteries surrounding pulsars, interstellar clouds, galaxy structures and various other celestial bodies.

18. S. Chandrashekar

Born on October 19, 1910 in Lahore, British India, he was awarded the 1983 Nobel Prize for Physics for his mathematical theory of black holes. He was nephew of CV Raman. Chandra became a United States citizen in 1953. He died on August 21, 1995, at the age of 82 in Chicago.

Contributions :

- The Chandrasekhar limit is named after him.
- His most celebrated work concerns the radiation of energy from stars, particularly white dwarf stars, which are the dying fragments of stars.

1.4.5 INDIAN WOMEN SCIENTISTS

19. E K Janaki Ammal (1897-1984)

D.Sc. (1931, Michigan), Founder Fellow of the Indian Academy of Sciences. Winner of Padmashri Award. Was a renowned botanist and plant cytologist who made significant contributions to genetics, evolution, phytogeography and ethnobotany.

20. Kamala Sohonie (1911-1996)

Ph.D. (1939, Cambridge). Recipient of the Rastra-pati award for best scientific research. Life time achievement felicitation by ICMR. Assistant Director, NRI, Cunnoor, India. Retired as First Lady Director, Institute of Science, Mumbai.

21. Chitra Mandal

Ph.D. (1978, IISc), FNA, FASc, FNASc. She is a recipient of several awards from the DBT, ICMR and VASVIK, as well as P B Rama Rao Memorial Award. Her specific interests are in the field of Glycobiology/Glycoimmunology in health and diseases.

22. Hema Ramachandran

Ph.D. (1992, Bombay) is at the Raman Research Institute, Bangalore. She is the recipient of the Homi Bhabha Award, the Indian National Science Academy Young Scientist Award. Her current research interests are quantum logic and quantum information, quantum optics, ultracold atomic systems and Bose-Einstein condensates.

1.5 SCIENTIFIC ATTITUDE, SCIENTIFIC APTITUDE, SCIENTIFIC CREATIVITY, SCIENTIFIC SENSITIVITY

1.5.1 SCIENTIFIC ATTITUDE

Scientific attitude is the most important outcome of science teaching and which enables us to think rationally. It is the combination of many qualities and virtues which is reflected through the behaviour and action of the person. Scientific attitude is important for critical thinking and reasoning.

A person with scientific attitude will have the following attributes.

- Curiosity
- Open mindedness
- Objectivity
- Belief in cause effect relationship
- Perseverance
- Respect for others opinions
- Methodical way of solving a problem on hand
- Critical in observation and thought
- Judgement based on scientific facts
- Up-to-datedness
- Intellectual honesty
- Skepticism

Techniques for developing scientific attitudes

- The increase in degree of consistency of environment help in developing and inculcating scientific attitude in pupil

- The scientific attitude can be inculcated in pupil by providing him a more opportunities for making satisfying adjustment to the attitude situations
- By providing him opportunity for analysis of the problem or situations so that a pupil may understand and then reset intellectually in desirable attitude

Role of a teacher

- Making use of planned exercise
- Wide reading
- Proper use of practical period
- Personal example of the teacher
- Study on superstitions
- Co-curricular activities
- Classroom atmosphere & motivation

1.5.2 SCIENTIFIC APTITUDE

- An aptitude is a component of a competence to do a certain kind of work at a certain level.
- Outstanding aptitude can be considered “talent/passion”.
- An aptitude may be physical or mental.
- Aptitude is inborn potential to do certain kinds of work whether developed or undeveloped.
- Ability is developed knowledge, understanding, learned or acquired abilities (skills) or attitude.
- The innate nature of aptitude is in contrast to skills and achievement, which represent knowledge or ability that is gained through learning

.

1.5.3 SCIENTIFIC CREATIVITY

Scientific creativity is a phenomenon where by something new and somehow valuable is formed in science. Creativity in science is a mental process involving the generation of new ideas or concepts, or new associations between existing ideas or concepts. Innovation and invention are impossible without creativity.

Divergent thinking – Multiple ideas, it is important in creativity. The 4 important points in divergent thinking are:

1. **Fluency**: It is the ability to speak or write language easily& accurately. Also it is the speedy retrieval of maximum information from memory
2. **Flexibility**: Ability to transfer information to interpret, adapt it to know uses
3. **Elaboration**: Seeing extended implication of original ideas. Provide new ways of doing old ideas & activity to children
4. **Originality**: It is the ability to have a new or novel ideas

Stages involved in the process of creativity

1. Preparation: Collect information, materials
2. Incubation: Thinking
3. Illumination: Finding solution to problem
4. Verification: Verify the problem

Techniques to develop scientific creativity

- Encourage originality
- Encourage independent thinking
- Build basic skills
- Encourage acquisitions of knowledge
- Ask challenging questions
- Stimulate and reward curiosity and exploration
- Adopt proper reinforcement techniques

Role of teacher

- Assist students in developing models of inquiry and discovery
- Guide students in the use of multidisciplinary approach
- Recognize and appreciate creative ideas and products of students
- Provide rich verity of learning experience to students
- Encourage students to frame questions and browse variety of reading materials
- Accept and encourage divergent thinking

1.5.4 SCIENTIFIC SENSITIVITY

Scientific sensitivity is the critical awareness of the role of science in society combined with a caring and responsible disposition. Sensitivity involves being critically reflected about social, moral, environmental, and health issues. And ways in which these relate to the role of science in wealth creation. It is rooted in and informed, responsible, respectful, view of the world and its people.

UNIT -II

CURRICULUM IN PHYSICAL SCIENCE

2.1 Curriculum- principles of construction, factors affecting.

2.2 Approaches to curriculum organization - concentric plan, type study, Integrated, disciplinary and inter disciplinary approaches.

2.3 Science curricular projects – Chemstudy, Nuffield project, PSSC.

2.4 Science education as envisaged by NCF and KCF.

2.1 CURRICULUM

Curriculum is the crux of the whole educational process. The word 'Curriculum' originates from the Latin word 'Currere' which means to run or path. The Latin root of the word Curriculum means the race course. Hence Curriculum is the course to be run for reaching the goal or path through which the student has to go forward to reach the goal. It can be regarded as the sum total of experiences during teaching learning process.

"Curriculum is the planned and guided learning experiences and intended learning outcomes formulated through systematic reconstruction of knowledge and experiences, under the auspicious of the school, for the learners continues and willful growth in personal-social competence." -Tanner & Tanner (1988)

"Curriculum embodies all the experiences which are utilized by the schools to attain the aims of education" - Munroe

"Curriculum is a tool in the hands of an artist (teacher) to mould his materials (pupils) according to his ideals (objectives) in his studio (School)." - Arthur Cunningham

"Curriculum is a plan for learning" - Taba

2.1.1 PRINCIPLES OF CURRICULUM DEVELOPMENT

Basic principles of curriculum development are:

1) **The principle of Child-Centeredness**

   Curriculum should be child-centered. It should be constructed according to the need, aptitude, attitude, interest and abilities of a child.

2) **The principle of community- centeredness**

   The learner is going to be an active member of the community. So the curriculum has to prepare the learners to face the challenges posed by the community with efficiency.

3) **The principle of activity centeredness**

   Action is the sign of life. Man is an active being. Therefore, the curriculum should provide for a variety of activities both physical and mental in which children are naturally interested.

4) **The principle of integration**

   Curriculum should integrate child's needs and the needs of the democratic society. This will help the child to establish a functional unity with the environment.

5) **Principle of Conservation of culture**

   The curriculum should preserve and transmit the traditions and culture of human race

6) **Renewal principle**

   While knowing the culture and traditions of the past, the child should be in a position to renew the culture to suit the requirement of changing world.

7) **Principle of Creativity**

   By nature, man is creative. Curriculum should have the provisions to develop creativity of child. Once this is developed they can utilize this creativity which enables them to modify the environment according to the needs of time.

8) **Principle of Motivation**

   Curriculum should construct in such a way to motivate the pupils to actively participate in the learning process with an innate desire arising out of intrinsic motivation.

9) **Principle of Maturity**

   The curriculum should be suited to the mental and physical maturity of the pupil.

10) **Principle of Elasticity and Flexibility**

The curriculum should not be rigid. It should be change to suit the change in needs of people and society.

11) **The principle of Utility**

Curriculum should be of practical use to pupil, and hence should maintain vocational and technical bias.

12) **The principle of balance**

Curriculum should maintain a proper balance between

- Direct and indirect experiences
- Subjects and activities
- Academic and vocational education
- Formal and informal education
- Compulsory and optional subjects
- Individual and social aims

2.1.2 FACTORS AFFECTING CURRICULUM

The factors contributing to curriculum organization are:

i. Pupils
ii. Teacher
iii. Textbook, Instructional materials
iv. Examination and Evaluation
v. Guidance and Counseling
vi. Supervision and Administration
vii. Research
viii. Psychological factors
ix. Sociological and philosophical factors

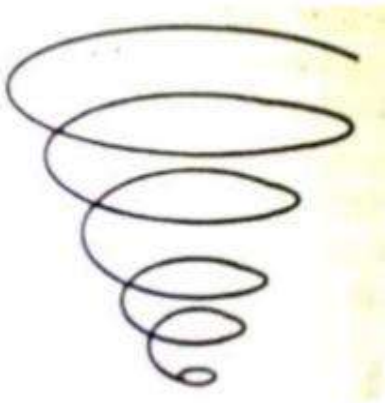
2.2 APPROACHES TO CURRICULUM ORGANISATION

1. Concentric and spiral approaches
2. Type study
3. Integrated approach
4. Disciplinary approach
5. Interdisciplinary curriculum

2.2.1 Concentric and spiral approaches

The whole curriculum is spread over a number of years. A general treatment of almost all the topics are attempted at the beginning and it is developed in successive years according to the mental development of the pupils. In the beginning of the course, the whole aspect is given to pupils in a simplified way. In the next year more and more details of its parts are added. It follows the maximum of teaching, such as from whole to part, simple to complex, easy to difficult etc. Among educationist of modern times, Burner is the main exponent of the approach is maintained. Sometimes this approach is referred to as concentric approach.

The term "spiral approach" is preferred to the other. The term spiral gives the additional implication that while attempting gradation the linkage too is taken care of and the continuing of the topic concerned is never broken. While conceiving it as concentric only the widening of the scope is indicated but the linkage is not taken care of Spiral approach demands the division of topic into number of small independent units to be dealt with, in order of difficulty suiting the mental capabilities of children. It is based on the principle that a topic cannot be given an exhaustive treatment at one stage. To begin with the elementary concepts are presented in one class, gaps are filled in the next class and more gaps a year or two later, in accordance with the amount of knowledge which the students are capable of assimilating. In spiral approach the entire unit is gradually and successively introduced over the years.



2.2.2 Type study

Materials to be taught are classified into types. A type is that which exemplifiers the characteristics of a group. It is a thing or event considered as an example of a class or group. The types are arranged according to the increasing order of complexity in the syllabus.

Advantages:

● It helps the pupils to make their own generalization from the type.

● It is based on sound psychological principles and gives training inScientific thinking and develops power of observation.

Disadvantages:

● All the content to be taught cannot be classified into types

2.2.3 Integrated approach

It is a curriculum in which subject matter boundaries are ignored, all subjects being taught in a relation to broad areas of study and in relation to one another as mutually associated to some genuine life relation.

It can generally be defined as a curriculum approach that purposefully draws together knowledge, skills, attitudes, and values from within or across subject areas to develop a more powerful understanding of key ideas. Curriculum integration occurs when components of the curriculum are connected and related in meaningful ways by both the students and teachers.

Integrated curriculum is a way to teach students that attempts to break down barriers between subjects and make learning more meaningful to students. In its simplest conception, it is about making connections. The integrated approach aspires to help pupils obtain a coherent view of science by establishing numerous links between the various branches of science. Integrated science integrates the perspectives of subdisciplines such as biology, chemistry, physics, and earth/space science. Through this integration, teachers expect students to understand the connections between the different subdisciplines and their relationship to the real world.

Integrated curriculum requires accessing knowledge from all of the traditional subjects without labelling them as such. In addition, integrated curriculum adds problem-

solving, real-world application and social consciousness to the learning process, making it a more comprehensive way of educating and of learning.

Curriculum integration enables teacher to:

• Identify the connections within and among the content of subject areas

• Provide a relevant context for learning, based on the needs of students

• Assess students' skills and understandings in a variety of learning contexts

• Manage the content of the program of studies more easily because outcomes from different areas or key learning skills are both addressed at the same time and reinforced

• Increases student's motivation and participation.

2.2.4 Disciplinary approach

In stark contrast to the holistic views of science, critics point to the fragmentation of "science" into an array of sub-disciplines or specialties. Integrating the disciplines ignores important philosophical, conceptual, and methodological difference between the basic scientific disciplines. At the high school level of education, however, curriculum in most schools is locked into a strictly disciplinary approach.

2.2.5 Interdisciplinary curriculum

An interdisciplinary curriculum combines several school subjects into one active project or is organized to cut across subject-matter lines, bringing together various aspects of the curriculum into meaningful association. It focuses on broad areas of study since that is how children encounter subjects in the real worldcombined in one activity. In the interdisciplinary curriculum, the planned learning experiences not only provide the learners with a unified view of commonly held knowledge (by learning models, systems, and structures) but also motivate and develop learners' power to perceive new relationships and thus to create new models, systems, and structures. Interdisciplinary curriculum involves using the knowledge view and curricular approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience. In inter disciplinary science curriculum science is treated as one discipline, a combination of separate disciplines such as physics, chemistry, biology.

2.3 SCIENCE CURRICULAR PROJECTS

1. Nuffield Science Teaching Project

2. Physical Science Study Committee (PSSC)

3.Chemical Education Material Study (CHEM study)

2.3.1 Nuffield Science Teaching Project

It is one of the **UK**'s best known charitable trusts established in **1943 by William Morris** (Lord Nuffield) the founder of Morris motors. Nuffield science teaching projects were initiated in England.

Nuffield programme do not provide a highly structured, readymade curriculum with clearly defined behavioural objectives and an elaborate text book. The main purpose was to develop materials that will help teachers to present science in a lively, exciting and intelligible way. The students are expected to learn by inquiry. The teacher has greater freedom to translate and adapt the programme to meet student's needs and systems requirements. The teacher's guide, rather than the student's text represent the real heart of the programme. The course content is treated as molecule, cellular tissue and population level. The main feature of the subject matter is that it focuses the pupils attention on living organisms and not just biological principles. An attempt has been made to link various biological themes. For eg. Population, geneticis and ecology can be considered together.

Objectives:

1. To make science intelligible and accessible to pupils of all kinds in schools of all kinds.
2. To make science a more useful tool, both intellectually and practically.
3. To develop material that will help teachers to present science in lively and exciting manner.
4. To develop and encourage an attitude of curiosity and enquiry
5. To develop programme which is relevant to the world outside the classroom
6. To show science is a carefully woven fabric of three subjects – physics, chemistry and biology
7. The aim is not only to produce a new syllabus but a new approach to teaching.

Study Materials

1. ***Reading material in the form of book***: At the end of each chapter , references are provided for teachers as well as more inquisitive students.
2. ***Films*** **:** a) dealing with processes , b)illustrating experiments ,c)showing the sequence of a teaching of a technique
3. ***Teacher's guide:***
    - It help teachers to make their style of teaching more lively and dynamic
    - The teacher is given a lot of flexibility in carrying out the experiments.

2.3.2 Physical Science Study Committee (PSSC)

The founder of PSSC is Uri Haber Sehaim, MIT, Cambridge, **United States**. The aim of PSSC is to present a view of modern physics to the student. To achieve this aim the committee has devoted its efforts to develop a course involving scientific inquiry on the part of the students, equally important, that the student see physics as an unfinished and continuing activity. Stresses on understanding of facts, how to use them for interpreting more complex physical phenomena.

Objectives:

- To present physics as unified but ever changing subject.
- To demonstrate the interplay between experiment and theory in the development of physics.
- To lead students to recapitulate the process by which knowledge is gained in the first place, rather than merely absorbing what they were told by textbooks and teachers.
- To learn to observe nature closely and to interrogate it,thus learning not only the laws and principles of physics but the evidence on which they are based.
- To extend the capacity of students to read critically.
- To provide foundation for those students who will go for further study in science and technology.

Study Materials

- Text book
- Teacher's guide
- Laboratory experiments

- Films/documentaries
- Achievement test
- Supplementary textual materials
- Simplified low cost apparatus

2.3.3 Chemical Education Material Study (CHEM study)

CHEM study is originated in **1960 by J A Campel** and it is an experimental based course that usually taught in class 11^{th}. CHEM Study was established in 1959 on the basis of a recommendation by an ad hoc committee of the **American Chemical Society**. The project was awarded continuing grants by the National Science Foundation in order to develop an original curriculum in high school chemistry and the materials needed to implement it. CHEM Study still provides videos and films designed to improve the teaching of chemistry at the high school level. A series of 24 videos and related teachers guides and teaching aids specially designed to improve the teaching of high school chemistry, and a correlation chart relating individual videos to specific chapters of the most popular chemistry texts is available from : It uses inductive approach (from particular to general). Experimental nature of science is the basis for student investigation of chemical reactions.

The CHEM study begins with an overview of chemistry an experimental science, followed by some fundamental concepts of chemistry. The course then moves to a macroscopic view of chemical reactions and a microscopic view of substances. CHEM study emphasis on, the structure of chemical systems, including electron structure, the geometrical arrangement of the atoms, their relative size and shapes, the packing together of atoms and molecules, the forces between them and how these affect their chemistry, is expected to guide the student in his understanding and interpretation of the complex chemical formula. After generalizations have been developed through experimentation, the students are expected to continue using what they have learned in interpreting and understanding more complex ideas.

Objectives

- To update chemistry according to the latest development in the project.
- To provide better understanding of the subject for the students.
- To organize content in unifying concepts and principles.
- To create some insight in the field of scientific thinking.

- To provide opportunities for laboratory work not only to supplement the theoretical knowledge but also to facilitate students in exercising scientific and critical modes of thinking.
- To make students aware of the applications of chemistry in everyday life and in industry through a study of topics such as fibers, plastics, elastomers, detergents, drugs and insecticides.

The study materials include:

- Text book
- Lab manual
- Teacher's guide
- Tests
- Films
- Supplementary experiments
- 16mm colour movie films.
- Series of chemistry monographs

Advantages

- It attempts to rectify the drawbacks of the traditional chemistry by updating the content in the light of new discoveries and by giving students opportunities for first land experience in the laboratory
- It has led to improvements in laboratory facilities
- In service training of teachers has raised the quality of teacher
- The students have been able to learn through the heuristic method
- The films have been an integral part of the course.

2.4 NATIONAL CURRICULUM FRAMEWORK (NCF) 2005

NCF or National Curriculum Framework is a document that seeks to present a framework within which schools and teachers can select and plan experiences that they feel all children should have. Earlier the National Council of Educational Research and Training in India had published three National Curriculum Frameworks in 2000, 1988, and 1975. The latest NCF was published in 2005. The document offers a framework for making textbooks, syllabi, as well as teaching practices within the educational programs in Indian schools.

Salient Features of NCF 2005

The five basic principles of National Curriculum Framework 2005 are as follows –

- Connecting knowledge to life outside school
- Ensuring that students do not just learn mechanically, without thinking
- Enriching the curriculum so that it goes beyond textbooks
- Integrating exams with classroom life to make them more flexible
- Nurturing an identity of prime importance informed by caring concerns within the country's democratic polity

NCF primarily focused on –

- Learning without any pressure so that learning turns into a joyful experience, move away from textbooks as a basis for examination, and reduce stress – it suggested significant changes in the pattern of the syllabus.
- To form a sense of self-reliance and individual dignity, which would be the basis of social relations and develop a sense of unity and non-violence across society
- To come up with a child- centered approach to learning, promote universal enrolment and retention up to age 14
- To instill the feeling of unity, democracy, and oneness in students
- P. Naik has described quality, quantity, and equality as the three pillars of the education system in India
- With reference to social context, the recently published curriculum ensures that all schools are provided with a standard framework irrespective of sex, religion, creed, and caste

Development of NCF 2005

- The National Curriculum Framework begins with a quotation from one of Tagore's essays – 'Civilization and Progress' – where the poet reminds us that 'generous joy' and 'creative spirit' are essential in childhood. However, an unthinking adult world can distort both the elements.
- Under the Chairmanship of Professor Yashpal, the National Steering Committee was established
- After much discussion, it was passed in the Central Advisory Board of Education on September 2005

- The national education policy emphasized on employing educational technology to enhance the quality of education
- The policy led to two centrally sponsored schemes – computer literacy and educational technology
- NCF addresses four issues – educational experience, educational purpose, assessing the learner, and an organization of experience
- While the previous NCFs are based on Behaviourist Psychology, the 2005 curriculum has its basis on Constructivist theory
- The latest NCF owes its present form and shape to the swirl of ideas generated through a string of intensive deliberations by renowned scholars from various disciples – parents, teachers, principals, and the NCERT faculty

NCF 2005: The Objectives of Teaching Science

- To obtain skills and understand the processes and methods leading to validation and generation of scientific knowledge
- To form a developmental and historical perspective of science
- To relate to and appreciate global and local issues at the interface of technology, science, and society
- To obtain the theoretical knowledge and as well as practical skills to enter the professional field
- To imbibe certain values – honesty, cooperation, integrity, preservation of the environment, and concern for life – and cultivate critical thinking

2.5 KERALA CURRICULUM FRAMEWORK (KCF) 2007

The curriculum revision programme in Kerala is launched as part of an endeavour to strengthen the Primary, Secondary and Higher Secondary school education in Kerala. The curriculum revision programme in Kerala was conceptualised on the basis of the recommendations of the National Curriculum Framework (N.C.F-2005).The curriculum revision initiated in 1996 in Kerala had a strong influence in the formation of National Curriculum Framework. Kerala could display the active working model of a learning process that has its foundation in the principles of Constructivism and a learner-centred, activity-based and process-oriented pedagogy.

2.5.1 According to KCF aims of education are

- Social justice
- Awareness on environment
- Citizenship
- Nationalism
- Awareness of one's rights
- Awareness of Science and Technology
- Scientific temper
- Cultural identity
- Vocational skills
- Democratic values
- Resistance
- Construction of knowledge
- Critical approach

2.5.2 Aims of science education as in KCF 2007

- development of scientific temperament and its application in daily life
- engagement in scientific methods like observation, experimentation, data collection, interpretation of data, analysis, theorising, examining for construction of knowledge
- nurturing the ability to examine scientifically the problems of daily life as well as social issues and seeking logical solutions
- recognising and developing one's own interests and abilities in technical and vocational fields
- encouraging the development of logical thinking
- imbibing a humanistic outlook and developing a world view based on it
- recognising the importance of understanding historical development of ideas
- nurturing lateral thinking ability for enabling the learners to look at things from different perspectives and to seek new solutions
- developing scientific literacy that provides for building awareness of scientific process

2.5.3 Methods for science learning:

1. Individual learning: Every student fixes a specific aim and works towards the achievement of it.

2. Competitive learning: Students compete with each other and learn.

3. Co-operative learning: Students cooperate and work towards the achievement of a common goal.

2.5.4 Evaluation

- Learners should not be evaluated solely by the written mode of examination. Skills developed by the process of science education including the ability to do experiments should be evaluated
- Tthe relevance of multiple choice questions in evaluating science learning has been widely criticized. They are inadequate to evaluate the higher order mental processes
- Evaluation should give importance to assessing performance in which skills of the hands and the mind are at work
- In science education, it is difficult to separate the process of evaluation from the teaching-learning process

The following areas of science education need to be evaluated:

- Experiments
- The Process Of Experimentation And Observation
- Projects
- Skills That Exhibit A Scientific Temperament
- Attitude
- Outdoor Activities
- Journals
- The Use Of Library
- Co-Operative Tests
- Self-Learning
- Concept Mapping
- Drawings
- Problem Solving
- Research
- Debate/Group Discussions

UNIT III

APPROACHES AND STRATEGIES OF LEARNING PHYSICAL SCIENCE

3.1 Scientific method – steps involved.

3.2 Science a process approach (SAPA).

3.3 Behaviourist approach Vs constructivist approach ; critical pedagogy.

3.4 Inductive and deductive approach of teaching – Mill's canons of induction.

3.5 Communication in science, lecture cum demonstration, problem solving, project method, Heuristic method, historical method, brain storming, group discussion, seminar.

3.6 Graphic organizers, concept mapping, collaborative learning and experiential learning.

3.7 Facilitating learners for self study.

3.8 Models of teaching – concept attainment model and inquiry training model.

3.1 SCIENTIFIC METHOD – STEPS INVOLVED

Scientific method means the method of procedure adopted by scientists in their investigation of natural phenomena, the way in which scientific generalizations are arrived at and made use of. The scientist mostly arise out of the instincts of wonder and curiosity, and they aim at bringing an event or a phenomenon into an intelligent system into which it fits.

Scientific method consists of two process

1. Empirical process – It comprises of observation, experimentation, measurement and manipulation. It is hands on activity.

2. Logical process – Logical process is more important than empirical process, because it is in the minds of scientist that conclusions originate. It is common to all sciences. Logical process is minds on activity.

3.1.1 The steps involved in the scientific method

1. Sensing the problem

The teacher should provide such situations in which the student feels the need of asking some questions. The teacher may also put such questions which require reflective thinking and reasoning for the part of his students and this may become the problem for the students to solve. The setting up of a problem may be a cooperative approach of the student and the teacher.

2. Defining the problem

The students now define their problem in a concise, definite and clear language. There should be some key words in the statement of the problem.

3. Analysis of problem

The students now find out the key words and phrases in the problem which furnish clue to the further study of the problem. The keywords help in finding out the required information.

4. Collecting the data

The teacher suggests references on the problem. The students consult the references and collect evidence bearing upon their problem. It is a good opportunity for the teacher to guide the students in developing a variety of skills and techniques. The teacher calls upon the students to use devices such as models, pictures, field experiments, textbook etc. Which require special techniques and skills.

5. Interpreting the data

This step involves reflective thinking. The students require a lot of practices in interpreting the data. They organize the data by similarity and difference, and plan experiments to answer questions and text ideas. The superfluous data is discarded.

6. Formulate tentative solutions and hypothesis

After data is interpreted and organized, the students may be asked to write down the inferences based on given evidence and to purpose ways of testing out these inferences.

7. Selecting and testing of most likely hypothesis

Selecting the most likely hypothesis out of a number of hypothesis requires special skill and involve analyzing, selecting and interpreting the relevant data, judging pertinence or significance of the data or immediate problem. The students can select the most tenable hypothesis by rejecting the other through discussions and experimentations. The selected hypothesis is again tested experimentally to find out its truth.

8. Drawing conclusions and making generalizations

The tested hypothesis is the conclusion to be reached at. Some demonstrations can be arranged to arrive at the conclusion. The generalization can be made by arranging a set of experiments which also show the same conclusion already reach at.

9. Application of generalization to new situations.

The students should apply the generalization to their daily life. This will bridge the gap between the classroom situation and real life situation. As it is important to start the cycle of reflective thinking with a problem which is interesting and useful to the students, so it is important to close the cycle with application of generalization to new life situation.

3.1.2 Characteristics of scientific method

The scientific method is an elaboration of thought process and its distinguishing characteristics are the following :

1) A problematic situation that finds no ready solution is the starting point of scientific method. Most of the scientific problems are concerned with cause and effect relations and lead to the discovery of new generalisations or laws or even application of known generalisations to new examples or facts.

2) Careful and extensive observation, accurate measurement, critical distinguishing of likeness and differences, and generalisations are necessary to locate and define the problem.

3) Elaborate and deep thinking involving analysis, synthesis, careful methodical inferences and imagination lead to several hypothesis or suggestions of probable solution. All available hypothesis are taken up for consideration without prejudice or personal influence.

4) The implication of each hypothesis are reasoned out logically [eg:- metals expand on heating. Test whether Zn or Cu expands on heating and tested by comparison with facts through observation and experiment. If the derivations from the hypothesis do not agree with observed experiment that fact is rejected. This process is repeated until that suggestion which is in perfect agreement with facts is obtained.

5) The most important characteristic is the tendency to discourage hasty or rash judgement. The scientist subjects his conclusions to repeated, rigorous tests. So the conclusions in science possess a high degree of certainty than those in other fields. Nevertheless the scientist keeps his ideas and generalisations in a semi – fluid state and is always ready to alter or enlarge them in the light of new experiences.

3.2 SCIENCE A PROCESS APPROACH (SAPA)

Science - A Process Approach (SAPA)'s prime assumption is that children need to learn how to do science and this means acquiring the skills essential to learning and understanding science information. These knowledge acquiring skills are called cognitive skills or process skills and are similar to the procedures used by scientists to acquire new knowledge. American Association for the Advancement of Science's Commission on Science Education assumed that a sequential program was necessary for developing a child's intellect. In 1963 a team of scientists, psychologist, elementary teachers and curriculum specialists developed plans and materials for trial versions of what became SAPA.

SAPA is the most structured programme. It's structure arises from behavioural psychology .The underlying psychological assumptions were that any skill can be broken down in to smaller steps and that children need to learn lower-level skills before they can learn more advanced skills. Original version of SAPA developed in to a set of skills to be mastered through a complex, highly structured hierarchy and step-by-step teaching.

SAPA science process skills are divided in to two types ; Basic and Integrated skills .In the primary grades children develop these skills including Observing, Using space / time relationships, Classifying, Using numbers, Measuring etc. In the intermediate grades children

use these skills as a foundation for developing more complex skills like controlling variables, Interpreting data, Formulating hypothesis etc. It is a unique programme that emphasises science skills over content. SAPA's intention is to equip each child with the thinking skills that can be used to solve problems they find in the future.

3.3 BEHAVIOURIST APPROCH Vs CONSTRUCTIVIST APPROACH; CRITICAL PEDAGOGY

3.3.1 Behaviourist approach Vs Constructivist approach

According to behavioural perspective learning can be defined as an observable change in behaviour. Learning is conceived as an incidental event as a result of stimulus-response establishment. Behaviourism explains behaviour by observable experience and not by mental process. According to behaviourism learning is strengthening of desirable responses. Reinforcement is emphasized as determinant of learning. Behaviourism is more a teacher centered model of instruction.

Constructivism is a subset of cognitive perspective, which is more a student centered model of instruction. The hall mark of this model is that the learners actively construct their own knowledge. Constructivism calls for learners to be active. Learners can construct and use memorization strategies on their own. The foundation of constructivist model is the idea that learners bring with them prior knowledge and briefs. Learning builds on what learners have already constructed in other contexts. Collecting and constructing knowledge in the form of conceptual, factual and processing knowledge is the process in constructivist approach. In learning process teachers are better learners and helps learners to change the level of support. Teachers are co-learners and they are scaffolding learners by considering them as little scientists to become autonomous.

In a constructive classroom learning is

1. Constructive
2. Active
3. Reflective
4. Inquiry based
5. Evolving

3.3.2 Comparison between behaviourism and constructivism

Behaviourist approach	Constructivist approach
Knowledge is communicated	Knowledge is constructed
Teacher centered education	Learner centered education
Content oriented approach	Process oriented approach
Learner as a receiver of knowledge	Learner is an active constructor of knowledge
Learning is stimulus-response relationship	Learning is active mental process
Learning is behavior modification and response strengthening	Learning is collecting and constructing of knowledge.ie knowledge acquisition
Reinforcement, punishment, reward make learning effective	Asking questions, problem solving, responsible actions makes learning effective
Teacher's role as a trainer	Teachers role as a facilitator or scaffolder
Learning is imitating and remembering and importance is given to products of learning	Learning discovering, inventing and developing action plans and give importance to process of learning

3.3.3 Critical pedagogy

It is a philosophy of education and social movements that combines education with critical theory that was originated at Brazil in 1972 by Paulo Freire. It is a teaching method that aims to challenging and actively struggling against ant form of social oppression and the related customs and beliefs. Liberation from oppression and human suffering should be an important dimension in education. It focuses on personal liberation through development of critical consciousness

Critical pedagogy provides an opportunity to reflect critically on issues in terms of their political, social, economic and moral aspects. It entails the acceptance of multiples views on social issues and commitments to democratic forms of interaction. This is important in views of the multiple contexts in which our schools functions. A critical frame work helps children to see social issues from different perspective and understand such issues are connected to their lives. Critical pedagogy facilitates collective decision through open discussions and by encouraging and recognizing multiple views.

Critical pedagogy is child centered pedagogy. It facilitates collective decision-marking through open mindedness and by encouraging and recognizing multiple views of the learners. It emphasizes to move beyond authoritative role of the teacher by promoting sharing of power with the learners by encouraging critical thinking and commitment to democratic forms of interaction. It is a pedagogy that takes into accounts the experiences and perceptions of learners and helps them to learner in a fear free and independent form.

Characteristics of critical pedagogy

- It provides the learner with tools to better themselves
- Its approach is issue based or problem based
- It transforms the learner from role of passive listener to active participants
- Transforms the learner from object to subject
- It focused on dialogue instead of a one way transmission of knowledge
- Critical pedagogy argues for an approach to education that is rooted in the experiences of marginalized people.

Role of Teacher in Critical Pedagogy

- The role of teacher is to provide safe space for children to express themselves, and simultaneously to build in certain forms of interactions.
- Teachers need to set out of the role of 'moral authority' and learn to listen with empathy and without judgment, and to enable the children to listen to each other
- While consolidating and constructively stretching the limit of children's understanding, they need to be conscious of how differences are expressed.
- An atmosphere of trust would make the classroom a safe space, where children can share experiences, where conflict can be acknowledged and constructively questioned, and where resolutions, however tentative can be mutually worked out.

3.4 INDUCTIVE AND DEDUCTIVE APPROACH OF TEACHING – MILL'S CANONS OF INDUCTION

3.4.1 Approaches to teaching:

An approach is defined as a way of dealing with a situation or problem. An approach to teaching is a description of how you go about teaching your students. This description includes the sorts of teaching learning activities, the ways you engage students with the subject matter, the ways in which you support your students. An approach is a combination of techniques, methods and strategies to results in better teaching

3.4.2 Primitive philosophical methods

1. Authority

   Answers to the questions are given by head or people with powers. Others follows the opinion of people with more powers.

2. Testimony

   Conclusions are made based on victims words.

3. Analogy

   When two object or phenomena are similar in some respects, we anticipate that they can be similar in other respects also. The recognition of analogy is helpful in apprehending new experiences and suggesting casual relations. The conclusions are arrived by using analogical reasoning.

4. Analysis and synthesis

   Analysis means separating into meaningful parts and synthesis means putting them together. These are extremely important in the study of a phenomenon having plurality of causes and characteristics.

5. Inductive Approach

   Inductive reasoning starts with specific observation leading to generalization. In science it has both empirical and analytical processes. In empirical process it has two methods. i.e. observation and experimentation. The products of these empirical

processes are scientific facts. Drawing inferences from empirical products to logical process is through the method of induction. Through the logical process of induction scientific concepts are developed from scientific facts.

6. Deductive Approach

   The deductive approach emphasizes observing a single instance from a generalized theory. This approach is a move from general to specific.It is top down approach beginning with analytical products to empirical products.

3.4.3 MILL'S CANONS OF INDUCTION

There are two scientific processes in the scientific method. Empirical process and analytical process. All types of argumentation come under the analytical process, that is induction, deduction, authority, testimony and analogy. Inductive reasoning works the other way, moving from specific observation to broader generalization and theories. All inductive inferences are based on two laws:

- **The law of uniformity of nature**:

A phenomenon that takes place in certain circumstances will repeat itself whenever the same circumstances occur. That is nature uniform in her behavior.

- **The law of causation:**

Nothing takes place by sheer chances. Every phenomenon has a cause or a set of causes invariably connected with it.

In complex cases, when there is a plurality of cause, it is difficult to decide which the cause which is the effect is. In such cases, we adopt one of the following five methods known as Mill's canons induction .John Stuart Mill is the first among several others to provide the most systematic analysis of causation, which are presented in the five canons.

The five canons are,

1. **Method of agreement**

"If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon". If in every observed instance of a phenomenon, only

one circumstance is common that circumstance is probably a cause or condition of that phenomenon.

Or in other words "if in every observed instance of a phenomenon only one factor or circumstance is common, then that factor or circumstance is probably the cause of that phenomenon."

Example:

- Suppose that six students – A, B, C, D,E and F went to a debating tournament and subsequently three of them A, B, and C became ill. To find out the cause of illness the doctor might question A,B and C about what food they had eaten and find that every item they had selected differed except for strawberry cream pie. In other words, the only food consumed by all those who became ill was the pie.

- Solids become liquids and liquids to gases under all kinds of varying circumstances, but one element, the presence of heat is common to many of them. This inference is that heat is probably the cause of the change.

2. Method of difference

"If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one(except one), that one occurring only in the former; the circumstance in which alone two instances differ is the effect, or the cause, or an indispensable part of the cause of the phenomenon". Whenever the elimination of a single circumstance is accompanied by the non-occurrence of a phenomenon, that circumstance is probably related to its causation.

Or in other words "Whenever the elimination of a single circumstance is accompanied by the non-occurrence of a phenomenon that circumstance is probably related to the causation."

Example:

- If a surface exposed to air is dry at the atmospheric temperature and it becomes wet on lowering its temperature while other conditions remain unaltered it may be concluded that lowering of temperature is the cause for the wetness of the surface.

3. Joint method of agreement and disagreement

"If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause of the phenomenon".

Or in other words "If in a group of cases in which a phenomenon occurs and there is one and only one common circumstance, while in another group of case in which the phenomenon does not occur and there is nothing in common except the absence of the above circumstance, then the phenomenon is causally related to that circumstance."It is the combination of methods of agreement and difference.

Example

- To apply this method in the above example, the doctor would have to determine not only that strawberry cream pie was the only food that all the students with the illness consumed, but he also would have to question members of the groups who did not become ill – D, E and F. If he found the only item common to those who suffered no ill effect was the absence of pie, he would have strengthened his conclusion was strawberry cream pie was causally related to the illness of the students.

4. Method of Residue

"If part of complex phenomenon is known to be casually related to certain operating circumstances the residual part of the phenomenon must be due to the rest of the relevant circumstances."

Example:

- The density of atmospheric nitrogen(separated from liquefied air)in comparison with that of chemically prepared nitrogen, was found to be different and this finding led to the discovery of the element Argon in atmosphere.

5. Method of Concomitant Variations

"Whatever a phenomenon varies in any manner whenever another phenomenon varies in particular manner, is either a cause or effect of that phenomenon, or is connected with it through some fact of causation" That is if two phenomena vary concomitantly, while all other relevant circumstances remain unchanged, they must be causally related.

Example:

- The change of volume of a given mass of gas is observed to be accompanied by a change of temperature as well as a change of pressure. To decide which of them is the cause or whether both of them are independent causes it is not possible to eliminate either. However each of them might be kept constant and the other varied. The observations thus made reveal the concomitant variation of pressure and volume as also of temperature and volume. Hence it is concluded that both pressure and temperature are causally related to volume.

3.5 COMMUNICATION IN SCIENCE

3.5.1 Lecture-cum-Demonstration Method

It is one of traditional method. This is also known as Chalk and talk method. Teacher centred method. In this method Teacher is active and learners are passive. The essentials qualities in learning science such as independent thinking, power of Observation and reasoning can be developed in this method. . Demonstration method is a teacher- centred method as the teacher demonstrates the pictures/charts/models /experiments and explains the principles, concepts involved in these demonstrated materials or processes.

3.5.1.1 Steps in Lecture-cum-demonstration

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

2) **Introduction of lesson**: The lesson may be introduced on the following basis

- Student's personal experience
- Student's environment
- Telling story

3) **Presentation of the subject matter**

- A simple and interesting experiment
- 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.

3.5.1.2 Advantages of Lecture-cum-Demonstration Method

a) Student participation

b) Save time and effort

c) Helpful to promote useful discussion

d) More efficient method

e) Activity method

f) Useful for all types of students

g) Helpful for teacher

3.5.1.3 Disadvantages of Lecture-cum-demonstration Method

a) The maxim of education, 'Learning by Doing' and the principles of psychology of learning has no place in this method.

b) This method totally ignores the main principle of psychology.

c) Not useful for developing scientific attitude.

d) Speed of experiment.

3.5.2 Problem Solving method

Problem-solving is a process—an ongoing activity in which we take what we know to discover what we don't know. It involves overcoming obstacles by generating hypo-theses, testing those predictions, and arriving at satisfactory solutions. In a problem solving method, children learn by working on problems. This enables the students to learn new knowledge by facing the problems to be solved. The students are expected to observe, understand, analyse, interpret find solutions, and perform applications that lead to a holistic understanding of the concept. This method develops scientific process skills. This method helps in developing brainstorming approach to learning concepts.

3.5.2.1 Steps of Problem Solving Method

i. Sensing the problem

ii. Defining the problem.

iii. Proposing a tentative solution.

iv. Collection of data

v. Organizing data

vi. Deducing conclusion

3.5.2.2 Teacher's Role in Problem Solving

Teacher's has a very important role in Teaching Learning Process. He or She has the duty to provide proper guideline to the students in the completion of their work. Some important roles are given below:

1. Give suggestions not answers

2. Offer a problem solving heuristic

3. Teach a variety of problem solving strategies

4. Allow time for the students to struggle with the problem

5. Choose problems that require time to think through a solution

Merits

- Helps to develop critical, logical and reflective thinking.
- It promote scientific attitude.
- Develop confidence and self reliance in the students.
- Provide opportunity of interaction with community

Demerits

- This method does not suit to all topics
- Need resourceful and expert teachers
- It is a time consuming method.

3.5.3 Project Method

This method is the direct outcome of John Dewey's pragmatic philosophy. In this method of teaching the curriculum and its transaction are considered from the Student's point of view. 'Learning by doing and Learning by living are the two cardinal principles of this

method. Project method aims at bringing out what is in the child and at allowing him to develop himself. The project method takes children out of the class room atmosphere to the realities of actual life –i.e. from academic to practical.

3.5.3.1 Definition

Dr. Kilpatric defined project as. “A whole hearted, purposeful activity proceeding in a social environment.”

According to Stevenson. “A Project is a problematic act carried to completion in Its natural setting”.

Professor Ballard defines it as. “A bit of real life that has been imparted into the school.

3.5.3.2 Principles of the project method

Some of the basic principles of the project method are given below:

- Purpose: The project should be purposeful. Every project chosen should be useful and practicable to the daily life of the pupil.
- Activity: The project should cater to the natural tendency of young boys and girls to engage in activity. The students should be made active both physically and mentally.
- Utility: The experience gained from the project should be useful. Activities undertaken must be completed and the knowledge gained there from must lead to further acquisition of knowledge.
- Freedom: There should be full freedom of the students to work on their own accord.
- Economical: The project should be economical and the purpose of the project should be achieved without any waste of time, money or effort.
- Challenging: The project should be challenging. Psychologists have proved that, students would prefer to do a task which requires reasonable amount of effort.
- Feasibility: The project should be feasible. Before giving final approval to the project, this factor also should be considered.

The project method is a teacher-facilitated collaborative approach in which students acquire and apply knowledge and skills to define and solve realistic problems using a process of extended inquiry. Projects are Student-centred, following standards, parameters, and milestones clearly identified by the instructor.

3.5.3.3 Steps involved in the project method

1. Providing a situation
2. Choosing and purposing
3. Planning
4. Executing the project
5. Evaluation of project

3.5.3.4 Role of the teacher in the project method

Though it appears that the teacher plays only an advisory role, it is nevertheless most vital. The following are expected from a teacher in relation to a project work.

i. Should provide occasions for every student to come forward and contribute

Something towards the success of the project.

ii. Should learn with the students and should not claim to know everything.

iii. Should create and maintain a democratic atmosphere so that the students can

Express themselves freely without any fear or hesitation.

iv. Should be alert all the time to see that the project is running on its right track.

Merits of the project method

1. It is original.
2. It provides a good deal of independence to the pupils.
3. It has practical value. Pupils themselves are given opportunity to solve their problem.

4. This method follows psychological principles.

5. There is no place for the application of rote memory.

Demerits of the project method

1. It is too expensive. It requires lot of money for equipments.

2. Many topics of the curriculum will not yield themselves to project work.

3. In this system, very little time is given for strengthening the experiences. It is because there is no time for practice.

4. There is a good deal of wastage of time.

3.5.4 Heuristic Method

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.

3.5.4.1 Meaning of Heuristic Method of teaching:

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

This teaching strategy is focused on;

1. To develop problem solving attitude.
2. To develop scientific attitudes towards the problem.
3. To develop power of self expression.

Basic Principles

1. To teach as little as possible at one time

2. To encourage learner to learn himself as much as possible.

Primary Objectives

1. Inculcate in the students the habit of enquiry and research
2. Enable him to listen, to observe, to ask and to discover.
3. Make the pupils more exact observant and thoughtful.
4. Lay solid foundation for future self learning.
5. Inculcate the spirit of scientific enquiry

3.5.4.2 Definition

According to H E Armstrong, 'this is the method of teaching which places the pupils as far as possible in the attitude of a discoverer.

Merits

- Psychological methods as the student learn by self practice.
- Creates clear understanding.
- Meaningful learning.
- Student learns by doing so there is little scope of forgetting.
- Develops self-confidence, self- discipline in the students.
- Students acquire command of the subject.
- Gives the students a sense of confidence and achievements.
- Make them exact and bring them closer to truth.
- Inculcates in the students, the interest for the subject and also develops willingness.

Demerits

- Not suitable for lower classes as they are not independent thinkers (discovery of a thing needs hard work, patience, concentration, reasoning and thinking powers, creative abilities)

- Very slow method- time consuming
- Lengthy method
- Students have to spend a lot of time to find out minor results
- Teacher may find it difficult to finish the syllabus in time
- Does not suit larger classes, suits only for hardworking and original thinking teachers
- Successful only if well equipped libraries, laboratories and good textbook written in Heuristic lines, but such facilities are lacking in our school.

3.5.5 Historical Method

The historical method of teaching science developed out of a concern that although each student would not be expected to become a scientist, but each citizen should have some understanding the role of physical science and scientists play in determining public policy and allocating public resources. In this approach, students are exposed to a series of case stories, which attempt to show how context, concept, process and individual creativity of scientists have combined to establish what is known as the 'structure of the scientific disciplines'.

This method if employed successfully gives depth to students understanding because every scientific idea has its own past history. It provides students with the inside story of science from an emotive angle. Even the crude attempts made at forming hypothesis, setting up controlling experiments and narrating inferences can be informative. A resourceful teacher can bridge the gap between present and past knowledge and make the present interesting by recalling past anecdotes.

3.5.5.1 Approaches of historical method

There are several ways of using this method while teaching physical science. In the classroom, the commonly using approaches are;

I. The Anecdotal Approach

- Teacher can start a lesson with an interesting incident or anecdotes from the lives of scientists leading to a particular scientific discovery (Archimedes and Eureka, Newton and Apple).

II. The Biographical Approach

- The complete study of the life history and work contributed by scientists would be really useful to the students.
- It would enable the students to look into their life and project themselves onto the life experiences of scientists.
- They would be able to experience success and frustrations as they learn their biographies and appreciate their hopes and disappointments.

III. The Evolutionary Approach

- Different theories arranged in a chronological order may be presented as they were developed
- Linking the present topic with the historical background – When teaching the lesson on Oxygen we may trace back to the 'Phlogiston theory' anddeal with the contribution of Priestly and Lavoisier. From there on we can reach the modern methods of preparing oxygen and its use in the industry. This approach can be applied to topics like theories of light, or the evolution of classifications of the elements etc.

IV. The Social Approach

- Scientists have often engaged themselves in tackling the problems of immediate importance and interest to the society. The potentialities of Atomic Energy for destruction and peaceful purposes are the best example of science and social relations.

Four Essential Steps involved in doing a Historical Study

- Defining the problem or hypothesis to be investigated.
- Searching for relevant source material-from past.
- Summarizing and evaluating the sources the researcher is able to locate.

- Interpreting the evidence obtained and then drawing conclusions about the problem or hypothesis

Four basic categories:

- Documents
- Numerical records
- Oral statements
- Relics

Merits

- Permits the investigation of topics that could be studied in no other way
- Only historical method can study evidence from the past
- To help people learn from past failures and successes
- When well-designed and carefully executed, historical research can lead to the confirmation or rejection of relational hypotheses

Demerits

- Can only give a fractional view of the past.
- Knowledge is not complete.
- Derived from surviving records of a limited number of past events
- Depends on valuable materials which are difficult to preserve

3.5.6 Brain storming

Brain storming is basically an activity designed to promote creativity. It is a form of discussion which enables the group to do collective creative thinking. The emphasis in brain storming is on eliciting from the students as many different ideas as possible for more careful consideration at a later time.

Brain storming is a group of creativity technique designed to generate large number of ideas for the solution to a problem in a period of time the term was popularized by Alex Faickney Osborn in 1953.

3.5.6.1Stages

1. Warm up : Alternating the members to the topic.
2. Ideation : This stage is of free expression of idea and record the ideas.
3. Evaluation : Ideas expressed as evaluated.

3.5.6.2 Principles

1. Freewheeling : Once started, it should progress like the lubricated. wheel
2. No criticism : Expression and gestures do not reflect a critical attitude.
3. Quantity breeds quality: Maximum number of ideas should be collected

Merits

- It make pupils creative and innovative.
- It give opportunity for pupils for analysing and solving the problems.
- Encourage participation and can be used by all students.

Demerits

- Difficulty in selecting a problem oriented topics.
- Problem of discipline.
- Finding out tentative solutions is challenging.

3.5.7 Group discussion

A discussion is a teaching technique that involves an exchange of ideas with active learning and participation by all concerned. Discussion is an active process of student-teacher involvement in the classroom environment. Discussion allows a student to discover and state a personal opinion perspective, not merely repeat what the teacher or text has already

presented. Besides promoting meaningful personal interaction, discussion promotes a variety of learning, including content, skills, attitudes and processes. It is an appropriate way to improve both the thinking and the speaking skills of students. Four basic concepts are to be considered for initiating small group discussion.

- Process – the interactions that take place within the group
- Roles – each group member's specific responsibilities within the group
- Leadership – the capacity to guide and direct others in a group setting.
- Cohesion – group members' support for one another

3.5.7.1 Principles

- Active participation
- Freedom for work
- Group work and equal opportunities to ask questions and to answer them.

Procedure

- Teacher can introduce a topic. Then questions can be asked, with other facts supplied as they are needed.
- Students can be called upon by a teacher to give the facts to get a discussion started.
- Students or teacher can prepare outline of point co-operatively to be discussed as basis of discussion.
- Students can describe their own experiences.
- Some special papers on topic under discussion can be used to add extra facts
- Importance of audio-visual aids for starting discussion is very great.

Preparation

Teacher should first introduce the topic and may read out the method purposefully and critical points need to be arranged in a sequence logically.

Discussion

- Face to face talk should be arranged.
- Discussion should conduct in a disciplined manner.
- Adequate data has to be presented.

3.5.8 Seminar

Seminar is a teaching technique for higher learning. A specific subject or topic is delivered as an article or report in the seminar. The article and its concepts submitted in the seminar are analyzed and discussed through group discussion to arrive a final decision or concept.

3.5.8.1 Aim and objectives

Cognitive objectives :

- To develop higher cognitive abilities.
- To develop the ability of responding in this manner would involve higher cognitive actions.
- To develop the ability of keen observation of experience, feelings
- To develop the ability to seek clarification and defend the ideas of others effectively.

Affective objectives :

- To develop the feeling of tolerance to the opposite ideas of others.
- To develop the feelings of co-operation with other colleagues and respect of the ideas and feelings of others.
- To develop the emotional ability among the participants of the seminar.
- To acquire the good manners of putting questions and answering the questions of others effectively.

3.5.8.2 Basic principles to be included in the seminar

- This seminar method depends with the lingual, social and emotional instances and its maturity level.

- The complex and undefined concept or article must be read and discussed for themeaningful learning experiences and new concept.

- Group discussion is emphasized. The kernel of seminar is stressed.

- The value and success of the seminar depends on the path of the learner and their learning experiences through the discussion. The learner can advocate and interact in group discussion with his experiences and concept derived. Both the group and learner can transform their ideas and to derive a new conclusion also be anticipated.

- In the lower level of learning experiences the concepts are explanatory but in this higher level of learning experience the theme or concept cantered and need more evidences and explanations through the discussion.

- The interactions in this method develop observation and questioning skills, evaluation skills using their own learning experience.

3.6 GRAPHIC ORGANIZERS, CONCEPT MAPPING, COLLABORATIVE LEARNING AND EXPERIENTIAL LEARNING.

3.6.1 GRAPHIC ORGANIZERS

Graphic organizers are visual representation of knowledge that structures information by arranging important aspects of a concept or topic into a pattern using labels (Bromley, DeVitis & Modlo, 1999). Their main function is to help present information in concise ways that highlight the organization and relationships of concepts.

A graphic organizer also known as a knowledge map, concept map, story map, cognitive organizer, advance organizer or concept diagram is a communication tool that uses visual symbols to express knowledge, concepts, thoughts or ideas and the relationship between them. The main purpose of a graphic organizer is to provide a visual aid to facilitate learning and instruction. Graphic organizers helps students to organise ideas, see relationships and retain information. It facilitates effective student learning via organising concepts, idea and facts graphically.

Graphic organizers take many forms:

1. Relational Organizers
    a. Story board
    b. Chart
2. Category/ Classification Organizers
    a. Concept mapping
    b. Mind mapping
3. Sequence Organizers
    a. Chain
    b. Ladder
    c. Cycle
4. Compare contrast Organizers
    a. Dashboard (business)
    b. Venn diagrams
5. Concept Development Organizers
    a. Circle chart
    b. Flow chart

3.6.1.1 Reasons for Using Graphic Organizers

- Tools for critical and creative thinking

Graphic organizers help students focus on what is important (Bromley, DeVitis and Modlo, 1995) because they highlight key concepts and vocabulary, and the relationships among them, thus providing the tools for critical and creative thinking.

- Tools for organizing information

The human mind organizes and stores information in a series of networks (Ausubel, 1968). Graphic organizers are visual depictions that resemble networks and allow students to add or modify their background knowledge by seeing the connections and contradictions between existing knowledge and new information.

- Tools for understanding information and relationships

Graphic organizers serve as mental tools (Vygotsky, 1962) to help the students understand and retain important information and relationships.

- Tools for depicting knowledge and understanding

Graphic organizers provide an optional way of depicting knowledge and understanding (Sorenson, 1991), so it is particularly beneficial for students who have difficulty with expressing relationship among parts of economic concepts in written word.

- Tools for self-learning

Students who use graphic organizers in the classroom develop their ability to use them independently as study tools for note taking, planning, presentation, and review (Dunston, 1992). In other words, graphic organizers are beneficial to students learning inside and beyond classrooms.

3.6.1.2 Specific Benefits to Students and Teachers:

Graphic organizers enable teachers to show and explain relationships between content and sub content and how they in turn relate to other content areas. On the other hand, through the use of the organizers, students can make more abstract comparisons, evaluations, and conclusions. In short, graphic organizers allow students an active role in their learning.

3.6.2 CONCEPT MAPPING

A concept map or conceptual diagram is a diagram that depicts suggested relationships between concepts. It is a graphical tool that instructional designers, engineers, technical writers and others use to organize and structure knowledge.

A concept map typically represents ideas and information as boxes or circles, which it connects with labelled arrows in a downward- branching hierarchical structure. The relationship between concepts can be articulated in linking phrases such as causes, requires,

or contributes to the technique for visualizing these relationships among different concepts is called concept mapping. A concept map is a way of representing relationships between ideas, images, or words. Each word or phrase connects to another, and links back to the original idea, word, or phrase. Concept maps are a way to develop logical thinking and study skills by revealing connections and helping students see how individual ideas form a larger whole.

3.6.3 COLLABORATIVE LEARNING

Collaborative learning is a personal philosophy, not just a classroom technique. In learning situations where pupils come together in groups, it suggests a way of dealing with pupils which respects and highlights individual group members' abilities and contributions. The underlying premise of collaborative learning is based on consensus building through co-operation by group members, in contrast to competition among group members. Collaborative learning involves the development of collaborative communities, where groups or pairs of learners interact to learn and solve authentic problems, fosters constructive learning.

Collaborative learning advocates distrust structure and allow students more in forming friendship and interest groups. Student talk is stressed as a means for working things out. Interaction with peers and teachers supports question refinement and reflection, promotes a shared discourse and establish a learner culture, which fosters co-operation and mutual interdependence.

Steps in collaborative approach:

1. Identification of the problem to be discussed
2. Formation of groups facilitate by both teacher and students
3. Sharing of ideas – performance of activities or experiments in groups
4. Teacher facilitates the interactions directed towards the set goal within stipulated time frame.
5. Learning evidences are assessed throughout the teaching long process and feedback is provided to all groups of learners.

Fundamental Elements:

- Positive interdependence
- Individual and group accountability
- International and small group skills
- Face to face primitive interaction
- Group processing

Collaborative activities:

- Group discussions
- Brainstorming
- Debates
- Group projects
- Class room problems
- Jigsaw activity
- Role play

DIFFERENCE BETWEEN COLLABORATIVE AND CO-OPERATIVE LEARNING

In co-operative learning the centre of authority is teacher and the group is held responsible for collective learning. The collaborative learning encourages self governance, shouldering responsible according to interest and skill. The co-operative learning can be used when a task can be done by one way only.

Benefits

- Develops higher level thinking skills
- Promotes student – faculty interaction and familiarity
- Increases student retention
- develops oral communication skills
- Encourage diversity understanding

- Creates an environment of active involved, exploratory

Demerits

- A burden is making the students responsible for each other's learning apart from themselves
- One study showed that in groups of mixed ability, low- achieving students become passive and do not focus on the task.
- Depending on an individual's motivation and interest on a particular subject that will determine how well they would learn.

3.6.4 Experiential learning

Experiential learning is the process of learning from direct experiences. However, experiential learning is not just a fieldwork or connected with learning from real-life situations. It is a theory that defines the cognitive process of learning, emphasising the importance of developing four kinds of abilities, viz. concrete experience, reflective observation, abstract conceptualisation and active experimentation where a learner encounters some experiences. These four stages are suggested by Kolb & Fry (1975).

Concrete experience is followed by reflection on that experience on a personal basis. This may then be followed by the derivation of general rules describing the experience, or the application of known theories to it (abstract conceptualisation), and hence to the construction of ways of modifying the next occurrence of the experience (active experimentation), leading in turn to the next concrete experience. All this may happen in a flash, or over days, weeks or months, depending on the topic. This complete process allows one to learn new skills, new attitudes or even entirely new ways of thinking.

Abilities of an experiential learner

Based on the four stages of his model, Kolb argues that effective learning necessitates the possession of four different abilities on the part of the learner.

1. Willingness to get actively involved in the experience.
2. Has ability to reflect on the experience.

3. Possesses decision-making and problem solving skills in order to use new ideas gained from the experience.
4. Possesses and uses analytical skills to conceptualise the experience.

Role of a facilitator

An effective experiential facilitator is one who is passionate about his or her work and is able to immerse learners totally in the learning situation, allowing them to gain new knowledge from their peers and the learning environment created. The facilitator stimulates the imagination, keeping learners hooked to the experiences.

3.7 FACILITATING LEARNERS FOR SELF STUDY

Self Study is defined as something studied by oneself without any kind of help or supervision by a teacher or a trainer, though the person studying may take help of some external sources like books, tutorials, and encyclopedia etc, hence it would not be wrong to say that it is a form of study in which the student himself is responsible to a large extent for his one's own instruction and is himself his teacher.

Advantages of Self Study

- Helps the students to broaden their thinking level.
- Freedom of learning without any restriction.
- Self-learning would enable the learner to limit the number of interests undertaken.
- Self-learning is more fun than regular teaching.
- Student tends to build a sense of responsibility and they start accepting responsibility.
- Self-learning means that you can read different interesting new books, rather than boring notes by teachers or textbooks.
- You can make study material of your own.
- No fear of criticism.
- You may learn at your own desired time according to your schedule.

- Self-learning students tend to retain more naturally when they do the work themselves, as compared to the regular teaching where teacher's spoon feed the information into them.
- Self-learning gives an opportunity to the enthusiastic people to go as deeply into a subject and interact with the subject matter as deeply they would like to go.
- With the self-learning, there is a great opportunity to develop a good work ethic.
- Gives self-confidence and a good feeling of doing a job well
- Student performs well in tests because they are already used to tackling problems on their own, which increases their confidence.

In order to promote self study:

- Choice - Not every student is the same kind of learner, so try giving them multiple options when assigning projects. This shows that you respect their unique learning style. It also shows that you're more interested in facilitating their learning than exercising your authority.
- Variation - Vary class activities to give students the ability to try out different learning styles, and to give each student their moment to shine. It also will help them to choose their approach to assigned projects.
- Connection - Give context for each lesson, and show how it relates to other things your students might be learning or experiencing. Tie the material in to other lessons, classes, subjects, current events, or real-life examples. Tell them why the lesson is relevant to their lives and why it should matter to them.
- Conversation - Learning how to problem-solve is just as important as knowing the answer, so give students time to talk through a problem in small groups or as a class. Conversation also promotes communication skills, socialization, and cooperation.
- Resources - Today's students have access to a lot more information than the students of previous generations. The real challenge is teaching them how to assess the quality and validity of the information they find. Provide students with resources they can trust, and tools for gauging trustworthiness.

10 Tools Used to Facilitate Learning Strategies

1. Facilitate class, group, and one-on-one discussions and debates.
2. Allow students to call on one another for answers, rather than the instructor.
3. Ask questions that don't have one single answer. Leave it open-ended.
4. Role play different scenarios or play games to illustrate lessons.
5. Create multimedia presentations, utilizing technology your students use at home.
6. Record and post lessons and resources online for students to reference later.
7. Use guest teachers and speakers to show a different perspective.
8. Supplement lessons with virtual field trips or projects that involve field research.
9. Collaborate with other teachers to teach related lessons in different subjects.
10. Have students explain what they learned to someone who doesn't know the material.

When teachers facilitate learning, they also facilitate career success. Creative, imaginative, and problem-solving skills are becoming increasingly valuable, as well as the ability to think critically and analyze information. Supporting and encouraging students to learn for themselves is providing them with tools they'll benefit from for the rest of their lives.

3.8 MODELS OF TEACHING/LEARNING – CONCEPT ATTAINMENT MODEL & INQUIRY TRAINING MODEL

Models of Teaching are really models of learning. As we helps students acquire information ideas skills, values, ways of thinking, and means of expressing themselves, we are also teaching them how to learn. In fact the most important long term outcome of instruction may be the student’s increased capabilities to learn more easily and effectively in the future ,both because of the knowledge and skills they have acquired and because they have mastered learning processes. And it also help teachers to become more effective and efficient.

Families of models of teaching

The most comprehensive review of teaching models is that of Joyce and Weil (1980). Bruce R. Joyce has divided all the teaching models under the title "Modern teaching models". They identified 23 models which are classified into four basic families based on the nature, distinctive characteristics and effects of the models.

These four families are:

1. Information Processing Models

The models of this type are concerned with the intellectual development of the individual and help to develop the method of processing information from the environment. These models focus on intellectual capacity. They are concerned with the ability of the learner to observe, organize data, understand information, form concepts, employ verbal and nonverbal symbols and solve problems.

The models which belong to this family are:

a. The Concept Attainment Model

b. Inquiry Training Model

2. Personal Models

Personal development models assist the individual in the development of selfhood, they focus on the emotional life an individual.

The emphasis of these models is on developing an individual into an integrated, confident and competent personality. They attempt to help students understand themselves and their goals, and to develop the means for educating themselves.

3. Social Interaction Models

The models in this family emphasize the relationships of the individual to the society or other persons. The core objective is to help students learn to work together to identify and solve problems, either academic or social in nature.

4. Behaviour Modification Models

All the models in this family share a common theoretical base, a body of knowledge which referred to as behaviour theory. The common thrust of these models is the emphasis on changing the visible behaviour of the learner.

Elements of the models

- Focus - It is the main point in a teaching model; simply it is an objective and tells about what is the reason for teaching a particular topic in the class room.
- Syntax – Syntax refers to the phases or the stages as to how it begins and what the sequence of activities is. These sequence are unique to specific models.
- Social system – It describes the role of students and the teachers, and the relationship between them.
- Principle of reaction - It is the reaction or mode of a teacher when a learner respond to a particular thing.
- Support system – It refers to additional requirements beyond usual capacities and technical facilitating necessary to implement model.

  Eg: books, encyclopedia, video clips, slides, films etc.
- Instructional and Nurturant Effects

3.8.1 CONCEPT ATTAINMENT MODEL

This model has been developed, based upon the studies made by Jerome S. Bruner and his associates Jacqueline Goodnow and George Austin, mainly about the nature of concepts and the strategies of concept formation. Concept attainment is a structured inquiry process to help bring meaning to new concepts by highlighting similarities and differences. Students determine the attributes of a concept by comparing like examples and contrasting them with non-examples provided by the teacher.

Concept: They are mental organizations about the world,that are based on similarities among objects or observations or events. concepts do not really exist in reality.

Eg: solids, bird, water etc.

Elements of a concept:

- Name of the concept - it is the word that describes a concept for communication

Eg : acid, pollination, parasite etc.

- Definition of the concept – used to describe a concept on the basis of the essential attributes

- Attributes of the concept (essential and non essential) – features or characteristics on the basis of which a no. of items could be categorized into a particular group or class that represents the concept.

Eg: for the concept of pollination ,pollen grains and falling of them on stigma are essential attributes , but the no. of pollen grains, nature of stigma etc. are not essential attributes .

- Examples of the concept –Are instances or items that could be observed and studied in the process of categorization. These may include items that are positive examples that obey all the essential cues used for categorization leading to the concept as well as negative items or non examples that do not satisfy all the cues of a positive example,but are needed for making the grouping meaningful.

Eg: to make the concept of parasite clear ,independent organisms and non parasite climbers may be presented as negative examples.

3.8.1.1 Description of the model

A). Focus

1. To enhance long term learning

2. Enable students to develop a habit of analysis through inductive reasoning

B). Syntax

Phase 1. Presentation of data and identification of concept . Teacher presents labelled (as yes or no) exemplars; students compare attributes and generate hypotheses; attempts a definition.

Phase 2. Testing the attainment of concept. Students classify unlabelled examples as yes or no. Teacher confirms hypothesis, gives the name and helps arrive at the restatement of the definition. Students generate more examples.

Phase 3. Analysis of the thinking strategies . The pupils recollect how they attain the concept.

C). Social system

Teacher carefully prepares in advance exemplars and no exemplars and labels them and sequence them. At this stage the teacher controls actions and as such the social system is highly structured. but gradually, in the subsequent phases student interaction is encouraged . Thus the social system becomes moderately structured and also low structured. Even then the teacher intervenes if necessary. Thus the nature the structure goes on changing.

D). Principles of reaction

The teacher acts as a guide, motivator, facilitator, etc. He supports the pupil's hypotheses and creates an atmosphere of meaningful dialogue . Again becomes supportive at the final phase. Encourages different strategies.

E). Support system

The success of a lesson for concept attainment depends up on presentation of appropriate examples /non examples. That acts as the most essential support system. A free atmosphere that promotes active participation also becomes essential.

F). Instructional and Nurturant Effects

1. Instructional effects:

i. Getting clear notions about nature of concepts

ii. Developing skills in using appropriate concept – building strategies

iii. Attaining the specific concepts

iv. Develops skills in inductive reasoning

2. Nurturant effects

i. Sensitivity to logical reasoning

ii. Tolerance of ambiguity and initial errors

iii. A sense of using alternative perspectives

3.8.2 INQUIRY TRAINING MODEL

Inquiry training model is designed to bring students directly into the scientific process through exercises that compress the scientific process into small periods of time. Inquiry training was developed by Richard Suchman to teach students the art of of independent inquiry in disciplined way. The general goal of inquiry training is to help students develop the intellectual disciplines and skills necessary to raise questions and search out answers stemming from their curiosity.

The inquiry training model is based on the fllowing assumptions :

a) All knowledge is tentative

b) There cannot be one answer to particular cause and effect question

c) People inquire naturally when they are puzzled

d) The process of inquiry can be taught to students

e) Students can become conscious of and learn to analysis their thinking strategies .

f) Team approach is better than the individual approach to find solutions to a problem

3.8.2.1 Description of the model

A). Focus

The inquiry training model has following goals.

1. To enhance the thinking ability of the student.
2. To enable them to form conclusions based on facts.
3. To enable them to have fluency in their thinking and speaking.
4. More speciality to impart training of inquiry skills.

B). Syntax

Phase 1. Encounter with the problem

Teacher explains inquiry procedures

Teacher presents discrepant event

Phase 2. Data gathering: Verification

Learners verify the nature of objects and conditions

Learners verify the occurrence of the problem situation

Phase 3. Data gathering: Experimentation

Learners with the help of the teacher search for related data and isolate relevant ones with a view to find out relations

Learners hypothesize (and test)causal relationships

Phase 4. Formulation of explanation

Learners formulate rules or explanations as solution to the descripant event

Phase 5 . Analysis of the inquiry process

Analysis inquiry strategy and develop more effective ones.

C). Social system

The social system is an important element of this model. Here both teacher and students play a significant role in teaching learning process. The success of this model depends on mutual cooperation between teacher and the student

D). Principle of reaction

Ensuring that question are framed so that they can be answered by “yes” or “no”. Following points should be kept in mind:-

1. Asking students to refresh the questions
2. Encouraging the students to give a clear statement.
3. Neither approving nor rejecting students theories.

4. Encouraging interaction among students.
5. Using the language of the inquiry process.

E). Support system

While working with Inquiry Training Model, a teacher requires additional support in the form of

1) A set of confronting the material
2) Technical understanding of the intellectual process and strategies of inquiry.
3) Teacher may require resource material related to the problem.

F). Instructional and Nurturant effect

1. Instructional effect

I. Scientific process skills
II. Strategies for creative enquiry

2. Nurturant effect

I. Spirit of creativity
II. Autonomy in learning
III. Tolerance of ambiguity
IV. Tentative nature of knowledge

The skills needed for training inquiry

1. Designing the discrepant event
2. Presenting the discrepant event
3. Guiding pupils to account for the discrepancy
4. Explain the rules of the inquiry process
5. Guiding and handling verification questions

6. Guiding and handling experimentation questions
7. Guiding interaction among students
8. Guiding theory building
9. Guiding the review of the steps of inquiry process
10. Guiding the analysis of the thinking process

UNIT IV

EXPLORING LEARNERS

4.1 LEARNING AS A GENERATIVE PROCESS

Learning is the modification of behaviour as result of experience. The child brings changes in his behaviour after gaining experiences from the environment. As a result of studying and analysis of the various definitions by psychologists and educationists, the following facts come to the light:

1. Learning is a modification in behaviour.
2. Learning is the organization of behaviour.
3. Learning is the confirmation of a new process.
4. Learning can be termed as a mental process.

Learning occurs when learners are both physically and cognitively active in organizing and integrating new information into their existing knowledge structure. The process of

generating relationship among new and existing knowledge leads to meaning making that leads to deeper understanding of the content.

Generative learning process has four components

1. Motivational process
2. Learning process
3. Knowledge creation process
4. Generation process

Generative learning is therefore the process of constructing meaning through generating relationships and associations between stimuli and existing knowledge, beliefs and experiences.

Learner as a little scientist

- Children have an inbuilt drive for discovery. Encourage your child to observe the world and to feel a sense of wonder for everything in it.
- Maria Montessori believed that all children behave like “little scientists” in that they are eager to observe and make “what if” discoveries about their world.

The national curriculum for science (2007) placed greater emphasis on the way scientists work. This aims to develop skills and attributes of scientists in students.

- These include observational and measuring skills, the ability to use and select resources, analyze data, spot patterns if they exist and communicate their findings to others effectively.
- The NCF increasingly emphasizing on risk assessment, group working, and using secondary resources, and asks pupils to communicate the way of presentations and discussing and again mirroring how scientists work.
- Pupils should be allowed to develop skills like creativity, research, enterprise and communication.
- They need an appreciation of how scientists work and the limitations of what science can do.

- The science teacher needs to develop the practical and investigational skills in students that are intrinsic to scientists.
- This is the challenge to new science teachers in the coming decade and beyond.

4.2 ENCOURAGING LEARNERS TO RAISE QUESTIONS

- Science involves several process skills, in that raising question is one of the most valuable skills.
- NCF 2005 emphasizing the importance of equality and equity in classroom condition. Which provides fearless, secure atmosphere for students to raise questions.
- Also such an environment creates self confidence, self esteem and improves the quality of learning themselves.

Strategies to encourage learners to raise questions;

- Welcome and value each and every question.
- Acknowledge their question as very good, interesting, intelligent, you are thinking, you are creative etc.
- Provide equal opportunities for all.
- Familiarize them with the fact that asking good question requires thinking and knowledge.
- Provide hint for difficult problem.
- Neglect readymade answer getting situation.
- Creating the habit of listening to learners.

Appreciating dialogue among peer group;

- Raising question leads to dialogue among peers.
- Dialogue is an important class room tool, which can be used to focus on a problem and has a potential to inculcate interest among learners and encourage them to open up for discussion and argumentation.

- Which develops bonding among learners that provides foundation for collaborative learning, negotiating ideas and other life skills.
- Dialogue may be structured & unstructured
- Here they collect previous knowledge and learn how to express their opinions.
- Here guidance of teacher is important to remain focused on issue.
- Here teacher empowers the learner through conversation which makes them think analytically.
- Formulates multiple point of view through social interaction
- Vygotsky's view that learning is a complex activity. And learner learns lot when they interact with their environment.

Ensuring equal partnership of learners with special needs

To explore the world through discussion and raising questioning the teacher needs to encourage all little scientists (both normal and special needed learner)and ensure their equal participation in classroom activities.

Equal opportunity for learners with special needs;

- There are other sections/groups of students whose needs are unique.
- This is a specialized area and techniques of teaching need to evolve in consultation with the concerned experts.
- The system should display the courage of conviction to mobilize required resources to put in place support systems that will help these children to overcome their inadequacies in learning science in a meaningful manner.

For the fulfillment of learners with special needs teacher can do:

- Maintain an organized classroom
- Breakdown instruction into smaller , manageable tasks
- Use multi-sensory strategies

- Give students with special needs opportunities for success
- Teacher must have patience , organization , creativity , acceptance , intuitive and calming nature , good sense of humor , true love of children.

4.3 ENCOURAGING STUDENTS TO COLLECT LOCAL RESOURCES

Children construct knowledge through different experiences from inside or outside of school and home. Learners get interest in learning when teacher plan suitable activities properly. Teacher can provide many situations where learners can collect materials from their local resources and to develop suitable activities with the help of teacher. Human resources, Material and non material resources, Digital resources, Animal and plant resources etc are some of the locally available resources. Some activities for encouraging the students to collect resources are:

- Developing a science corner in school
- Organizing field trips
- Arranging for bulletin board or wall magazine
- Developing improvised aids
- Maintaining a scrap book
- Taking up a project
- Making static and working model
- Conducting exhibitions
- Formation of science club

Through these activities, teachers can generate interest in learners and motivates them to collect relevant materials and information from their surroundings. For the completion of all these task/activities, students can collect resource materials like:

- Sheets and wires, torch cells, colored stones, bottles, dropper, syringes without needle, small bulbs, thread, Balloon, ball, stick, straw, soil, water, fiber, toys, magnet etc

- Students can collect stamps with pictures of scientists, current issues and related cuttings (inventions, discoveries, phenomena, history of science) from magazine, newspaper, internet, books etc

4.4 STIMULATING CREATIVITY AND INVENTIVENESS IN SCIENCE

Creativity is the emergence of a novel, relational product growing out of the uniqueness of the individual. It is related with critical thinking and higher order cognitive skills. Stimulation of creativity and inventiveness have much importance in the field of science. Creative thinking enables the learners to explore available alternatives and consequences of actions and contributes to decision making and problem solving. Fundamental qualities of creativity:

- Fluency
- Flexibility
- Originality
- Elaboration

The teacher can take following steps to foster creativity and inventiveness among his students:

1) Divergent thinking develops creativity. So encourage the children to think about as many ideas as they may for the solution of the problem
2) Originality on the part of the children in any form should be encouraged
3) Appropriate opportunities and atmosphere for creative expressions should be provided in the school.
4) Develop healthy habits like industriousness, persistence, reliance and self confidence in children.
5) Artistic expression gives an opportunity to originate new ideas. Schools can develop creativity through artistic expression by providing materials.

6) Students should be given full freedom for the development of their imagination because imagination helps in the development of creativity which can led to new inventions

There are special techniques for fostering creativity and inventiveness in children:

a) Elaboration

b) Brain storming

c) Synectics

d) Debate and Discussions

4.4.1 Nurturing creative talent at the local level and exploring linkage with the District/ State / Central agencies

Creativity is the crucial 21th century skill which we will need to solve every day life problems. Along with the science activities at the school or local level, launch large scale science and technology fair at the national level for college students, with feeder events at local/district/state levels with the objective of searching and nurturing inventive/creative talents among students. Incorporate experiments/ technological modules and other parts of co-curricular components into the textbook as far as feasible, which should be subjected to internal assessment. Other co-curricular components should be encouraged through non formal channels. These can create curiosity, excitement and exploration among school children in science mathematics and technology. Some of the innovative programmes for nurturing creativity are:

- **National Curricular Framework (NCF)**

It recommends science education should nurture natural curiosity, aesthetic sense and creativity of the child in science and technology. Implementation of various curricular activities through a massive expansion of non formal channels such as organization of science exhibitions at the national level for school student with the events at school/block/district/region/state levels.

- **Kerala State Council for Science Technology and Environment (KSCSTE)**

KSCSTE provide financial assistance to the students of university departments and colleges in Kerala to carry out scientific projects.

- **RashtriyaAvishkarAbhiyan (RAA)**

RAA developed by ministry of human resource development for the age group of 6-18 years. This is a convergent framework for nurturing creativity and spirit in science and mathematics.

- **Jawaharlal Nehru National Science Exhibition for Children (JNNSEC)**

NCERT New Delhi organizes JNNSEC every year for popularizing science among children, teachers and public. This exhibition is culmination of various exhibition organized in the previous year by the states UTs and other organizations at district, regional and finally at the state level.

UNIT V

PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS

5.1 Professional development programmes for science teachers

5.2 Participation on Seminar, Conference, Online sharing, Membership of professional organizations

5.3 Teacher as community learners, Collaboration of schools with universities

5.4 Role of reflective practices in professional development of teachers.

5.5 Teacher as a researcher: Learning to understand how children learn science.

5.1 PROFESSIONAL DEVELOPMENT PROGRAMMES FOR SCIENCE TEACHERS

5.1.1 Need for Professional Development Programmes

Responsibility of a science teacher is not just the teaching-learning of a particular subject to learners in the school, but also helping them in their all-round development of personality. As a teacher, one has to understand and explore the learners to provide conducive environment for learning and suitable learning experiences. Thus, ***pre-service training*** is needed to empower student-teachers in facilitating learners for their,

- intellectual development;
- emotional development;
- behavioural development;
- physical development; and
- social development.

It is observed that there is a difference in the skills and attitude of the teachers who have received proper training as compared to those who have not received it. If a teacher is trained, she can design effective teaching-learning experiences considering individual differences.

Though the pre-service professional training is very important, they need***in-service professional training***.

- She has to ***think creatively*** for context-specific examples and to come up with the innovative ideas for using local resources to provide meaningful teaching-learning experiences in physical science to the learners.
- ***New developments in science*** and pedagogy of physical sciences are occurring continuously. Unless teachers are facilated to keep themselvesabrest of these developments, they are bound to show resistance to new ideas no matter how sound they look to educationists. Therefore, in-service training programme is conducted by many organisations and institutes that can contribute significantly to the professional development of new teachers as well as experienced teachers.
- Science teachers also need to keep track of developments in other curricular areas so that they can adopt ***integrated approach*** and provide holistic learning experiences to the learners.
- ***Local indigenous knowledge and practices*** in the local area are important to consider in the training of teachers. In order to make generalised knowledge relevant and meaningful, school knowledge should be connected to local knowledge.
- The teacher should continuously improve her skills in development of ***teaching aids, science kits, improvised apparatus; laboratory work;***
  writing better test items; continuous and comprehensive assessment of learners and how to:
    - create and organise constructivist learning situations such as observation, collaboration, multiple interpretation, etc.
    - move beyond textbook and classroom; and
    - engage learners to reflect, analyse and interpret in the process ofknowledge construction, etc.
- In-service training provides opportunity to the participating teachers to ***work collaboratively***; share ideas, thoughts and experiences on learning resources,

activities, experiments and strategies of transaction of different concepts. All these requirements make continual in-service training important for teachers.

- Science teachers also need to ***understand the problems of students having special needs*** such as:
    - **Dyslexia i**s the difficulty to write and read, however students with this problem may be smart at other skills.
    - **Dyscalculia** is the problem associated with numbers. They interchange the places of digits. This makes it difficult for childrento learn mathematics.
    - **Dyspraxia** is characterised by lack of or poorly developed skills in skilled tasks like typing, sewing, etc.

Helping such children and instilling in them a sense of confidence is essential for the development of these children and to help them lead a successful life. Science teachers have to be sensitive to the needs of these diverse groups of learners.

5.2 Examples for Professional Development Programmes

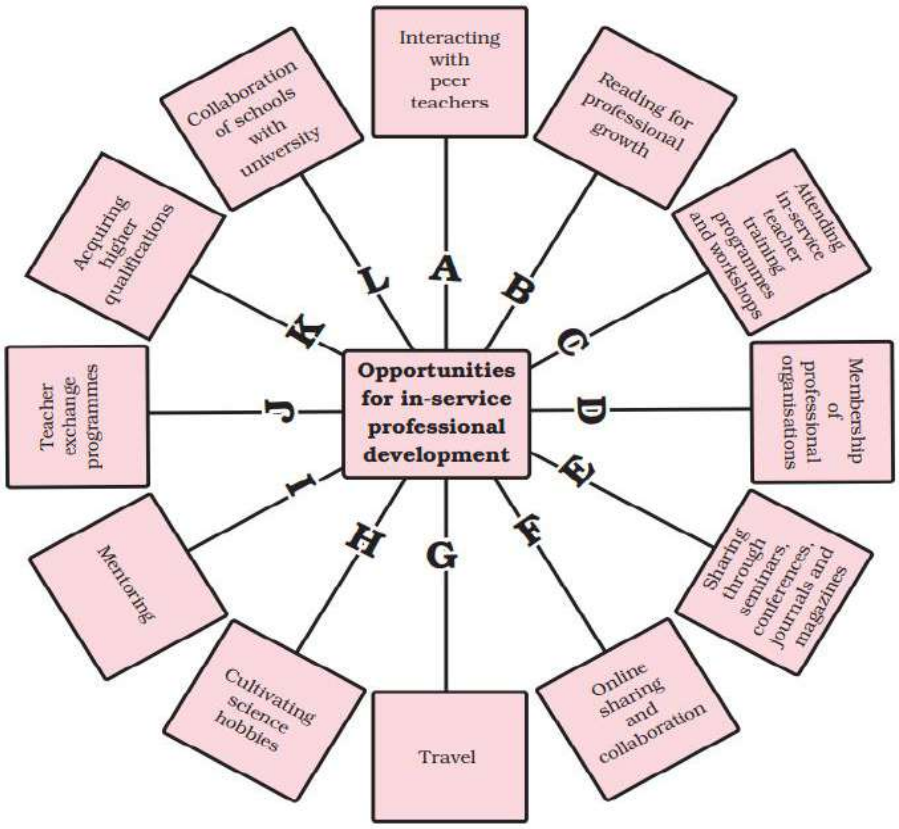


Fig. 5.1 Some opportunities for in–service professional development

5.2.1 Participation in seminars&conferences

Participation in seminar, conference and course will increase the subject knowledge and subject content. And also it helps to create a different attitude towards subject making new approach to that subject. Attending a seminar has numerous benefits including improving communication skills, gaining expert knowledge, networking with others and renewing motivation and confidence. Attending conference benefits include learning in new space, breakout our comfort zone, attain new tips and tricks, networking opportunities, meet experts etc.

5.2.2 Online sharing

Theonlinesharingistheprocessofsharingafilewithoneormoreusersviatheinternet.Internet penetration is increasing in the country day-by-day and hence, the internet facility is becoming available to an increasingly large number of teachers. There are many online blogs, discussion forums, e-journals and e-magazines which provide teachers immense possibilities to share experiences and learn from each other. Through internet, teachers across the regions and nations can connect with each other, discuss and exchange views. In fact, irrespective of the distance between them they can collaborate and work together.

5.2.3 Membership of professional organisation

There are many national and international professional organisationswhich provide an excellent forum to teachers for exchanging their ideas. These are dedicated to the promotion of science education and professional growth of science teachers.

Some professional organisations for science teachers are:

- All India Science Teachers' Association (Kolkata)
- Indian Science Congress Association (Kolkata)
- Indian Association of Physics Teachers (Chandigarh)
- Delhi State Science Teachers' Forum (Delhi)
- Indian Association of Teacher Educators (Delhi)
- All India Secondary Teachers Federation (Delhi)
- National Science Teachers Association (Arlington, USA)
- National Association for Research in Science Teaching (Virginia, USA)
- American Association of Physics Teachers (Washington)

5.2.4 Attending in-service teacher training programmes and workshops

Many teacher training programmes and workshops are conducted round the year, all over the country, by various organisations such as NCERT, SCERTs, DIETs, KVS (Kendriya Vidyalaya Sangathan), NVS (Navodaya Vidyalaya Sangathan), Teacher Education Colleges, Teacher Associations,University Education Departments and NGOs. In-service training programmes and workshops are conducted by experts to take care of the particular needs of teachers. Some of the areas in which teacher training programmes and workshops are conducted regularly in Physical sciences are Designing improvised apparatus, developinglow- cost teaching-learning materials, writing test items, improving laboratory skills, content enrichment in science/physics/chemistry, activity-based teaching-learning and Use of Science kits.

5.2.5 Teacher exchange programmes

There are many teacher exchange programmes which enable the teachers to go for a few months to school in another locality or state within the country or even outside the country. The participating teachers get an opportunity to teach and learn in different settings and interact with a different set of peer teachers. Similarly, schools may also play host to visiting teachers and plan how best to utilise the services of visiting teachers. Teachers can share their expertise in science education with each other.

5.2.6 Acquiring higher qualifications

A physical science teacher may try to improve her qualifications by enrolling for M.Sc., M.Ed., Ph.D. or other such programmes. Some schools allow their teachers to take study leave/sabbatical leave to obtain an advanced degree. Acquiringhigher qualifications is beneficial for enriching content and pedagogy knowledge of science and making teaching-learning more effective. It may enhance the possibility of promotion of the teacher in future.

5.2.7 Interacting with peer teachers

Science teachers could come together and form their own forum to discuss academic matters. For a teacher desiring to bring an improvement in her professional work, the best way is to share and seek help from other experienced teachers of the school who are themselves keen to grow as effective teachers. Issues like planning for learning experiences, designing improvised apparatus, context specific examples, etc. can be discussed for mutual

enrichment. Observing classroom teaching-learning and laboratory work conducted by colleagues may also be helpful in getting many ideas.Integrated approach to science teaching-learning implies continuous interaction with the teachers of other subjects as well. Interacting with other teachers, science teachers learn to see better correlation between science and other subjects such as mathematics social science, literature, art and computer science. It provides enrichment of their teaching-learning experiences. This practice can initiate the breaking of tight boundaries between various disciplines.

5.3 TEACHERS AS A COMMUNITY OF LEARNERS, COLLABORATION OF SCHOOLS WITH UNIVERSITIES

5.3.1 Teacher As Community Learners

A community learner is one who interested to learn from a community. A community of learners is a group of people who support each other in their collective and individual learning. They are cooperative and can work productively together.

A community of learners can be defined as a group of people who share values and beliefs and who actively engage in learning from one another. It can be learners from teachers, teachers from learners, learners from learners and teachers from teachers. Community of learners are inter connected, supportive, mutually respectful and cooperative.

Characteristics of learning communities

- Common relational characteristics like, sense of belonging, interdependence or reliance among the members, trust among members and faith or trust in the shared purpose of the community will be there.
- Community of learners enables the all round development of each members of the community.
- Good discussions can lead to reach the perfect conclusions and perfect solutions of certain problems.
- Community of learners can improve the knowledge level of each member.
- A wider perspective can be created in approaching subjects
- An issue can be viewed through different perspective and most appropriate action plan can be selected through community of learners.
- Good communication skills and presentation skills can be developed.
- In every situation an expert opinion will boost up the confidence level.

5.3.2 Collaboration Of Schools With Universities

Collaboration means to work with another person or group in order to achieve or do something. Collaborative learning can occur peer-to-peer or in larger groups. Peer learning, or peer instruction, that involves students working in pairs or small groups to discuss concepts or find solutions to problems. Similar to the idea that two or three heads are better than one.

The school–university partnership has become a powerful model of professional development. With genuine collaboration between the two teacher education settings, it was also expected that university teacher educators, school teachers and student teachers would acquire a shared understanding of learning to teach which enabled collaborative reflection. In collaboration of schools with university one or several university members work with one or several school teachers, aiming at providing resources and expertise for teachers in improving classroom instruction and teachers' professional development. Apart from teacher training, there are a handful of school– university partnership projects that have been implemented in the last decades which have introduced new initiatives into schools and contributed to substantial changes in school leadership, teachers professional development and school-based curriculum development there by generating a positive impact on children's learning.

Features of collaboration of schools with universities.

- providing resources and expertise for teachers in improving classroom instruction and teacher's professional development.
- Development of higher-level thinking, oral communication, self-management, and leadership skills.
- Promotion of student-faculty interaction.
- Increase in student retention, self-esteem, and responsibility.
- Exposure to and an increase in understanding of diverse perspectives.
- Preparation for real life social and employment situations.
- It enables resource exchange, man power exchange, exchange of lab, library facilities and availability of better technologies for schools.

5.4. ROLE OF REFLECTIVE PRACTICES IN PROFESSIONAL DEVELOPMENT OF TEACHERS.

Reflective teaching means looking at what you do in the classroom, thinking about why you do it, and thinking about if it works – a process of self-observation and self-evaluation. Donald (1983) by collecting information about what goes on in our classroom, and by analyzing and evaluating this information, we identify and explore our own practices and underlying beliefs. This may then lead to changes and improvements in our teaching. Reflective teaching involves recognizing, examining, and ruminating over the way an individual teaches. As individuals possess their own background and experience, bring certain beliefs, assumptions, knowledge, attitudes and values to teach. It is also seen that teaching takes place in a social setting that has its own unique characteristics, opportunities and constraints. The practice of reflective teaching explores the implications of all these complex factors with the intention of understanding and improving teaching-learning practice. Schon (1993) suggested that reflective teaching practice is a continuous process and involves the learner thoughtfully considering one's own experience in applying knowledge to practice while being taught by professionals. It helps the individuals to develop their own personality. Gibbs (1988) reflective practice suggests that individuals develop an analysis of feelings, evaluation of experience etc. Engaging in reflective practice is associated with the improvement of the quality of care, stimulating personal and professional growth and closing the gap between theory and practice.

Advantage Of Reflective Practices

1.Research on reflective teaching over the past two decades has shown that itis linked to the inquiry, and continuous professional growth.

2.Reflective practice can be a beneficial form of professional development at both the pre-service and in-service levels of teaching.

3. It develops critical thinking and promotes experiential learning.

4. It enhances personal growth.

5.It gives freedom to teachers to impose their own methodology enhancing rational thinking.

6. It is a beneficial form of professional development at both the pre-service and in-service levels of teaching. By gaining a better understanding of their own individual

teaching styles through reflective practice, teachers can improve their effectiveness in the classroom.

7. It enriches students' personal reflections on their work and provides insight to refine their teaching practices

Strategies To Practice Reflection

The findings of the research on reflective practices helped the researchers to identify different strategies that can be practised in the pre-service training programme. The first step towards the process of reflection is to gather information about what happens in the class followed by analysis of the data. Here are some different ways of doing this.

- **Reflective journal /diary** : This is the easiest way to begin a process of reflection since it is purely personal. Student teachers encounter many issues in classroom settings. After each activity/ practice lesson, the student teacher has to write in a notebook about what happened. They can describe about own reactions and feelings and those things which happened during each sessions. Diary writing does require a certain discipline in taking the time to do it on a regular basis.

- **Collaborative learning** : Brookfield (1995) maintains the importance of continual dialogue with peers about teaching in the mutually cooperative environment rather than a competitive one. Collaboration with peer members increases the probability that students teachers will be successfully reflective and more confident in their professional development. While discussing their experience with their peers, they can describe their own experiences and check, reframe and broaden their own theories of practice.

- **Recording Lessons** : Video or audio recordings of lessons can provide very useful information for reflection. Through watching their own or other peer members' audio and video recordings, student teachers can develop their awareness of teaching. A teacher may do many things in class but may not be aware of many things happening in the class which the teacher may not normally see. A classroom video can vividly picture the whole process of teaching. It can trigger teachers' reflective thinking,

reflect on their weaknesses and help them get some inspiration and ideas for their teaching improvement. The recording can be audio or video.

- Audio recordings can be useful for considering aspects of teacher talk
  - ✓ How much do you talk?
  - ✓ About what ?
  - ✓ Are instructions and explanations clear?
  - ✓ How much time do you allocate to student talk?
  - ✓ How do you respond to student talk?
- Video recordings can be useful in showing the aspects of teacher's own behavior,
  - ✓ Where do you stand?
  - ✓ Who do you speak to?
  - ✓ How do you approach the students?

- **Teacher Educator's Feedback** : The feedback from the teacher educator can help the student teacher to reflect upon their lesson or any activity conducted in the institution.
- **Peer Observation** : Observation is the most basic research technique that student teachers employ in classrooms. The student teacher invites a peer member to observe his/her class to collect information about the lesson. This may be with a simple observation task or through note taking. The student teacher can ask their peer member to focus on which students contribute the most in the lesson, what different patterns of interaction occur and his/her performance. For observation to be viewed as a positive rather than a negative experience, the observer's function should be limited to that of gathering information. The observer should not be involved in evaluating a student teacher's lesson. Mutual observation of classes are really fruitful. Therefore, observation is a good way for their professional development. 4.6 Student Feedback The student teacher can ask their students about what goes on in the classroom. Their opinions and perceptions can add a different and valuable perspective. This can be done with simple questionnaires.

- **Action Research** : Action research is also a kind of reflective practices. It is a reflective process of progressive problem solving led by teachers to understand their practice and improve the way they address issues and solve problems. It helps student teachers to become aware of what's happening in the classroom by identifying common problems and hypothesising about possible causes and solutions and attempting to apply an action plan. Once the student teacher has some information recorded about what goes on in their classroom, they must think, talk, read and ask about the information they have collected. They can identify the patterns occurring in their teaching through the observation. Then, he/she should find out the ways to overcome it. In this research study, the student teachers adopted all the strategies and reflected on their practices. The researchers could find a significant change in the behaviour of the student teachers.

The Action Research Process

Educational action research can be engaged in by a single teacher, by a group of colleagues who share an interest in a common problem, or by the entire faculty of a school. Whatever the scenario, action research always involves the same seven-step process. These seven steps, which become an endless cycle for the inquiring teacher, are the following:

1. Selecting a focus
2. Clarifying theories
3. Identifying research questions
4. Collecting data
5. Analyzing data
6. Reporting results
7. Taking informed action

Step 1—Selecting a Focus

The action research process begins with serious reflection directed toward identifying a topic or topics worthy of a busy teacher's time.Thus, selecting a focus, the first step in the process, is vitally important. Selecting a focus begins with the teacher researcher or the team of action researchers asking:

Step 2—Clarifying Theories

The second step involves identifying the values, beliefs, and theoretical perspectives the researchers hold relating to their focus. For example, if teachers are concerned about increasing responsible classroom behavior, it will be helpful for them to begin by clarifying which approach—using punishments and rewards, allowing students to experience the natural consequences of their behaviors, or some other strategy—they feel will work best in helping students acquire responsible classroom behavior habits.

Step 3—Identifying Research Questions

Once a focus area has been selected and the researcher's perspectives and beliefs about that focus have been clarified, the next step is to generate a set of personally meaningful research questions to guide the inquiry.

Step 4—Collecting Data

Professional educators always want their instructional decisions to be based on the best possible data. Action researchers can accomplish this by making sure that the data used to justify their actions are *valid* (meaning the information represents what the researchers say it does) and *reliable* (meaning the researchers are confident about the accuracy of their data). Lastly, before data are used to make teaching decisions, teachers must be confident that the lessons drawn from the data align with any unique characteristics of their classroom or school.

Step 5—Analyzing Data

Although data analysis often brings to mind the use of complex statistical calculations, this is rarely the case for the action researcher. A number of relatively user-friendly procedures can help a practitioner identify the trends and patterns in action research data. During this portion of the seven-step process, teacher researchers will methodically sort, sift, rank, and examine their data to answer two generic questions:

- *What is the story told by these data?*
- *Why did the story play itself out this way?*

By answering these two questions, the teacher researcher can acquire a better understanding of the phenomenon under investigation and as a result can end up producing grounded theory regarding what might be done to improve the situation.

Step 6—Reporting Results

It is often said that teaching is a lonely endeavor. It is doubly sad that so many teachers are left alone in their classrooms to reinvent the wheel on a daily basis. The loneliness of teaching is unfortunate not only because of its inefficiency, but also because when dealing with complex problems the wisdom of several minds is inevitably better than one.

The sad history of teacher isolation may explain why the very act of reporting on their action research has proven so powerful for both the researchers and their colleagues. The reporting of action research most often occurs in informal settings that are far less intimidating than the venues where scholarly research has traditionally been shared. Faculty meetings, brown bag lunch seminars, and teacher conferences are among the most common venues for sharing action research with peers. However, each year more and more teacher researchers are writing up their work for publication or to help fulfill requirements in graduate programs. Regardless of which venue or technique educators select for reporting on research, the simple knowledge that they are making a contribution to a collective knowledge base regarding teaching and learning frequently proves to be among the most rewarding aspects of this work.

Step 7—Taking Informed Action

Taking informed action, or "action planning," the last step in the action research process, is very familiar to most teachers. When teachers write lesson plans or develop academic programs, they are engaged in the action planning process. What makes action planning particularly satisfying for the teacher researcher is that with each piece of data uncovered (about teaching or student learning) the educator will feel greater confidence in the wisdom of the next steps. Although all teaching can be classified as trial and error, action researchers find that the research process liberates them from continuously repeating their past mistakes. More important, with each refinement of practice, action researchers gain valid and reliable data on their developing virtuosity.

Three Purposes for Action Research

As stated earlier, action research can be engaged in by an individual teacher, a collaborative group of colleagues sharing a common concern, or an entire school faculty. These three different approaches to organizing for research serve three compatible, yet distinct, purposes:

- Building the reflective practitioner
- Making progress on schoolwide priorities
- Building professional cultures

How Action Research Professionalize Teaching

Teaching in North America has evolved in a manner that makes it more like blue-collar work than a professional undertaking. Although blue-collar workers are expected to do their jobs with vigilance and vigor, it is also assumed that their tasks will be routine, straightforward, and, therefore, easily handled by an isolated worker with only the occasional support of a supervisor.

Professional work, on the other hand, is expected to be complex and non routine, and will generally require collaboration among practitioners to produce satisfactory results. With the exploding knowledge base on teaching and learning and the heightened demands on teachers to help all children achieve mastery of meaningful objectives, the inadequacy of the blue-collar model for teaching is becoming much clearer.

When the teachers in a school begin conducting action research, their workplace begins to take on more of the flavor of the workplaces of other professionals. The wisdom that informs practice starts coming from those doing the work, not from supervisors who oftentimes are less in touch with and less sensitive to the issues of teaching and learning than the teachers doing the work. Furthermore, when teachers begin engaging their colleagues in discussions of classroom issues, the multiple perspectives that emerge and thus frame the dialogue tend to produce wiser professional decisions.

ACTION RESEARCH IN SCIENCE TEACHER EDUCATION

Action research has been used in both preservice and inservice science teacher education, and as a way for teachers to collaborate with one another to improve practice.

Hewson and colleagues (1999) use action research to help prospective teachers become reflective about what it means to teach for conceptual change. Prospective teachers designed, conducted, and presented research projects, used reflective journals as research notebooks, and participated in seminars. The process was found to help participants focus more on student conceptions and explanations, important aspects of teaching for conceptual change. Teachers can present their findings through research festivals, Web pages, presentations at local and national conferences, and submission of case studies for publication in practitioner-based journals.

5.5 TEACHER AS A RESEARCHER : LEARNING TO UNDERSTAND HOW CHILDREN LEARN SCIENCE

Teacher research is intentional, systematic inquiry by teachers with the goals of gaining insights into teaching and learning, becoming more reflective practitioners, effecting changes in the classroom or school, and improving the lives of children . Research is not just the domain of an expert outside the classroom; it is also the domain of the teaching professional. Good teachers have always been good researchers. Attentive teachers observe their students and, through systematic and embedded study, come to understand the culture of their learning environment.

A strong educator will analyze the individual needs of students or learning environments and, after reflection and consideration, adjust her actions to best meet student and system needs. The cycle then continues again within the same, or a new group, of students, as the teacher/researcher begins an iterative cycle of question, observation, reflection and action. Teachers continuously empower students to create knowledge . Any educator who has explored new curriculum, evaluated teaching practices, chosen one new idea over another, or re-evaluated a daily teaching choice based on evidence and a guiding question, has engaged in research. Such research is essential to both teaching and learning.

Teaching practices are generative in nature and there are possibilities of continuous growth and development. Understanding one's teaching-learning practices helps in professional development of the teacher. Action research is one of the many forms of research. It is for empowering teachers to reflect on her own practices and work with her own insight for the betterment of teaching-learning processes. Findings of the action research not only encourages others to develop new vision, but it also instills the idea that new vision for teaching learning of science is possible.

Young children are active and native science learners who, with the encouragement and support from adults, will eagerly explore, experiment with, and learn about the natural, physical, and social world around them .Young children think like scientists in many ways, a teacher can engage them in:

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence,
- Obtaining, evaluating, and communicating information

Through these experiences, children develop science-related interests, gain knowledge of science topics and activities, and practice science skills and the use of scientific tools and language

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