ACCORDING TO NEW SYLLABUS OF TWO YEARS B. ED. OF MUMBAI UNIVERSITY

PEDAGOGY OF SCHOOL SUBJECT

SCIENCE

SHIVANSH PUBLICATION, PANVEL

Index

Module 1 Fundamentals of Science Education

Unit 1 Basics of Academic Disciplines

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c) Place of Science subject in present school curriculum

a) Meaning of academic disciplines, Relationship between academic disciplines and Science subject

Academic discipline:-

Meaning:-

An academic discipline or field of study is a branch of knowledge that is taught and researched as part of higher education. A scholar's discipline is commonly defined and recognized by the university faculties and learned societies to which he or she belongs and the academic journals in which he or she publishes research. However, there exist no formal criteria for defining an academic discipline.

Disciplines vary between well-established ones that exist in almost all universities and have well-defined rosters of journals and conferences and nascent ones supported by only a few universities and publications. A discipline may have branches, and these are often called sub-disciplines.

There is no consensus on how some academic disciplines should be classified (e.g., whether anthropology and linguistics are disciplines of social sciences or fields within the humanities). More generally, the proper criteria for organizing knowledge into disciplines are also open to debate.

An academic discipline is a branch of knowledge that is taught and researched as part of higher education.

Definition:-

- Discipline is defined by the Oxford English Dictionary as "a branch of learning or scholarly instruction."
- According to Moti Nissani (1997), a discipline can be conveniently defined as the study of "any comparatively self- contained isolated

domain of human experience which possesses its own community of experts"

- As Morieson (2012) notes in her adaption of Krishan's work, disciplines are "a form of specific and rigorous scientific training"(Krishnan, 2009)
- Arthur Dirks points out 'discipline in an academic sense, pertains to the practice of study of a certain category of experience, its methodologies, how it goes about its pursuit of truth. There is fundamental theory and fact (one might call it doctrine) that informs the practice of that pursuit, but it is the pursuit that counts.'

An academic discipline is clearly defined by its expertise, people, projects, communities, challenges, studies, inquiry, and research areas that are strongly associated with a given discipline.

An academic discipline is a branch of knowledge. It incorporates expertise, people, projects, communities, challenges, studies, inquiry, and research areas that are strongly associated with a given academic discipline. For example, the branches of science are commonly referred to as the scientific disciplines, e.g. physics, mathematics, computer science.

Individuals associated with academic disciplines are commonly referred to as experts or specialists. Others, who may have studied liberal arts or systems theory rather than concentrating in a specific academic discipline, are classified as generalists.

While academic disciplines in and of themselves are more or less focused practices, scholarly approaches such as multidisciplinarity, interdisciplinarity, transdisciplinarity, and crossdisciplinarity, integrate aspects from multiple academic disciplines, therefore addressing any problems that may arise from narrow concentration within specialized fields of study. For example, professionals may encounter trouble communicating across academic disciplines because of differences in language and/or specified concepts.

Characteristics of academic disciplines

1) **Body of specialized knowledge**:-

Disciplines have a body of accumulated specialist knowledge referring to their object of research, which is specific to them and not generally shared with another discipline;

2) **Has theories and concepts**:-

Disciplines have theories and concepts that can organize the specialized knowledge effectively. Take the discipline of Psychology for instance. The process of how learning occurs is elucidated by different theories. A single theory may not explain every kind of learning, yet when one examines different theories, one gains an understanding of the process of learning under different circumstances.

3) **Specific terminology:-**

Disciplines use specific terminologies or a specific technical language adjusted to their research object. The discipline of Science has its own technical language. Specific terminologies are used in the discipline. For example words like 'consumer', 'ecosystem', 'producer' will have a definite meaning in Environmental Sciences but the same terms used in the discipline of Business Studies would mean something entirely different.

4) **Specific object of research**:-

Disciplines have a particular object of research (e.g. law, society, politics), though the object of research may be shared with another discipline. For example 'human behavior' is one object of research in the fields of Psychology, Education and Management.

5) **Definite methodology of research:-**

Disciplines have developed specific research methods according to their specific research requirements. A discipline is defined by its method. For example if someone is studying Science then there is a particular method incorporated in the study. Disciplines defined by a particular method a capable to realizing genuine change and their scope is also concrete.

6) Institutional manifestation in form of subjects taught, professional organizations:-

Disciplines must have some institutional manifestation in the form of subjects taught at universities or colleges, respective academic departments and professional associations connected to it. The discipline of Medicine for example is characterized by medical colleges. The association of doctors and publications in this field are part of the institutional manifestation of the discipline of Medicine.

Let us examine how History is a discipline. (Some experts state that while Humanities and Social sciences are disciplines, History is a sub discipline under Humanities). History is an example of a discipline

because it meets several criteria ascribed to disciplines. It has a body of specialist knowledge which contains various events that have occurred in the past. It has definite key concepts like revolution, colonialism, racism, freedom etc. Theories such as Marxist Theory or the Great Man theory (which says that history is the impact of great people or highly influential individuals) are specific to History. History as a discipline uses specific terms for elucidation. E.g. the term civilization has a definite connotation. When presenting historical events specific language is used. The objects of research in History are quite well defined. Events of the past, people movements, archeological remnants are some examples of areas of research in History. While pursuing research in History some definite steps are involved. The methodology to be followed is specified. Many universities have departments of history. One finds that history is included in the curriculum right from Primary stage. One comes across bodies of academicians connected with History. Since History exhibits all criteria associated with disciplines, it is classified as an academic discipline.

Thus each discipline has its own defining elements viz its phenomena, assumptions, epistemology, concepts, theories, and methods that distinguish it from other disciplines.

Different subjects share common areas of study and the nature of research. On the basis of these common aspects, subjects could be grouped under a specific discipline. If one looks at the courses offered by various universities one can see that broadly subjects are classified under the following disciplines.

1) Humanities (also called Arts and Humanities)
2) Social Sciences
3) Natural Sciences
4) Mathematics
5) Business

Natural Sciences as a discipline

Man always looks for ways to understand the environment around him, interpret various relationships and adapt to the changes in his surroundings. This human endeavor to build concepts to interact with the surrounding world is Science. Natural sciences refer to disciplines that seek to offer a systematic interpretation of the phenomena in the universe. Natural Sciences explain rules governing the natural world by applying

scientific and empirical methods to the study of the universe. Sub disciplines as Physics, Chemistry, Geosciences (Oceanography, Ecology, Geology), Life Sciences (Biology, Zoology, Botany) are some examples of Natural Sciences. The sciences are primarily concerned with the world as it is, and the arts are primarily concerned with the world man wants to live in.

Science is dynamic with a body of knowledge that covers new domains of experience. Knowledge in Natural Sciences comes through the scientific method which includes hypotheses building, prediction, testing and review. Science always stands by objectivity and neutrality. The history of Natural Sciences is perhaps as old as our ancient civilizations. Natural Science as a discipline shows some unique features. It demands evidence. For example we accept that the earth is round because we have adequate evidence for the same. Science is unbiased. No subjectivity can creep into Science. It is based on observable facts which can be replicated, for example if we say that the density of mercury is 13.6 gm/cc, it will be so at any place on the earth. Science relies on evidence and this evidence is examined using logic. Science is non-dogmatic. Science never requires ideas to be accepted on belief or faith alone.

Natural Science as a discipline has dispelled many myths and baseless beliefs. Life has become more comfortable thanks to the contribution of Science. Man has come out of the shadow of ignorance due to Science. Logical thinking, decision making, scientific inquiry and scientific attitude are all by products of learning Science. We have been able to harness wind energy, move from one country to another and fight diseases due to Science. Science is predictive and has the power to explain the conditions that can follow a given condition. This provides warning signals and helps to take steps to prevent certain pitfalls. In fact the quality of life has significantly improved due to Science.

Science, in the contemporary world, is the basis for several vocations. Careers in nursing, medicine, industry, health care and production are all dependent on Science. Over the past few decades new careers as those Information Technology, Communication Technology, Food Technology and Environmental Sciences have carved a niche for themselves in the world of work.

Relationship between academic disciplines and Science subject

1) Academic disciplines comprise of subjects. The specific characteristics of different disciplines make it easy to classify specific subjects (or sub disciplines) to specific disciplines. The broad outline of a discipline gives an idea of what one can expect to learn in a given subject.
2) A subject is best understood against the background of the discipline that it is classified under. If one understands the basic characteristics of Natural sciences then one can understand its specific subjects like Chemistry and Physics.
3) Subjects form a discipline. The scope of the discipline widens due to subjects. New subjects or sub disciplines may emerge with changing times. This can bring better understanding of subjects that pre-exist in that discipline.
4) Inter relationships exist between subjects clubbed under one discipline. Hence for better clarity of a subject one may need to refer to other subjects. The other subjects are understood effectively if one has clarity about the parent discipline.
5) Students of a particular discipline share common goals, common content and common research methodology. Hence they should be aware of the main discipline and its component subjects as it lends clarity to the subject being studied. For example a researcher in Education will benefit if there is a firm grounding of the disciplines of Humanities and Social Sciences as Education draws from both these disciplines. If the topic being researched is something like 'Brain Based Learning' or 'Cognition', an understanding of a subject like Physiology will be beneficial. Research papers or academic writings on a subject are also guided by the discipline to which that subject belongs.
6) A subtle difference between academic disciplines and subjects is that subjects normally pertain to syllabi, teaching –learning experiences and assessment. Subjects are generally associated with educational institutions. An academic discipline has wider connotations. It includes research done in the scope of that discipline; it includes communities of practice, emphasizes publication of work and thus goes beyond instruction and assessment.
7) Subjects lend substance to a discipline. In turn the discipline fine tunes the subject lending it a distinct flavor. Those who pursue a particular subject should have a good understanding of the discipline

of the subject so that the subject is understood comprehensively. Academic disciplines and subjects are like ground and figure. One without the other is meaningless.

Why do teachers require an understanding of disciplines and subjects?

Most teachers are involved in teaching and learning activities that concern a particular subject. Yet the understanding of disciplines and subjects is extremely vital for the following reasons:

1) Adequate understanding of the discipline under which one's subject is classified helps a teacher to view the subject against the right background. This helps to understand how the subject emerged and evolved over time. Every discipline has a specific focus and follows a definite system to build knowledge. This helps a teacher to do justice to the subject being taught. A teacher who teaches History must understand what the discipline of Social Sciences comprises of. Against the background of a thorough knowledge of Social Sciences, the teacher can deal with History in an elaborate manner.
2) Subjects within a discipline bear a common thread among themselves. An understanding of one's discipline promotes appreciation of other subjects within the discipline. External correlation between subjects is an integral part of the teaching-learning process. A teacher teaching Physics is able to appreciate the contribution of other subjects like Chemistry and Life Sciences if there is clarity about Science as a discipline.
3) Learning experiences can be planned more meaning fully if one is aware of different disciplines. Inter disciplinary strategies and learning experiences can be planned to expand the horizons of the pupil's understanding. While teaching Economics, a teacher can take the help of subjects like Statistics, Mathematics and Commerce to facilitate the teaching learning process.
4) Effective teachers have clarity regarding the concepts they teach. Concept clarity depends on how well one has understood one's own discipline and subject and how well one understands other subjects. Understanding and being able to apply discipline knowledge builds self- confidence, and self-confidence is central in the development of an effective teacher. Discipline knowledge encompasses an

understanding of the salient concepts, relations among concepts, ideas and skills of a subject and has always been acknowledged as the first prerequisite of ability to effectively teach a discipline. The effective teacher is more likely to chunk information, access relevant information, attach deeper meaning and extract more information from the environment in a more significant way. Discipline knowledge is a crucial prerequisite in the development of teacher self-confidence (Tisher, 1990)

5) Teachers often have to offer advice to students regarding the choice of subjects needed for a degree or the kind of professions available should one undertake a particular course. To provide such kind of guidance, teachers need to have an in depth understanding of disciplines. For example a student interested in pursuing a career in Civil Services will be benefited by subjects like Economics, Political Science and Statistics. A career in Finance will need subjects from the Business Studies group, at the same time knowledge of Computers in Accounting Systems will also be useful. Thus a good understanding of what is included under each discipline will be advantageous while offering career guidance.
6) Academicians are involved in research work. Every discipline has its own specific work style regarding research. Effective research is possible if one understand the research practices within a discipline. This will help to choose select the area for research and decide the methodology and tools. A researcher with good knowledge of different disciplines can look at enriching the research by blending it with inputs from other disciplines. For example a research on 'Impact of Globalization on Education' will draw from varied subjects such as Education, Political Science and Economics.
7) Teachers of a specific subject are bound to interact with one another regarding matters related to their subjects. These communities of practice are sustained by healthy contributions from teachers. These contributions are in form of researches, discussions, academic forums and publications in magazines and journals. A teacher with a firm foundation in one's own disciplines can contribute much to the community of practice.
8) A good understanding of disciplines and subjects is useful to understand the world around us. Events that affect us are better understood through knowledge of disciplines. The choices that one

makes, the way one faces challenges and the vision that one develops are all impacted by one's knowledge of disciplines and subjects. Take for example investments made by an individual. A person with good knowledge of finance, world affairs and political conditions within one's nation will be able to make wise decisions about how to invest. Knowledge of Statistics, Economics and Business Studies will help to understand how the share market or banks function. A person with good knowledge of Psychology can handle problems with level-headedness. Thus the application of what one learns in various subjects can influence the quality of life.

b) Classification of academic disciplines: Bechar-Biglan typology (pure-hard, pure-soft, applied-hard, applied-soft types) with emphasis on nature of knowledge in each type.

There is no definite system with respect to classification of disciplines. Some experts classify disciplines based on the focus of their content as Arts and Humanities, Socials Sciences, Natural Sciences, Mathematics and Business Studies. In the early 1970s Anthony Biglan carried out a study to investigate the faculty's judgment about similarities and differences between several academic fields. These perceptions were classified as

i. Pure vs applied
ii. Hard vs soft (or paradigmatic vs non paradigmatic disciplines)
iii. Concerned with life systems vs those not concerned with life systems.

Pure disciplines:-

- Pure disciplines refer to those disciplines that tend towards fundamental research.
- There is systematic observation of phenomena solely for the purpose of discovering unknown facts which may develop into theories.
- The product of these disciplines is some kind of new knowledge. Simply put a pure discipline is a discipline that involves study purely for the sake of knowledge and not for its application.
- Some examples are Pure Mathematics, Pure Physics, Pure Chemistry, Pure History. To elaborate, Pure Mathematics solves problems, finds facts and answers questions that don't depend on the world around us, but on the rules of Mathematics itself.

Applied Disciplines:-

- Applied disciplines relate existing knowledge to real world situations.
- These disciplines make significant contributions to the world by articulating the theoretical foundations in their field of study.
- For example Human Resource Development is an applied discipline that draws heavily from pure disciplines like Psychology and Sociology.
- Engineering is an applied science dependent on the pure sciences of Mathematics and Physics.

Hard disciplines:-

- Disciplines that tend to use quantitative data, tend to be predictive and use experimental methods are classified as a hard disciplines.
- Eg: Physics, Chemistry, Engineering, Computing are all examples of hard disciplines as they deal with quantitative data.
- They use experimental methods to build their repository of knowledge.
- Braxton (1995) represents the hard disciplines as being characterized by greater concern for career development and cognitive goals (such as the learning of facts and concepts).

Soft Disciplines:-

- Soft disciplines are those disciplines that rely on qualitative data.
- They generally do not use experimental methods and hence cannot make conclusive predictions concerning the future.
- Examples of soft disciplines are Languages, Law, Anthropology and Education.
- The soft disciplines as being characterized by greater concern for general education development, character development, critical thinking and 'scholarly' activities (such as the reading of research articles).

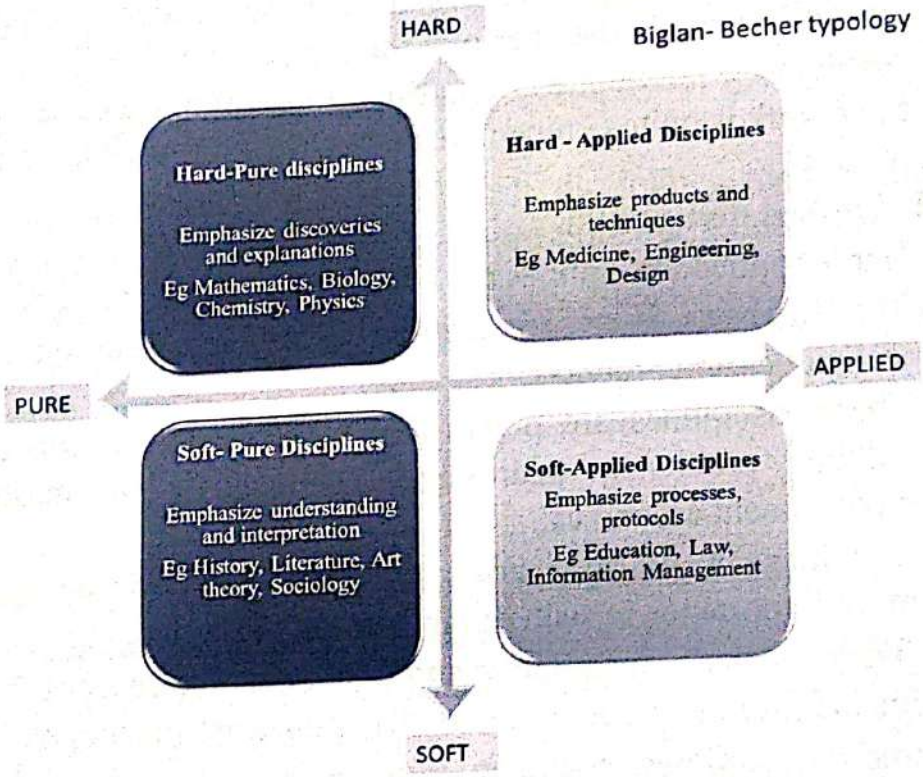
Disciplines are also classified as those dealing with life systems or living beings as against those that deal with inanimate objects. Examples of the former are Biology, Psychology and those of the latter type are Physics, Mathematics, Geology.

A study by Smart and Ethington (1995) reports the opinions on the goals of undergraduate education from over 4000 university faculty

members who regularly taught undergraduate students. The conclusions were that soft and applied disciplines place greater emphasis on knowledge acquisition, and hard disciplines have more concern for knowledge application. Knowledge integration and application were both perceived to be more important in the applied disciplines than in the pure.

Biglan's work concentrated on the cognitive dimension of disciplines, Becher in 1989 called attention to the social dimensions of academic disciplines. From this emerged the Biglan-Becher typology of academic disciplines. According to this typology, four main types of groups are possible

1. Hard and Pure disciplines
2. Hard and Applied disciplines
3. Soft and Pure disciplines
4. Soft and Applied disciplines



Hard-Pure disciplines:-

- Hard-Pure disciplines involve general areas of human understanding and are clustered around limited number of problems.
- The nature of knowledge in these disciplines is cumulative and concerned with universal phenomena.

- The result of such knowledge is discovery of something new or expansion of already existing knowledge. Just like a crystal grows as more and more molecules add on to it, so is it in case of this group of disciplines.
- As new knowledge keeps adding, the older form of knowledge is enhanced. For example, consider the knowledge about an atom. As research on the atom progressed, our knowledge about atoms made incremental progress.
- The relationship between the knowledge seeker and knowledge is unbiased and very objective.
- There are very definite criteria to verify knowledge in such disciplines.
- There is a high degree of consensus over significant questions. For example if two scientists are studying the effect of temperature on the states of matter, their results will be similar no matter which parts of the world they perform their experiments in.
- Academic communities in hard-pure disciplines are well organized, their work is quite competitive and publication rates are high.

Hard- Applied disciplines:-

- Hard-Applied Disciplines are involved in purposive work.
- The emphasis is on application of theories resulting in creating techniques and products.
- These disciplines are practical in nature and are concerned with solving problems, addressing challenges and mastering the environment around us.
- The focus is on application and hence heuristic approaches find more importance in such disciplines.
- They use both quantitative and qualitative approaches. The criteria for judging the product of such disciplines are functional.
- Such disciplines result in new techniques and products being created.
- Engineering, for example, is a hard-applied discipline which draws from Mathematics, Physics and Chemistry.
- Clinical Medicine is a hard-applied discipline dependent upon Biology and Chemistry.

- The ethos in such disciplines is entrepreneurial and dominated by professional values. Patents are submitted for publication.

Soft -Pure disciplines:-

- Soft-Pure Disciplines stress on understanding and interpretation of phenomena.
- Knowledge in these disciplines is reiterative which means there may be repetition of knowledge when examined in different situations.
- These disciplines are concerned with particular happenings rather than general occurrences.
- Unlike hard sciences, here data is qualitative.
- The researcher and knowledge share a personal relationship.
- There can be different views regarding what verification of data.
- Subjectivity can be high when interpretations are made.
- There is no definiteness as to what significant questions are to be answered.
- Anthropology and History are some examples of disciplines in this type.
- The academic communities of such disciplines tend to be less structured compared to those from hard-pure disciplines.
- Publication rate is also lower.
- It is interesting to note that while a discipline like Sociology is a soft-pure discipline, Sociometrics, a subfield of Sociology, is hard-pure.

Soft Applied disciplines:-

- Soft-Applied Disciplines emphasize processes and protocols.
- These are functional and utilitarian in nature.
- They are concerned with the enhancement of professional practice.
- Often their status is uncertain.
- They also appear to be dominated by intellectual fashions.
- They use a mix of qualitative and quantitative data for their growth.
- Case studies form an important tool in such disciplines.
- Law and Education are examples of soft-applied disciplines.

- Education depends upon other soft disciplines like Psychology, Sociology and Philosophy. Publication rates in these disciplines are low.

Thus the understanding of Biglan-Becher typology gives an overview of how different disciplines are similar and how they differ. One also sees how a particular group of disciplines has somewhat similar characteristics with respect to research carried out or publications made.

c) Place of Science subject in present school curriculum

Place of the disciplines Science in present school curriculum

Science:-

The word science has its roots in the Latin word Scientia, meaning knowledge".

Definition:

1) "Science is a systematic and organized body of knowledge."
2) "Science can be defined as a systematic attempt to discover, by means of observation and reasoning, particular facts about the world, and to establish laws connecting facts with one another and, in some cases, to make it possible to predict future occurrences."

Science is not only mass of knowledge but ultimate source of such accumulated knowledge.

Science is a body of empirical, theoretical, and practical knowledge about the natural world, produced by scientists who emphasize the observation, explanation, and prediction of real world phenomena.

In its broadest sense science refers to the systematic acquisition of knowledge or a prescribed practice that is capable of prediction in a controlled environment.

In this sense science may refer to a highly skilled technique or practice.

Place of the disciplines Science in present school curriculum:-

- Compulsory subject from Class 1 in school education.
- Basic to most professions hence important.

According to National Curriculum framework for School Education (2000), Science education at different stages is as follows:

Primary School:-

- Environmental Studies as an integrated course
- 1st , 2nd standard Science as Environmental Studies
- 3rd , 4th standard Science as General Science

Upper Primary:-

- 5th to 8th Science as General science

Secondary:-

- In 9th and 10th , Science & Technology as an integrated approach

Higher Secondary:-

- Physics, Chemistry & Biology as separate disciplines in 11th and 12th.

Compulsory teaching of science and environmental orientation to science teaching up to secondary stage has been a common feature in science curricula of all the states/UTs.

Science Education at Primary School:-

Science & Social Science is to be integrated as Environmental Studies.

At this stage Science education should help to:

- Nurture the curiosity of the child about the world (natural environment, artifacts and people),
- Have the child engage in exploratory and hands-on activities for acquiring the basic cognitive and psychomotor skills through observation, classification, inference, etc.;
- Emphasize design and fabrication, estimation and measurement
- Develop basic language skills: speaking, reading and writing not only for science but also through science.

Science Education at Upper Primary School:-

At this stage,

- The child should be engaged in learning the principles of science through familiar experiences, working with hands to design simple technological units and models (e.g. designing and making a working model of a windmill to lift weights)
- Continue to learn more about the environment and health, including reproductive and sexual health, through activities and surveys.

- Scientific concepts are to be arrived at mainly from activities and experiments.
- Group activities, discussions with peers and teachers, surveys, organization of data and their display through exhibitions, etc. in schools and the neighborhood should be important components of pedagogy.

Science Education at Secondary School:-
At the secondary stage,

- Students should be engaged in learning science as a composite discipline,
- In working with hands and tools to design more advanced technological modules than at the upper primary stage, and
- In activities and analyses on issues concerning the environment and health, including reproductive and sexual health.
- Systematic experimentation as a tool to discover/verify theoretical principles,
- Working on locally significant projects involving science and technology, are to be important parts of the curriculum at this stage.

Science Education at Higher Secondary School:-
At the higher secondary stage,

- Science should be introduced as separate disciplines,
- With emphasis on experiments/technology and problem solving.

Unit 2 Place of Science in the Curriculum and Life

a) Meaning and nature (Product and Process) of science, Science Process Skills – Basic and Integrated
b) Aims and Objectives of teaching science at upper primary, secondary and higher secondary level (NCF 2005).
c) Values of teaching science in socio-cultural context.

a) Meaning and nature (Product and Process) of science, Science Process Skills – Basic and Integrated
Meaning and nature (Product and Process) of science:-
What is Science:-

Humans are curious by nature. This curiosity has driven them since time immemorial to explore the world around them. Over time, manipulation and controlling nature for the benefit of humans has become an objective of exploration.

Initially the pace of exploration was slow. But with the availability of better tools of exploration in the last few hundred years and also as a result of industrial revolution in the west, the pace of exploration has increased manifold. Unfortunately, the industrial revolution introduced an undesirable element into the exploration of nature. Exploration became a tool for not only modifying and controlling nature for the benefit of all, but also for controlling natural resources for the benefit of a select few.

Humans' exploratory activities have resulted in the accumulation of a vast source of knowledge called natural science. In natural science, we study about nature which means the entire universe. The knowledge is now organized in several disciplines for the convenience of study. This knowledge is based on inquiry, observations and logical extensions, and is testable by experiment or has logically convincing explanation. It is this organized knowledge with inquiry, logical reasoning and experimentation as its central themes, that we call science. Science may rightly be said to be a domain of inquiry.

The word science has its roots in the Latin word Scientia, meaning knowledge".

Definition:

1. Science is a systematic and organized body of knowledge.

2. Science is not only mass of knowledge but ultimate source of such accumulated knowledge.
3. Science can be defined as a systematic attempt to discover, by means of observation and reasoning, particular facts about the world, and to establish laws connecting facts with one another and, in some cases, to make it possible to predict future occurrences.
4. Science is a body of empirical, theoretical, and practical knowledge about the natural world, produced by scientists who emphasize the observation, explanation, and prediction of real world phenomena.

- In its broadest sense science refers to the systematic acquisition of knowledge or a prescribed practice that is capable of prediction in a controlled environment.
- In this sense science may refer to a highly skilled technique or practice.
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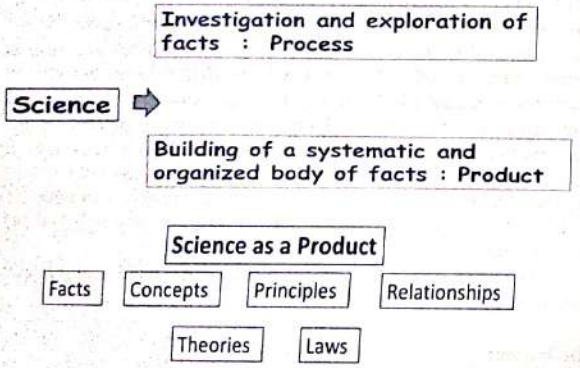
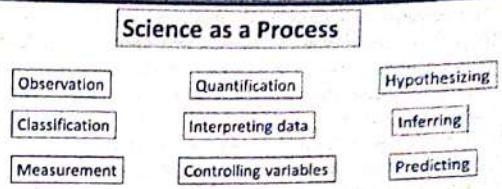




Science as Product:

Products are the outcome of process. Systematic observations and experimentation leads to the formulation of theories and generalizations. Empiricism generally encompasses systematic study of facts, theories and generalization. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts.

Science as a Process:-

In modern use, "science" more often refers to a way of pursuing knowledge, not only the knowledge itself.

Science is both thought and action. Thought is nothing but the ideas, conception, and beliefs about the natural phenomenon wherein the action is methods and procedures or processes followed by scientist or students. The process includes certain set of skills and abilities such as observation, measurement, communication, testing hypothesis, design experiment, changing variable etc. These skills are commonly called scientific method. These skills are the foundation for formulation of theories, generalization, principle, and laws. It encourages the spirit of inquiry through laboratory experiments

Experimentation:-

It is a process in the sense it helps to explore the truth and involves certain systematic procedures and mental faculties as reasoning, analysis and synthesis.

- The process of science is the scientific method. This is the process of constructing an accurate, reliable, repeatable model of the real world, by scientists collectively working towards this goal over time.
- Scientific ideas are developed through reasoning.
- The process of science is not predetermined.

Nature of Science:-

Science has certain characteristics which distinguish it from other spheres of human endeavor. These characteristics define the nature of science. These also set the terms on which you can engage with science. These are discussed below.

1. Science is a particular way of looking at nature

- A morning walker looks at the rising sun, pays obeisance to the sun-god for bestowing the earth with light and energy and may offer prayer to propitiate Him. Another walker with a scientific bent of mind or scientific attitude, while recognising it to be the source of all energy on the earth, may wonder where the sun gets its energy from, tries to understand the process of energy generation and may think of duplicating this process on the earth for the benefit of humankinds.
- At the time of an epidemic, people take to praying and seek divine intervention to save humanity. A scientist, on the other hand, seeks to isolate the pathogen responsible for the epidemic and develops preventive and curative strategies to fight the disease and save people.

2. Science is a rapidly expanding body of knowledge

- Newer disciplines are being discovered and established every day and the older ones are being enriched by researches being carried out in institutes of higher learning. Not only is the volume of knowledge increasing at a furious pace, but the newer knowledge is also replacing some of the older knowledge. Look around and you notice that the technology at the base of almost everything that you use has been overhauled in the last five to ten years. For example, the audio tape is now almost obsolete; its place has been taken by compact disc, which itself is being rapidly replaced by other media devices. In this respect science is a highly dynamic body of knowledge.

3. Science is an interdisciplinary area of learning

- Science flourished in ancient cultures like Indian, Chinese, Greek, Egyptian and others. But the science as we know today is not older than a few hundred years. In fact, the words science (meaning knowledge) and scientist are of comparatively recent origin. Earlier, science was called Natural Philosophy, alluding to the fact that science inquired into all natural phenomena—be they on the earth, be they in the sky, be they under water in the oceans, or be they inside the human body. However, when the volume of knowledge

became too large, scientists started specializing in certain areas. It is then that knowledge was organized for convenience into disciplines like physics, chemistry, biology, geology, astronomy, etc. though no natural phenomenon falls completely under just any one of these disciplines. Therefore, there cannot be any rigid demarcation of one discipline from another. Several scientific topics fall under more than one discipline. In fact, at the present time the trend is towards studying more than one discipline, or interdisciplinary subjects.

4. Science is a truly international enterprise

- There is another aspect of modern science that needs consideration, i.e., it is a truly international enterprise. Men and women of all countries participate in the progress of science and its applications. Most big projects in science are undertaken by teams of scientists drawn from many countries. This is because the human and financial resources needed for most big projects are beyond the reach of any single country.

5. Science is always tentative

- All theories, even the seemingly well-founded ones, can be revised or improved upon, or abandoned altogether whenever new evidence emerges, either as new experimental observations or as new theoretical developments. Since theories can change over time, all theories in science have the status as we know them at this instant, what happens tomorrow we cannot say. This should not be considered a weakness of science. It is actually its great strength. It is the tentativeness, or that the last word has not been said on any topic, that prompts scientists to keep striving to work for new theories or for the improvement of the existing theories, or for new explanations of the known phenomena. Scientists are always searching for evermore refined theories. That is how science prospers. If everything were final, there would be nothing new to discover, and science would never progress.

Other characteristics:-

1. Science is a Process as well as Product

It is a process in the sense it helps to explore the truth and involves certain systematic procedures and mental faculties as reasoning, analysis and synthesis.

It is a product because it results in an organized body of systematic knowledge.

2. Science helps to make descriptions

It answers questions like how, where, when, under what circumstances.

3. Science makes predictions

Extending knowledge to further situation is prediction. It involves the use of generalizations or application of knowledge in new situations.

4. Science is based on observation

Meticulous observation followed by inference drawing is an essential part of science. These observations and their conclusions are objective in nature. Unbiased approach is followed in science.

5. Science is concerned with past, present and future

- Science answers questions about the past.eg why could the dinosaurs have become extinct?
- It is involved with the present.
- E.g. Search for remedies to diseases.
- It also dwells in the future.eg what fuels can be used in the future?

6. Scientific ideas are subject to change

It is never a finished product. There is a lot more to be discovered. The quest in science is unending. Scientific laws are tentative and may be changed with further research. Science is an eternal quest for truth.

7. Science in its nature is dynamic.

Science Process Skills – Basic and Integrated

Science Process Skills:-

The science process skills are the tools that students use to investigate the world around them and to construct science concepts, so it's essential for teachers to have a good understanding of these skills. However, identifying and defining the process skills is not always a simple task.

Definition:-

- Process Skills are intellectual skills needed for scientific investigation attained by students as a result of learning of Science.
- These Skills are defined as a set of broadly transferable abilities, appropriate to many Science disciplines and reflective of the behavior of scientists

- Science process skills are the set of procedures which are employed by scientist during investigation and discoveries.
- SAPA (Science: A Process Approach) describes that scientific process skills are defined as transferable skills that are applicable to many sciences that reflect the behavior of scientists.
- Harlen (1992) stated that process skills include planning, following directions, observing, experimenting, measuring, predicting and inferring; these are concerned with processing evidence and ideas, and so are often called process skills.

By observing the above definitions it can be inferred that science process skills are the set of intellectual skills which are performed by our mind in association with sensory organs during the process of science.

Classification of Science Process Skills

The American Association for the Advancement of Science (AAAS), UNESCO (1992) identified thirteen process skills under two major classification namely Basic and integrated. Basic Science Process Skills (BSPS) are Observing, Classifying, Communicating, Measuring, Predicting and Inferring. These basic process skills are foundation for acquiring the integrated process skills. Integrated Science Process Skills (ISPS) are identifying and defining variables, describing the relationship between variables, formulating and testing hypothesis, collection of data, designing investigation and experimentation, manipulating the variables, identifying the cause and effects, acquiring organizing and displaying the data with charts, graphs, tables. All these process skills are interrelated; there is no sequence or particular order of these skills. Any skill can begins first, all other skills follows later. But most of the time observation skill starts first, rest of the skills follows later.

Basic Science Process Skills:-

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.

Skilled observers seem to proceed from general perceptions of a system to more specific ones so the nature of skilled observing can be thought of as analytical. Systems are first observed as a whole then analyzed for subsystem information. Subsequently, subsystems can be treated as a whole and subjected to further analysis in an ever tightening spiral. Technology can be used to amplify the senses, which provides for even more analysis. A microscope, for example, is a technology that allows us to see things that are too small to be seen with the unaided eye.

In summary, observation is an objective process of gathering data through the use of one's senses applied in an analytical way.

2) Classifying

Classification is the process of sorting, grouping, ordering or arranging objects on the basis of similarities and differences, larger or smaller and other common characteristics. Most intuitive thinkers can select and group the objects by some common property such as colour shape and size. The classification can be qualitative as well as quantitative.

3) Communicating

Communication skill refers to convey of information from one person to another by verbal or nonverbal means. Verbal communication conveys the information orally using scientific terminologies clearly. Nonverbal forms of communication are through charts, graphs, maps, and drawings, symbols, pie chart, tables, chemical formulas of particular element or compound, symbols of electric component, flow chart. Scientists use to communicate with another person about what they observed or discovered.

4) Measuring

Measurement is the act of using numbers to describe objects or events. Measurement is a process wherein measure the attributes that are measurable such as temperature, length, breadth, height, area, mass, and volume. Measurement is a process which involves comparison of an entity with standard measurement. Measurement skill follows calculation, after completion of every measurement it should be written with proper measurement unit for example: Units like centimeter or millimeter Kilogram length breadth temperature weight mass area volume etc.

5) Predicting

Predictions are the statements about what might happen or could be expected to happen in the future. It is based on some relevant prior knowledge in a form which can be investigated. Prediction is the act of

predicting the forecasting events based on a previously developed model or experience. A model is a visual or cognitive representation that relates various aspects to one another; a well-developed model allows one to be more confident in making predictions related to a situation.

6) Inferring

Inference is the act of making statements based on observations. Inference is a process of making suggestions, conclusions, assumptions or explanations about a specific event based on observation. Inference is different from observations, there can be a misconception that observations are inference but both are different conceptions. Observation is the use of one's senses to perceive objects and events and their properties. Inferences are making statements or conclusions after a deep observation and understanding of a phenomenon, therefore observations are the base for any inference.

Integrated Science Process Skills (ISPS)

1) Identifying and defining variables:-

Identification of Variables: Stating the factors or variables which affect the experiment.

Defining Variable Operationally: Operationally describe the variables of an experiment.

2) Manipulating the variables:- It is important to manipulate the variables being tested and keep all other variable constant. The one being manipulated is the independent variable. The one being measured is the dependent variable.

3) Describing the relationship between variables,

Describe the relationship between variables in an experiment such as independent and dependent variables

4) Formulating and testing hypothesis,

Formulating the tentative statements or expected outcome for experiments. These statements must be testable.

5) Collection of data:-

Collection of data: Collect qualitative and quantitative data during experiments through observations, measurements and any other means. Employ sensory organs to collect information.

Recording the Data: record the quantitative and qualitative data for further use.

6) Designing investigation and experimentation,

Designing Investigation: Design an experiment in a systematic way to test a hypothesis.

Experimenting: Carry out an experiment carefully by following correct procedure so that results can be verified by repeating the procedure several times.

7) Identifying the cause and effects,

Identifying the Cause and Effect Relationship: Identify the factor or variable which affect the experiment.

Analyzing Investigations: Interpreting data statistically, identifying human mistakes and experimental error, evaluating the hypothesis, deriving inferences, and design further investigation if necessary.

During the process of doing science, scientist and students employ both basic and integrated science process skills. By employing the process skills one can acquire the procedural of doing science and conceptual clarity

b) Aims and Objectives of teaching science at upper primary, secondary and higher secondary level (NCF 2005).

NCF-2005 states that .good science education is true to the child, true to life and true to science.

In the context of NCF- 2005

- **True to child** - means that the science we teach should be understandable to the child and be able to engage the child in meaningful and joyful learning.
- **True to life** - means that the science we teach should relate to the environment of the child, prepare her for the world of work and promote in her concerns for life and preservation of the environment.
- **True to science** - means the science we teach should convey significant aspects of science content at appropriate level and engage the child in learning the processes of acquiring and validating scientific knowledge.

Objectives of teaching science at upper primary level (NCF 2005):-

1. At the upper primary stage, the child should be engaged in learning the principles of science through familiar experiences, working with hands to design simple technological units and modules (e.g. designing and making a working model of a windmill to lift weights)

2. The students should continue to learn more about the environment and health, including reproductive and sexual health, through activities and surveys.
3. Scientific concepts are to be arrived at mainly from activities and experiments. Science content at this stage is not to be regarded as a diluted version of secondary school science.
4. Group activities, discussions with peers and teachers, surveys, organization of data and their display through exhibitions, etc. in schools and the neighborhood should be important components of pedagogy.

Objectives of teaching science at Secondary stage level (NCF 2005):-

1. The students should be engaged in learning science as a composite discipline.
2. The students should be engaged in working with hands and tools to design more advanced technological modules than at the upper primary stage.
3. The students should be involved in activities and analysis on issues concerning the environment and health, including reproductive and sexual health.
4. The students should be engaged in systematic experimentation as a tool to discover/verify theoretical principles.
5. The students should work on locally significant projects involving science and technology.

Objectives of teaching science at higher secondary level (NCF 2005):-

1. At the higher secondary stage, science should be introduced as separate disciplines, with emphasis on experiments/technology and problem solving.
2. The curriculum load should be rationalized to avoid the steep gradient between secondary and higher secondary syllabi.
3. The core topics of a discipline, taking into account recent advances in the field, should be identified carefully and treated with appropriate rigor and depth.

c) Values of teaching science in socio-cultural context.

Science has immense value in an individual's life and his life in society.

- Intellectual Value

- Moral Value
- Aesthetic Value
- Cultural Value
- Vocational Value
- Utilitarian Value
- Social Value
- Scientific Temper

1. Intellectual Value:-

The Science has introduced us to new ways of thinking and reasoning. Scientific knowledge helps to sharpen our intellect & promotes intellectual honesty. The science education can develop the positive attitudes like open mindedness such positive is helpful to an individual to understand, evaluate and solve many problems faced in life.

2. Moral Value:-

Knowledge of science develops in us truthfulness & reasoning. These qualities are desirable in all human beings. These qualities make the life worth living. This could be possible with the teaching of science.

3. Aesthetic Value:-

Knowledge of science develops in man a passion for truth & thus he has a passion for beauty. The English Poet Keats has said, "Truth is Beauty." Science is basically unfolding of the mysteries of nature & nature is a store house of all the beautiful things. Thus teaching of science is necessary for developing aesthetic sense in an individual.

4. Cultural Value:-

Science has played an important role in determining the culture & civilization of a country from time to time. It has affected our way of thinking & way of living. Science has a direct influence in dispelling many traditional beliefs. Science has made us more aware of the universe we live. The scientists take an equal responsible part in the vital issue of our country so as to bring about consideration & integration of scientific developments & our cultural heritage.

5. Vocational Value:-

In present age all the vocation need the knowledge of science more ever there are large no of vocations for which study of science is compulsory requirement examples: Medicine, Engineering, Computers, Para medicines, agriculture etc. The study of science at a school level is

the basis of many vocations & other productive activities in the latter life of students.

6. Utilitarian Value:-

Scientific principles & laws find a large number of applications in our everyday life. For proper utility of such applications knowledge of science is necessary Electronics, Electricity, Communication, transport etc all integral part of our life is strongly influenced & advanced due to advancement in science. Thus teaching of science is necessary from utilitarian point of view.

7. Psychological Value:-

Teaching of science is essential for developing scientific attitudes & scientific temper. The principle of learning by doing is the main basis of the teaching of science & satisfies the instincts of curiosity, creativeness, self-assertion, and self-expression etc. of the pupils.

8. Adjustment Value:-

Science develops in us a scientific attitude. It also develops in an individual a problem solving attitude. These attitudes help to solve any problems in life successfully. A person having scientific attitude lives a peaceful & successful life.

9. Leisure Time Value:-

Science has helped us to overcome the problem of passing our leisure time & to make best use of it. Science has provided us with a large number of devices such as television, radio, cinema etc. which are the source of entertainment to all of us. They also serve as source of knowledge & are used for spread of mass education & making the community aware of dangers of various ills. Science has also provided a large number of hobbies which we can pursue in our leisure time. For example Photography.

Thus from the above discussion it is very clear that a subject which is so valuable & psychologically based and so closely connected with our daily life, is justified to be included in the curriculum & hence science education is valuable in students individual life as also his life in society.

Importance of Science in Everyday Life

1. **Science has invaded every branch of modern life.** It is the noise of machines, cars, mills and factories, etc. which awakens us every-day in the morning. The food we eat, the clothes we wear, the books and

papers we read, the recreations we enjoy, the games we play – all have something or other to do with the application of science.

2. **Every person feels the effects of science in every sphere of life.** It is not merely the electric light or the electric fan, the radio or the cinema that displays the power of science in our daily life, but everything we do or is done to us is in some way or another connected with science.
3. **The things that we use in our daily life are mostly due to science.** Our forefathers put on clothes woven by hand. Our clothes are made in large factories where scientific methods are used. We get so much paper to write on only because the piper mills can turn out huge quantities of it. Cloth and paper we had even before science came on the scene but no one could then think of the huge quantities in which they are produced now.
4. **Science has conquered time and distance.** We can travel from one place to another with a quickness which our forefathers could not have dreamt of. In the morning, we get news of events that happened yesterday in all parts of the world. Why should we talk of yesterday? With the help of the radio, we can listen to an American speaking. It would seem that he is before us and we are part of his audience. If we want to send a message to a person in America, we can send an email and he will get it in a few hours. If we want to speak to our friends far from us, there is the telephone that will connect us.
5. **Effect of science of human life**: It is, indeed, true that science has added tremen-dously to the comforts and conveniences of mankind. Unless one is an ascetic, one has no reason to reject the things science offers. By conquering time and distance science has brought mankind together and so far made life richer. By inventing medicines it has made our day-to-day existence relatively free from disease, and has, indeed, added to our length of life.
6. ***Examples of use of Science in everyday life***: This fan and light works from the application of electricity. Electricity is one of the wonders of modern science. The bus which has an engine works with petroleum. The train is driven by the power of coal. This is possible only because of the application of science. My doctor gives certain injections and the patient soon well enough to come here. Medical science is another achievement of modern science, the marvel of medicine.

From the above, it is clear that science is playing an important part in our everyday life.

Unit 3 Organization of Science Curriculum

(a) Maxims of Teaching Science (Known to Unknown, Whole to Part, Empirical to Rational, Simple to complex, Concrete to abstract, particular to General)

b) Co-relation of science in the curriculum: Internal and external

c) i) Infusing global perspectives in the science curriculum (Need and Importance),

ii) Curriculum organization - Concentric and Topical approach

(a) Maxims of Teaching Science (Known to Unknown, Whole to Part, Empirical to Rational, Simple to complex, Concrete to abstract, particular to General)

Maxims of Teaching Science:-

- Maxims of teaching are pearls of wisdom, which teacher should follow for making teaching-learning process interesting and for facilitating learning.
- Maxims of Teaching are the universally facts found out by the teacher on the basis of experience. They are of universal significance and are trustworthy. The knowledge of different maxims helps the teacher to proceed systematically. It also help to find out his way of teaching, especially at the early stages of teaching.
  a. Known to Unknown,
  b. Whole to Part,
  c. Empirical to Rational,
  d. Simple to complex,
  e. Concrete to abstract,
  f. particular to General

i) Simple to Complex:

- It is well known maxims of teaching & this is the natural process of mind.
- It is also psychologically successful methods for imparting the knowledge of abiotic and biotic resources like sea & ocean.
- When simple (i.e. easy) matter is presented to the learner, he/ she feel confident and interested in learning. This motivates further learning and makes learner more receptive to learn complex or difficult aspects.

- A science teacher can show a pond or a tank to his students. Similarly a model of mountain can be used to explain various things about a mountain its role in giving shelter to various flora and fauna..
- For example, a teacher may give flower of hibiscus specimen to observe and learn. While learning the simple five whorls of the flower the students may learn initially only the simple structures or parts, its description and their immediate functions. It is only when the student leans the topic on sexual reproduction in flowering plants will they learn about the stages of pollination and fertilization, followed by theory of reduction division and formation of gametes. Thus the topic evolves as the purpose of flowering is understood from simple to complex and also the maxim from whole to parts is also seen in this example.

ii) Whole to Part:

- In the twentieth century, Gestalt psychologists proved that we first perceive the object as a whole and then its parts.
- In other words, we gain knowledge about the 'whole' first and then about the 'parts'.
- For example, when we see our fan working in our room, first of all, the whole picture of the fan comes before us and then of its parts. Similarly, when we see some tree, our attention goes on the entire tree, then on its stem, branches and leaves etc. This is called Gestalt theory.
- Remember that it is essential to study the background and environment of the object about which the knowledge is to be gained according to this Gestalt theory.
- Hence, the teacher should present before the pupils the new teaching matter as a whole and in an organized way first and then its parts should be explained on the basis of this 'whole' and organized teaching-matter.
- According to this maxim, by starting with the 'whole' object, the teacher imparts knowledge about each and every part of the object to the pupils. While teaching a language, first the sentences should be taught and then the words. In this concern, it should be pre-decided what the 'whole' is?

- Learning about something in totality is easier to understand;
- it is more motivating and helps in development of right perspective towards that thing.
- Hence teacher must first present a thing in totality first and then the finer details.

iii) Empirical to Rational:

- This maxim means to make the pupil's empirical knowledge more rational so that it becomes valid and definite.
- Remember that the empirical knowledge is that which a pupil gains through his own observations. The pupil observes usually the freezing of water in winter and converting water into steam in summer. Similarly, he looks every day rising up and setting down the sun. If the same pupils are questioned about the freezing of water and its steaming, these pupils, perhaps, will not be able to answer scientifically and logically.
- In such a situation, according to this maxim, it is necessary for a teacher to make the pupil's empirical knowledge more rational. This will make the pupil's knowledge more true and definite
- Empirical means through experimentation. Hence observation and first hand experiences become important here.
- Because of first hand experiences it is accepted easily by the learner. But every time experimentation and first hand experiences may not be possible.
- Here, rational thinking becomes more important and helps in developing higher mental abilities.

iv) Concrete to Abstract:

- It is a psychological fact that the mental development of the pupils begins with the concrete objects and afterwards he gains micro-words for them. Therefore, to begin the education of pupils, the concrete object and fact should be made known first.
- Concrete things can be visualized, whereas abstract things are imaginative.
- Child develops accurate ideas and concepts when things are presented in concrete manner and avoids misconceptions.

- Concrete things are solid things and they can be touched with five senses. But abstract things can only be imagined. So it is rather difficult to teach the children about abstract things. The students are likely to forget them soon.
- On the other hand, if we teach the students with the help of concrete objects, they will never forget the subject matter.

v) Known to Unknown:

- This maxim is based on the assumption that the student knows something. We are to increase his knowledge and widen his outlook. We have to interpret all new knowledge' in terms of the old. It is said that old knowledge serves as a hook on which the new one can be hung.
- Known is trustworthy and unknown cannot be trusted. So while teaching we should proceed from known and go towards unknown. For example, while teaching any lesson, the teacher can link the previous experiences of the child with the new lesson that is to be taught Teaching of Science.
- When student enters school, he possesses some knowledge. Teacher must take advantage of whatever is already known and link new knowledge to it. This motives learner and facilitates learning process.
- It is always better to proceed from known to unknown. It demands that the teacher should make efforts to establish some association with the previous knowledge of the students while imparting them any knew knowledge.
- For ex: while teaching about forests & their qualities the science or environmental education teacher can establish association with gardens that the students have seen. Due to this the regional science as well as geography is quite important.

vi) Particular to General:

- General facts, rules, formulae are difficult to comprehend and remember.
- If teacher gives particular examples and then proceeds to generalize, it is understood and retained better by the students.

- It is always better to cite some specific examples before proceeding to general principles of a phenomenon. It helps the students to follow things easily & properly.
- While teaching, the teacher should first of all take particular statements and then on the basis of those particular cases, generalization should be made.
- For example, if a teacher wants to explain his pupils that when the solids are immersed in a liquid, they lose their weight. He should perform two experiments before his pupils. First, the solids should be weighed in air. After this, the same solids should be weighed in a liquid. When the pupils conclude this, from their own observation and testing, that the solids lose their weights while immersed in a liquid, they will derive this general principle themselves without any difficulty. In this way, in any subject, especially while teaching science, mathematics and grammar; various laws can be derived with the help of pupils.

b) Co-relation of science in the curriculum: Internal and external

Co-relation:-

- Knowledge is one whole. We have divided it into various subjects for our convenience. But these subjects are not water-tight compartments.
- Co-relation is the reciprocal relationship between various subjects of the curriculum. It makes studying easier, interesting and natural.

Definition:-

1) According to **dictionary,** the meaning of correlation is mutual relations.

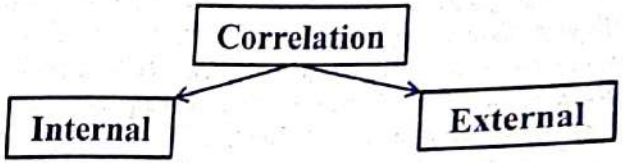
2) "Correlation is technique which tries to establish relationship between various subjects of curriculum."

3) Defines correlation as, "Bringing together the elements of two or more different subjects matter fields that bear on the same large problem or area of human experience in such a way that each element is reinforced, broadened and made richer through its association with the elements from the other fields."- **Carter V. Good**

4) "Correlation as a word signifies as the reciprocal relationship among the various subjects of the curriculum. A child cannot learn the various subjects of the curriculum in isolation and correlation of different subject is very essential for checking artificiality of treatment and for integration of the knowledge."- ds- **K.L. Arora**

5) "Facts and ideas have a real and useful influence over the mind only when the mind systematizes and co-ordinates them with other facts and ideas they are provided."

- In studying Science there are two types of co-relations – internal and external.
- Science has many branches and sub-branches, main ones being physics, chemistry and biology. All these branches are interdependent.



Within the subject
Physics
Chemistry
Biology

Other subjects
Languages
History
Geography
Mathematics
Art and Craft
Environmental studies

Internal co-relation

- Internal co-relation is the one, where v
co-related to each other.

External co-relation:

- Science is a part of whole quantum of knowledge. While teaching, teacher has to bring out the relationship of science with other parts of that quantum, such as languages, social sciences, art and craft, fine arts etc. This helps in developing holistic view and better application of the knowledge learnt.

External co-relation: (Correlation of Science with other Subjects) :-

As known that for overall development of the students, various subjects are being included in the curriculum. These subjects are not selected on ad-hoc basis, but this decision is taken after proper consideration and analyzation. Generally those subjects are included in the

curriculum which is found to be complementary to each other, as the main objective of all of them is to achieve set objective of education that is to bring about over all development of the students.

Science is quite a complex and vast kind of subject, because of which the task of correlating it with other subjects of curriculum seems to be quite an easy task. Deliberate effort should be done by the science teacher to bring about co-relation in between the science and other subjects of the curriculum, which are being imparted to the students.

Through this, students will find the opportunity to relate the knowledge which they have already gained, with the knowledge which they are gaining. This kind of relation activity leads to development of interest among the students.

While imparting knowledge of one subject, teacher gets much help in communicating his ideas if he makes use of examples or reference of concepts covered by other subjects. Although it is not very easy to co-relate various subjects with the complex subject like science, but it is not impossible. This can be done in the following manner:-

Science and Language:

Although Science is a practical subject, but it is very important for its learners to be able to express their views and ideas in clear and attractive form. For this purpose, it is necessary that they should have thorough knowledge of language which they use. Student who does not have good control over the language cannot express his views and various scientific laws and principles in front of others and especially in front of teacher.

Today, as a result of adoption of uniform technical terms and symbols, vocabulary of different languages have been enriched to considerable extent. In making students able to give answers of various scientific queries, in effective manner, either in written form or orally, science teacher and language teacher should take up a joint responsibility on their shoulders.

To co-relate science with language subjects, students can be asked to write essays on some scientific topic. If student make any kind of grammatical mistake, then the teacher can ask him to make correction in his language. Likewise, language teacher can give the task of writing about some scientific happening in the assignment designed for them. In this manner, he can correlate science with the language.

Science with Mathematics:

A large number of scientific principles and rules are represented in the form of mathematical expressions, for which it is very necessary for the student or person intending to get advanced study of science subjects to have sound mathematical basis. Without making use of mathematical expressions and rules, it is not possible for any teacher to conduct science teaching in effective manner.

The significance of mathematics in the science can be proved by the views of the experts that mathematics has given sound footing to the scientific laws and principles. Before beginning any topic in the science, it is essential for the teacher to make sure that mathematical basis of all the students is strong and vast.

Probably, mathematics is considered to be sole language of science because of which real understanding of science is considered to be impossible without adequate knowledge of mathematics. Some of the useful mathematical tools which are generally used in the science teaching are Algebraic equations, Geometrical formulas, Graphs etc.

Correlation existing in between one of the subject of science and mathematics can be understood. Astrology is an advanced branch of science in which it is predicted or enumerated that which planet revolves at which speed and when it will get appeared to the people of earth.

This is quite complex area, and no one can enter into this complex area without having a sound mathematical basis. Likewise, mathematical rules and theories are also applied to considerable extent in physics, in which no one can intend to take even single step without relying on the subject of mathematics.

Thus, it can be said that science teacher should make all efforts by which he can establish co-relation in between the subjects of science and mathematics. It will not be improper in any way to consider both of these subjects as complementary to each other, which can be studied simultaneously or at the same time.

For this reason it can be said that without making use of examples from mathematics, it is not possible for science teacher to explain various scientific principles and concepts properly to the students. To make it possible, sincere and deliberate efforts should be made by science as well as mathematics teacher to co-relate both the subjects in accordance with the syllabus.

Science and History:

It sounds quite amazing that some kind of correlation can exist in between the science and history as earlier subject is practical in nature while nature of later subject is purely theoretical. However, it is possible to co-relate these subjects with each other.

While mentioning about the various scientific discoveries taken place in the earlier periods, teacher can relate with the major events of the world history. Students should be told about, what was the situation of science at the time of reigns of various famous kings or rulers. Teacher should narrate to the incidences which inspired various scientists to found out the medical remedies of various diseases.

Not only this, the function of co-relating science with history can be done by mentioning the kind of living standard people used to experience at different parts of the human history. With such knowledge, they will become aware of the scientific concepts like sanitation and healthful living.

Science and Geography:

Geography is the subject in which various concepts relating to earth on which we live are dealt with. Everything existing on earth, on different planets of the universe is also main subjects of geography. Which kind of crop should be sown in which kind of soils, how many kinds of rocks are found on the earth are some of the main topics which are covered by Geography. One will be surprise by this fact as these topics are also covered by the subject of Science.

In science, various concepts relating to the atmosphere and earth in which living and non-living beings exist are made. For this reason, temperature, wind directions and measurement of rainfall are conducted in the subject of science by making use of various apparatus.

Results obtained by the science in terms of climate and the manner in which it affect the human beings and earth are being interpreted by subject of Geography. The manner in which, it is mentioned by the geography that how soil gets produced through crushing process of rocks, it makes the subject a special branch of science.

Therefore, geography lessons on these subjects will be best understood and appreciated if they have been discussed in length by the science teacher. There are various topics which are of common interest for

geographers and scientists. Thus, it can be said that both of these subjects are complementary to each other. Both of these subjects are very near to each other, thus science teacher will not find any kind of problem in relating science with the subject of geography.

Science and Social Studies:

If one explores the history of development of human society, he will find various incidences in which human got victory over forces of nature, by which he got control over the land, sky and seas. As said that an important impact of science teaching is that outlook and perspective of students or people become scientific in nature, as a result of which, various kinds of changes take place in their way of living.

Scientific thinking affects the standard of living of human beings to considerable extent, as through such information, outlook and perspective of human beings become more wide and they can freed themselves successfully from the clutches of superstitions and false beliefs.

Various evidences can be found in our life which can show the significant way in which life style of human beings have got affected by inclusion of scientific developments in their life. Today, we can found various kinds of machines for performing different functions, about which primitive men even did not think.

As a result of these machines, our life has become very easy and smooth and now we can accomplish complex functions within short period of time, which were considered to be very time consuming. Not only this, various research works has led to development of various medicines with the help of which physicians have found the remedies of various diseases, which were once considered to be incurable and were responsible for bringing about heavy loss of life in earlier times.

Not only this, earlier a large number of manpower was being engaged in the agricultural sector, but now we are moving towards highly developed industries, as a result of which we are ready to participate in the competition taking place in global market. We have third highest number of professionals engaged in different areas of the world.

Now a large number of students intend to get education from foreign universities, but they want to serve their own nation and want to play effective role in bringing about development of the nation with greater pace. Earlier people were not provided with the developments taking place

in the scientific area, as a result of which they used to accept all the orders imposed on them.

But now, in a scientific advanced time, people have learned that being human beings, they have certain rights, and if any attack is being made on their rights, they begin to agitate. This can be the possible reason that why women of our nation has attained those rights which were not permitted to them in the earlier time.

Another change which has taken place in our society through such reasoning ability is the manner in which people belonging to minority section of the society are asking or reservations in various spheres of the life. They are asking about reservations in educational institutions and even in parliament of the nation.

Thus it can be said that science and social sciences are two subjects which can be co-related with each other without much problem. A science teacher can correlate science with social studies on different occasions by providing suitable relations of relevance.

Science and Civics:

The main objective of imparting information of both the subjects is to create good and useful citizens for the nation, thus it is possible to correlate both of these subjects with each other. Through science, students become able to understand the utility of scientific inventions in their life, by which they become more responsible.

They begin to realize a sense of responsibility, which help them in playing important role in development of the nation. Through information of scientific facts, students get to know about various kinds of diseases and the role which they can play in creating a healthy and clean atmosphere around them. Through this kind of information, they become more responsible citizens and play an important role in creating an ideal civic life in the society and nation as a whole.

Science and Art:

It is considered by the majority of people that it is science who has contributed a great deal in developing the field of art, but this is not true, as both of these subjects or areas has played important roles in enriching each other. All types of arts have got enriched as a result of scientific developments, but it is not possible for a science teacher to impart

information relating to various scientific facts and principles without having thorough control over the art.

As known that science is a practical subject, as a result of which, science teacher is required to draw various kinds of diagrams, models and charts, which cannot be performed unless he does not have sound artistic skills. Not only this, it is equally important for an artist to have thorough knowledge of scientific principles, as without it, he will find it difficult to keep the colour contrast of his images in attractive and controlled position.

An artist should know the principles of light and shade, objects and background for drawing or keeping the colour contrast in attractive condition. Thus, it can be said that some common features are found in the subjects of science and art, because of which they can be co-related with each other effectively.

Science and Music:

In our nation, music has its own importance as different kinds of songs are found in different parts of the nation. There are songs and theories of music in different languages. Various musical stars got born in our nation, but the number of persons engaged in musical area has diminished to considerable extent as now people consider it as wastage of time and efforts.

To encourage people and especially students to get involve themselves in professions having their roots in music, this has been accepted as an independent subject in various schools and institutions and it forms an integral part of school curriculum. For the students of music, knowledge of resonance, vibration systems in strings and air columns is very necessary and important.

To make improvements in their voice and manner of singing, various scientific equipment's are being used today, which could not come into being without scientific developments? Thus, it is only through the utilization of scientific developments in the real life that led to development of various apparatuses used in the musical field. Science teacher can relate subject of science with the music by narrating the students that what led to development of various equipment's used by the musicians and on which principles do they operate or function.

Science and Craft Works:

Some people will find it quite unsound to relate science and craft works with each other, but various kinds of improvements can be brought about in ability of students to understand various scientific principles and facts. During craft periods, students can be provided with the task of designing various pieces of scientific apparatuses and equipment's.

Through such step, scientific interest can be developed in the students, which will help in arousing the interest of students in various scientific incidences. An urge will get developed in them to see or observe the equipment's or apparatuses designed by them in reality, by which they will be motivated to get more and more information regarding the research functions conducted in the scientific field through various means and sources.

Thus, it can be said that if science teacher will relate science with other subjects of the curriculum, then he will get more justifiable and satisfactory results.

c) i) Infusing global perspectives in the science curriculum (Need and Importance),
ii) Curriculum organization - Concentric and Topical approach

i) Infusing global perspectives in the science curriculum (Need and Importance):-

Meaning and concept of Global Perspectives:-

Globalization is mainly concept from economics and has been the most widespread trend of the present century. It has impacted every aspect of our life including education.

Meaning-

- An attitude that develops a sense of shared humanity towards the overall goal of world harmony.
- Awareness that we live in an interdependent world and that we cannot ignore the problems faced by mankind.
- It involves taking a broader and more critical view of experiences, learning and knowledge and includes seeking to understand the links between our own lives and those of people throughout the world.
- Through issues like pollution, global warming, depletion of natural resources, energy crisis, extinction of some species Science can highlight the aspect of global perspective in more natural way to learners.

- A global perspective is far more than an understanding of worldwide business and international career opportunities.
- Developing a global perspective involves taking a broader, more critical view of experience, knowledge and learning and includes seeking to understand the links between our own lives and those of people throughout the world.

What is a Global Perspective?

Hanvey (1976, p. 163) defined a global perspective as being composed of five elements or dimensions:

1. Perspective Consciousness
2. State of the Planet Awareness
3. Cross-Cultural Awareness
4. Knowledge of Global Dynamics
5. Awareness of Human Choices

Need for Global Perspectives:

- Due to scientific and technological development world has come very close and there is need to realize the importance of 'learning to live together'. There is need to realize that whatever happens in one part of the world has its impact in other part, which may be physically far away.
- It involves taking a broader and more critical view of experiences, learning and knowledge and includes seeking to understand the links between our own lives and those of people throughout the world.

Global Perspectives aim at:

- Encouraging empathy and mutual understanding by exposing students to different worldviews.
- Developing skills and attitudes among students to bring about effective change leading to more just and peaceful world.
- Preparing students to live in the world of increasing interdependence.
- Developing students' ability to think critically and have independence of mind in order to undertake whatever constructive action is appropriate.

- Work towards a more just and sustainable world where power and resources are more equitably shared.
- Develop skills, attitudes and values to enable people working together to bring about change for 'common good' and to take control of their own lives

Infusing Global Perspectives in the Science Curriculum:

- This is an approach to teaching and learning which promotes a critical awareness of issues of development, both locally and globally and enables students to acquire the knowledge, skills and attitudes which are essential for global citizenship and social justice.
- This can be done effectively and easily more through Science than any other school subject.
- Science, through issues like pollution, global warming, depletion of natural resources, energy crisis, extinction of some species can highlight the aspect of global perspective in more natural way to learners.

Infusing GP in the science curriculum

I. Incorporating a range of key concepts as appropriate

- *citizenship*
- *social justice*
- *interdependence*
- *sustainable development*
- *human rights*
- *values and perceptions*
- *diversity*
- *conflict resolution*

II. Incorporating a range of perspectives from different countries/communities:

- Feel for 'real world problems'
- Increasing students' sensitivity to local needs and problems and putting them in the global concerns, constraints and opportunities. Examples of solutions arrived at in different contexts.
- Eg. Nile Purification Project successfully carried out in Egypt can be related to Ganga Purification Project.

III. Including action for change

- Small actions to bring about change.
- Personal → local → global
- Strategies used for sensitization: games, role-play, stories, scientific inquiries or simple activities.

IV. Developing sustainable practices

- encourage those practices that are enduring
- incorporate into the curriculum
- Focus on exposing the students to socio-cultural realities of life, bringing in a new dimension of social relevance.

Steps to introduce GP through the Science curriculum:

- Identify two to three key concepts
- Locate plug points in the science curriculum
- Collect data/ information (both local and global)
- Design participatory methods/approaches
- Use appropriate strategies to further sensitize students to the issue
- Decide on small action- student initiative.

ii) Curriculum organization - Concentric and Topical approach

1. Topical Approach

Topical approach as suggested by name is of the opinion to allot a definite number of topics related to the study of science to the curriculum of any of the grades. In applying this approach, therefore a few topics of science may be marked for being included in the curriculum of a particular grade and then it is expected to cover all the contents or learning experiences related to that topic in that grade or class and not allowing their repetition in any way in the junior or senior grades. Thus a topic marked for a particular grade must have the beginning and end in that way grade without needing it to be taught in the earlier and later grades.
E.g: If we include the topic 'climate' in the curriculum of science of class VII. Hence we must include all what is taught on this topic to the students during the entire stage of secondary education, in this way we are required to have different sets of topics for their inclusion in the curriculum of different grades of elementary and secondary stages of school education.
Adaptation of this approach for the organization of science curriculum in science is sometimes credited for helping the students and teachers

- To deal with the simple topics in the earlier grades and difficult one in the higher grades.
- To focus only on a few topics included in their present curriculum while leaving the rest to the earlier or later grades.

Merits

- It provides continuity
- It gives significance to content
- Each topic has transfer value for other topics
- It facilitates learning.
- As topics are most easy to teach rather than the complicated content of thee text. It provides an effective aid for the teacher.
- The topical arrangement is helpful in advising the duplication in the curriculum.

Limitations

- Sometimes topic is not selected carefully to avoid duplication.
- It implies a false and misleading simplicity.
- As there is no agreement as to what constitutes a suitable topic, therefore some topic included are trivial and others are all inclusive.
- The sum total of topics falls for short of the subject or field.
- A proper study of topics requires a better library than is usually available.
- Lack of efficient teachers for proper selection of topics.

2. Concentric Approach or Spiral Approach

According to this approach children in the primary classes begin to develop simple generalizations about man carrying on his everyday activities. Gradually as they progress through the middle and high classes, they work with more and more difficult arrangement of information, and as a result, deepen and reshape the dimensions of their generalizations about these activities. Thus by the time they complete the secondary stage, children refine the same generalization many times using increasingly more abstract level of thought at each higher section of learning. An attempt is made to design a sequential arrangement of experiences that will produce a spiral of cumulative learning. Areas of study at each level are treated holistically – whatever is taught to the child is a whole in itself at

the same time, leaves scope for additions to be made with the addition of understanding and maturity on the part of the child.

Thus concentric approach is nothing but devising a strategy that fosters continuous, unbroken learning of the subject matter of social science through the primary, middle and secondary stages.

Although, in this approach the path is narrower the way is simpler, the pupil gets somewhere and will not easily forget his journey. Moreover he is interested from the very beginning. It is easy to proceed from the known to the unknown.

Use of this approach will make science a subject of immediate and real interest. For the average pupil, it will be the basis of an abiding interest and for the more intellectual; it will be the basis on which surely academic and specialist study can be built.

Merits

- Continuous learning of the subject matter through primary to the
- Simple to complex.
- Easy to proceed from known to unknown
- Provides basis for specialization

Limitations

- It is argued that the approach is psychologically unsound. The same facts are repeated again and again. The presentation being devoid of freshness and novelty fails to rouse curiosity and a sense of wonder in the pupil.
- It is difficult to develop time and space sense in the pupils through this approach.
- It is difficult if not possible to give a clear picture of a problem, vivid with detail.
- Hurried and passing references will not be of help in understanding complex problems.
- If this approach is followed, it is difficult to develop time and space sense in the problem
- A sense of boredom and dullness is inevitable because the children have gone through the whole course more than once. They develop a sense of familiarity without the fullness of knowledge.

MODULE 2 TRANSACTING SCIENCE CURRICULUM

Unit 4 Science Teaching: Methods, Approach and Tools

a) Methods of Teaching Lecture cum demonstration method, Project method, Problem solving method
b) Approach: Inducto – Deductive approach
c) Concept Mapping – Meaning, Steps and significance, PEOR (i.e. Predict, Explain, Observe and React)

a) Methods of Teaching Lecture cum demonstration method, Project method, Problem solving method

(a) Lecture cum demonstration method:-

Lecture Method

It is oldest teaching method given by philosophy of idealism. As used in education, the lecture method refers to the teaching procedure involved in clarification or explanation of the students of some major idea.

This method lays emphasis on the penetration of contents. Teacher is more active and students are passive but he also Uses question answers to keep them attentive in the class. It is used to motivate, clarify, expand and review the information. By changing Ms Voice, by impersonating characters, by shifting his posing, by using simple devices, a teacher can deliver lessons effectively, while delivering his lecture; a teacher can indicate by her facial expressions, gestures and tones the exact slode of meaning that he wishes to convey.

Thus we can say that when teacher takes the help of a lengthy-short explanation in order to clarify his ideas or some fact that explanation is termed as lecture or lecture method and after briefing about lecture method. Let's see what a demonstration is.

Demonstration method:

The dictionary meaning of the word "demonstration" is the outward showing of a feeling etc.; a description and explanation by experiment; so also logically to prove the truth; or a practical display of a piece of equipment to snow its display of a piece of equipment to show its capabilities . In short it is a proof provided by logic, argument etc.

To define "it is a physical display of the form, outline or a substance of object or events for the purpose of increasing knowledge of such objects or events.

Demonstration involves "showing what or showing how". Demonstration is relatively uncomplicated process in that it does not require extensive verbal elaboration.

Now it will be easy to define what is lecture cum demonstration method. To begin with, this method includes the merits of lecture method and demonstration method. The teacher performs the experiment in the class and goes on explaining what she does. It takes into account the active participation of the student and is thus not a lopsided process like the lecture method. The students see the actual apparatus and operations and help the teacher in demonstrating experiments and thereby they feel interested in learning. So also this mehod follows maxims from concrete to abstract Wherein the students observe the demonstration critically and try to draw inferences.

Thus with help of lecture cum demonstration method their power of observation and reasoning are also exercised. So the important principle on which this method works is "Truth is that works."

Requirements of good Demonstration:

The success of any demonstration following points should be kept in mind.

1. It should be planned and rehearsed by the teacher before hand
2. The apparatus used for demonstration should be big enough to be seen by the whole class. If the class may be disciplined she may allow them to sit on the benches to enable them a better view.
3. Adequate lighting arrangements be made on demonstration table and a proper background table need to be provided.
4. All the pieces of apparatus be placed in order before starting the demonstration. The apparatus likely to be used should be placed in the left hand side of the table and it should be arranged in the same order in which it is likely to be used
5. Before actually starting the demonstration a clear statement about the purpose of demonstration be made to the students.
6. The teacher makes sure that the demonstration lecture method leads to active participation of the students in the process of teaching.

7. The demonstration should be quick and slick and should not appear to linger on unnecessarily.
8. The demonstration should be interesting so that it captures the attention of the students.
9. It would be better if the teacher demonstrates with materials or things the children handles in everyday life.
10. For active participation of students the teacher may call individual student in turn to help him in demonstration.
11. The teacher should write the summary of the principles arrived at because of demonstration on the blackboard. The black board can be also used for drawing the necessary diagrams.

These are some of the requirements of good demonstrations.

Steps needed to conduct a Lecture -cum demonstration lesson.

1. Planning and preparation:

A great care is taken by the teacher while planning and preparing his demonstration. He should keep the following points I mind while preparing his lesson.

a. Subject matter.
b. Questions to be asked.
c. Apparatus required for the experiment

To achieve the above stated objective the teacher should thoroughly go through the pages of the text book, relevant to the lesson. After this he should prepare his lesson plan in which he should essentially include the principles to be explained, a lot of experiments to be demonstrated and type of questions to be asked form the students. These questions be arranged in a systematic order to be followed in the class. Before actually demonstrating the experiment to a class, the experiment be rehearsed under the condition prevailing in the classroom. In spite of this, something may go wrong at the actual lesson, so reserve apparatus is often useful the apparatus has to be arranged in a systematic manner on the demonstration table. Thus for the success of demonstration method a teacher has to prepare himself as thoroughly as possible.

2. Introduction of the lesson:

As in every subject so also in the case of science the lesson should start with proper motivation of the students. It is always considered more useful to introduce the lesson in a problematic way which would make the student's realize the importance of the topic. The usual way through which

the teacher can introduce the lesson is by telling some personal experience or incident of a simple and interesting experiment. A good experiment carefully demonstrated is likely to leave an everlasting impression on the mind of the young pupils and would set the students talking about it in the school.

3. Presentation:

The method presenting the subject matter is very important. A good teacher should present his lesson in an interesting manner and not in an boring manner. To make the lesson interesting the teacher may not be very rigid too remain within the prescribed course rather he or she should make the lesson as much as broad based as possible. For widening the lesson the teacher may think of various useful application taught by him. He is also at the liberty to take examples and illustrations for allied branches of science like history, geography etc. Constant questions and answer should form a part of every demonstration lesson. Questions and cross question are essential for properly illuminating the principles discussed. Question should be arranged in such a way that their answers may form a complete teaching unit.

4. Performance of experiment:

A good observer has been described as a person who has learnt the use the senses of touch, sight, smell in an intelligent way. Through this method we want children to observe what happens in a experiment and to state it carefully. We also want them to make generalization without violating scientific spirit i.e. we should allow children from one experiment or observation. The following steps are generally accepted as valuable in conducting science experiment generally.

a. Write the problem to be solved in simple words.
b. To make a list of activities that has to be used to solve the problem.
c. Gather material for conducting the experiment
d. Work out a format of steps in the order of preocedu8re so that everyone knows what is to be done.
e. Teacher should try the experiment before conduction. f. Record the findings.
g. Assist students to make generalization.

5. Black Board Summary:

A summary of important results and principles should be written in the Blackboard. Use of blackboard should be also frequently used to draw

sketches and diagrams. The entire procedure should be displayed to the students after the demonstration.

6. Supervision:

Students are asked to take the complete notes of the black board summary including the sketches and diagrams drawn. Such a record will be quite helpful to the student while learning his lessons .Such a summary will prove beneficial only if it has been copied correctly from the black boards and to make sure that it is done so the teacher must check it frequently during this stage.

Common Errors in Demonstration Lesson

A summary of the common errors committed while delivering a demonstration lesson is given below:

a) Apparatus may not be ready for use

b) There may not be an apparent relation between the demonstration experiment and the topic under discussion.

c) Black board summary not up to the mark

d) Teacher may be in a hurry to arrive at a generalization without allowing students to arrive at a generalization from facts.

e) Teacher may take to talking too much which will mar the enthusiasm of the students.

f) Teacher may not have allowed sufficient time for recording of data.

g) Teacher may fail to ask the right type of questions

Role of teacher:-

The teacher has to perform following roles:-

1. Encourage students to participate in discussion.
2. Ensure, student's attention span is maintained.
3. Pre plan and prepare properly for discussion and support ideas with factual evidence and examples.
4. Encourage student taking than teacher talking.
5. If possible give time before hand so that, the discussion becomes productive.
6. Do not dominate rather get the discussion started set goals, summarize, mediate and clarify.

Merits of Lecture cum Demonstration Method

a) It is an economical method as compared to a purely student centered method

b) It is a psychological method and students take active interest in the teaching learning process

c) It leads the students from concrete to abstract situations

d) It is suitable method if the apparatus to be handled is costly and sensitive. Such apparatus is likely to be handled and damaged by the students.

e) This method is safe if the experiment is dangerous.

f) In comparison to Heuristic, Project method it is time saving but purely Lecture method is too lengthy

g) It can be successfully used for all types of students

h) It improves the observational and reasoning skills of the students

Limitations of Lecture cum Demonstration Method

a) It provides no scope for "Learning by Doing" for the Students as students are only observing the Teacher performing.

b) Since Teacher performs the experiment at his/ her own pace many students may not be able to comprehend the concept being clarified.

c) Since this method is not child centered it makes no provision for individual differences, all types of students including slow learners and genius have to proceed with the same speed.

d) It fails to develop laboratory skills in the students.

e) It fails to impart training in scientific attitude. In this method students many a times fail to observe many finer details of the apparatus used because they observe it from a distance.

Suggestion for improvement:-

1. The teacher must maintain good eye contact with students in order to make the process meaningful.
2. The teacher must actively involve students.
3. The teacher must instruct clearly.
4. Must keep the group focused on the task.
5. Teacher should use good time management techniques and evaluate students as they learn in the class.
6. Teacher should not read extensively from lecture notes or text books.
7. Teacher must not ignore participant's comments and feedback.

(b) Project method:-

The project method is the outcome of the pragmatic educational philosophy of Dewey, the well-known American philosopher-cum educationist. It was developed and perfected by Dr. William Kilpatrick, Head of the University of Columbia.

Definitions:

W.H. Kilpatrick : A project is a whole-hearted purposeful activity proceeding in a social environment.

Ballard: A project is a bit of real life that has been imported into the school.

Burton: The problem is a project which results in doing. The motor element is not what makes the activity a project, but the problem-solving off practical nature accompanying the activity.

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

Snedden: Project is a unit of educative work in which the most prominent feature is some form of positive and concrete achievements.

W.W.Charters: In topical organization principles are learned first while in the projects the problems are proposed which demand in the solution the development of principles by the learner as needed.

The following points have been stressed in the above-mentioned definitions of the project:

1. A project is a problematic act.
2. A project is a purposeful activity.
3. A project is a whole-hearted activity.
4. A project is an activity in natural setting.
5. A project is an activity is a social setting.
6. A project is a bit of real life introduced in school.
7. A project is a problem solving of a practical nature.
8. A project is a positive and concrete achievement.
9. A project is an activity through which solution of various problems are found out.

Main Principles of the Project Method

1. The Principle of Purpose: *Knowledge of purpose is a great stimulus which motivates the child to realize his goal. The child must have an ideal.*

'Why is he doing certain things?' Purpose motivates learning. Interest cannot be aroused by aimless and meaningless activities.

2. The Principle of Activity: Opportunities should be provided to students that make them active and learn things by doing. Physical as well as mental activities are to be provided to them. They are to be allowed to 'do' and to 'live through doing'.

3. The Principle of Experience: Experience is the best teacher. What is learnt must be experienced. The children learn new facts and information through experience.

4. The Principle of Social Experience: The child is a social being and we have to prepare the student for social life. Training for a corporate life must be given to him. In the project method, the students work in groups.

5. The Principle of Reality: Life is real and education to be meaningful must be real. The project method is a method of education the child and therefore, it must also be real. Real life situations should be presented in the life of the school.

6. The Principle of Freedom: The desire for an activity must be spontaneous and not forced by the teacher. The student should be free from imposition, restrictions or obstructions so that he may express himself fully and freely. He must be given the freedom to choose an activity, to do an activity according to his interests, needs and capacities.

7. The Principle of Utility: Knowledge will be worthwhile only when it is useful and practical. This method develops various attitudes and values which are of great significance from the practical point of view.

Different Types of Projects -W.H.Kilpatrick

- Producer type
- Consumer type
- Problem type
- Drill type

1. 'The Producer type', in which the emphasis is directed towards actual construction of material object or article.
2. 'The Consumer type', where the objective is to obtain either direct or various experience, such a as reading and learning from stories, listening to a musical delectation etc.
3. 'The Problem type', in which the chief purpose is to solve a problem involving the intellectual processes.

4. 'The Drill type', where the objective is to attain a certain degree of skill in a reaction- as learning a vocabulary.

Various Steps in a Project

1. Providing a situation
2. Choosing and Purposing
3. Planning
4. Executing the Plan
5. Judging
6. Recording

1. Providing a situation:-

The teacher provides a situation to the students which must create same problems and students must feel interested to work.

2. Choosing and Purposing

The students are tempted to choose a project. The teacher should stimulate discussion by suggestion. While choosing the project the teacher should bear in need that it should be of real need to students. The purpose of project must be clearly defined to the students. The project must be common and acceptable to all. In case of wrong choosing, teacher must help students tactfully to see that the students choose a better project. They should be asked to write down the reasons for selection.

3. Planning

The success of the project lies in the good planning. The students should plan out ht whole project under the guidance of teacher. Every child must be encouraged to participate in the discussion and make suggestion. All the students are encouraged to write down the plan neatly and properly.

4. Executing the Plan

Execution of different activities to different students on the basis of their capacity leads to successful completion of the project work. It is the longest step and requires meticulous assignment of duties to different students or groups the teacher must guide and encourage students. It is the duty of the teacher to keep watch on the process of activities and instruct as and when requirement.

5. Judging/Evaluation

This is very important step as; the students review the project and find out mistakes if any. Self-Criticism is very important at this stage. The students discuss their work and rectify their mistakes and recollect useful

knowledge. The teacher sees that the objectives of the project have been achieved.

6. Recording

The students keep a complete record of entire activity. How they planned, discussions were held, how duties are assigned, how criticism were made, which will help them in their future work.

Examples of Projects: -

i) Arrangement of science fair.
ii) Preparation of soap/chalk/candle/ink etc.
iii) Improvise apparatus.
iv) Beautifying campus.
v) Establishing science museum.
vi) Establishing physical science laboratory.
vii) Painting iron apparatus to present it from rusting.

Essentials of a Good Project

- Timely
- Usefulness
- Interesting
- Challenging
- Economical
- Rich in experiences
- Cooperativeness

Role of A Teacher:-

Guide, Partner, Motivator, Stage setter, Evaluator, Gives references Facilitator

1) The teacher is not a dictator or a commander but a friend, guide and a working partner.
2) He should provide occasions for shy pupils to come forward and contribute something towards the success of the project.
3) He should help the students in developing the character and personality by allowing them to accept the responsibilities and discharge them efficiently.
4) He should provide democratic atmosphere in the class so that the pupils can express themselves fully without any fear of the teacher.

5) He should be alert and active all the time to see that the project is running in its right lines.
6) He should have a thorough knowledge of individual children so as to allot them work accordingly.
7) He should have initiative, tact and zest for learning
8) The project to be successful must be based on a definite procedure. The first and the main responsibility of the teacher is to provide those situations to the students wherein they should feel a spontaneous urge to solve some of their practical problems.
9) The teacher must be on the lookout of discovering their interests, tastes, aptitudes and needs. There are different methods of providing situations. As far as possible, problems or situations which are provided to the students should be social ones. These provide better social training and give more satisfaction.
10) The teacher may converse with the class on different topics of interest to them. Pictures of different scenes may be shown to them. Surveys of the local condition may be undertaken.
11) The teacher is to tap all resources to provide worthwhile situations. Most of the educators are of the view that the projects should be selected by the students themselves. They think that this will stimulate pupil purposing and that they will be more interested in their work if they have a share in determining what they are to make. Others who think that teachers should select the projects argue that this method will ensure that the students undertake only those projects which are within their reach. Students are immature and they require adequate guidance to select their projects.

Merits of the Project Method

1) It promotes Co-operative activity.
2) It arouses and maintains interest of students.
3) It keeps the students on freedom of thought and action while doing the work.
4) It develops scientific attitude.
5) It widens the mental horizon of student.
6) It develops dignity of labor.
7) The students learn by self-activity.
8) It supports all the laws of learning i.e., law of readiness, law of exercise, law of effect.

9) The correlation of subjects is best followed in this method. The subjects are not treated as water tight compartments.
10) This is a psychological method.

Demerits of the Project Method

1) Neglecting intellectual work
2) Haphazard and unconnected teaching
3) Upsetting of the time-table
4) Neglect of drill work
5) Difficulty in getting suitable text-books
6) Artificial correlation
7) Unsuitable for the shirkers and shy
8) Too much reliance on young children
9) Lack of competent teachers
10) Unsuitable for transfers
11) The knowledge is not acquired in a sequential manner.
12) There may be a chance of overlapping of subject matter.
13) If not planned and executed properly them, it may not be completed in time.
14) It is a time consuming process.
15) It may be a costly affair where in same items/things may not be available at times.
16) There may be overdevelopment of individualism and under development of co-operation and group responsibility.
17) If the topic in wrongly selected them the objective may not be achieved.
18) It gives to students a superficial knowledge of great many things. Therefore it is not suitable for all types of students.
19) This method is not suitable for a mature teacher.
20) The whole syllabus, for higher classes cannot be accomplished with this method.

Suggestions to improve: -

1. The topic should have same educational value.
2. Project should be selected according to the student's interest.
3. Entire course should not be planned only using this method.
4. The objectives of the project must be clear and defined.

5. Students should be assigned various duties according to their capabilities.
6. The students should be given freedom to interact among themselves.

(c) Problem solving method:-

Life is full of problems and the successful person in life is he who is fully equipped with adequate knowledge and reasoning skill to tackle these challenging problems. Therefore, the function of education is to enable the child to adjust and adapt himself to the environment, problem solving must be encouraged in the schools.

Meaning and Definition:-

Problem solving may be defined as a planned attack upon a difficulty or perplexity for the purpose of finding a solution. It is a method in which a person uses his ability to solve problems which confront him.

Gates: "A problem exists for an individual when he has s definite goal he cannot reach by the behavior pattern which he already has available."

Simpson: "a problem occurs in a situation in which a felt difficulty that is clearly present and recognized by the thinker. It may be a purely mental difficulty or it may be physical and may involve manipulation of data. The distinguishing thing about a problem, however, is that an individual who meets it as needing a solution. He recognizes it as a challenge."

Dewey: "The problem fixes the end of thought and the end controls the process of thinking."

Essential Features of A Problem

_ Meaningful, interesting and worthwhile for students
_ Correlation with life
_ Correlation with other subjects
_ Arise out of the real needs of the students
_ Clearly defined
_ Educational value
_ Solutions to be found out by the students

STEPS IN PROBLEM SOLVING METHOD: -

1. Selection of problem.
2. Presentation of problem.
3. Collection of facts.
4. Drawing an outlines.

5. To reach a satisfactory conclusion.
6. Evaluation.
7. Writing report.

1. Selection of problem.

A remember of problems are confronted by the students in the class or outside. They are made to select a problem as per their capacity and interest.

2. Presentation of problem.

Each student is made to feel responsible for presenting the problem in front of the teacher and class as per his insight. The students are free to give their suggestions on the problem.

3. Collection of facts.

All the facts related to problem are collected either by a students or group. As a number of facts will be collected, it will help the students to keep the most pertinent facts and discard rest.

4. Drawing an outlines.

This is most important phase as a proper outline at this stage will lead to purposeful activity. The teacher will guide students to draw exact plan and follow it properly so that the solution to problem is reached. It is more or less like planning stage, where in a clear indication of outline leads to better result.

5. To reach a satisfactory conclusion.

It is the longest step and requires outmost patience. The tentative solutions which are offered by students are properly noted down. A good number of arrangements, discussion and brainstorming results in reaching a satisfactory conclusion. The teacher has to be very careful at this stage as, if may lead to wrong conclusions. The discussions must be healthy and conducive atmosphere must be provided in the classroom for it.

6. Evaluation.

The students review the entire process and find out each and every stage where in they have made any mistakes. Self-criticism and Self-realization will give training of self-confidence. The teacher must see that objective have been achieved.

7. Writing report.

A complete report must be written by students. This will include, how they planned, what discussions were held, how duties were assigned, how satisfactory conclusion was reached etc. the writing of report will be maintained as a record which will be used in future course of time.

Teacher's Role in Problem Solving:-

- Selects problems
- students' development of thinking or reasoning skills
- Metacognition, and
- critical thinking,
- Helps to become independent and self-directed learners.
- Role modelling
- Provides feedback
- Teacher must work as a facilitator.
- Teacher must keep in mind that if in a child-directed learning not teacher-directed.
- Teacher must provide situation for all students to come formed and contribute towards the success of the activity.
- He must be alert and active to arouse interest among students.
- Teacher must provide democratic atmosphere.
- He must be initialize, tactful and we experienced.

Valentine Davis quotes Prof. Pasher who suggests the following points in problem solving regarding Teacher's Role in Problem Solving:

1. Get the students to define the problem clearly.
2. Aid them to keep the problem in mind.
3. Get them to make many suggestions by encouraging them:

(a) To analyze the situation in parts
(b) To recall previously known similar cases and general rules that applies
(c) to guess courageously and formulate guesses clearly

4. Get them time to evaluate each suggestion carefully by encouraging them to

(a) To maintain a state of doubt or suspended conclusion
(b) To criticize the suggestions by appeal to know facts, minister experiments and scientific treaties.

5. Get them to organize the material by proceeding:

(a) To build an outline on the board
(b) To use diagrams and graphs
(c) To formulate concise statements of the net outcomes of the discussion

It has been stated that for the success of problem-solving teaching technique we need "a teacher who has the ability to see problem clearly,

the power to analyze with as keen discernment and the faculty to synthesize and draw conclusions with and uncanny accuracy".

Procedures in Problem Solving

Inductive approach
Deductive approach

Merits of Problem Solving Method

1) Stimulates thinking
2) Develops reasoning power
3) Improves knowledge
4) Develops good study habits
5) Affords opportunities for participation in social activities
6) Self-dependency
7) Develops power of expression of the students
8) Provides opportunities to the teacher to know in detail their pupils
9) Helps the students to learn meaningful facts and which have been discovered by their own efforts
10) Helps in the maintenance of discipline
11) Assimilation of knowledge as it is the result of a purposeful activity
12) Learning becomes more interesting
13) Develops the power of critical judgement
14) Helps to verify an opinion
15) Satisfies curiosity
16) Helps to learn how to act in a new situation

Demerits of Problem Solving Method

1) Involves only mental activity
2) Large number of students do not possess sufficient background information and therefore they do not take interest in discussions
3) Lack of suitable reference and source books for students
4) Involves a lot of time and the teachers find it difficult to cover the prescribed syllabus
5) It is not economical from time and money point of view.
6) There is always a doubt of drawing wrong conclusions.
7) There is short of talented teachers to practice this method.
8) This is not suitable for all level students.

Suggestions to improve: -

1. The time period must be fixed.
2. The objective should be fixed for a problem.
3. Proper attention must be gain by teacher towards student's activities.
4. All students should be given equal opportunity to put forth their problems and ideas.
5. As far as possible the process of group formation should be psychological.
6. Apart from improvement of teaching the objective of this method should be development of routine problem solving skills.

Broadly speaking, there are two general approaches or procedures in problem-solving: the Inductive and the Deductive

b) Approach: Inducto – Deductive approach

The Inductive Method

The inductive method involves that the pupils are led from particular instances to general conclusion. Concrete examples are given with their help students are helped to arrive at certain conclusion or principles.

Merits of the Inductive Method

1) Knowledge is self-acquired and is soon transformed into 'wisdom'. 'General truths in order to be learned must be earned' is a famous saying and the inductive method is true to it.
2) It promotes mental activity on the part of the pupils and makes them active participants in the learning process.
3) It makes the lesson interesting by providing challenging situation to the students.
4) The method affords opportunities to the students to be self-dependent and develops self-confidence.
5) The student's curiosity is ell-kept up till the end when generalization is arrived at.
6) This method is very natural because the knowledge in possession of man has been acquired in this way from the practical side of experience.
7) The child learns how to tackle problems. He not only acquires more facts but also learns the process of acquiring facts which proves useful for practical life.

8) The method is based on sound psychological principles. Learning by doing is the basis of this method.

Demerits of Inductive Method

1) There is every possibility that the students may draw conclusion very hastily and these may be based on insufficient data and therefore may be wrong.
2) The method is very slow and lengthy.
3) It is not very helpful in the case of small children.
4) It is not very useful in the teaching of subjects in which there is more stress on the teaching of facts.
5) The inductive method is not a complete method in itself. It has been said, "Induction does not prove but only provides the material to prove, it only discovers."

The Deductive Method

This method is the other way round. In the deductive method rules, generalization and principles are providing to the students and then they are asked to verify them with the help of particular examples.

Merits of Deductive Method

1) The teacher's work is simplified. He gives general priniciples and the students verify them.
2) This method is very economical. It saves time and energy both of the students and the teachers. Many principles for the discovery of which mankind have taken a lot of pains can be told to the students easily.
3) It is very suitable for small children who cannot discover truths for themselves. They get ready-made material.

Demerits of Deductive Method

1) Knowledge is not self-acquired and therefore, not assimilated properly.
2) The child is deprived of the pleasure of self-activity and self-effort as ready-made formulae, principles and rules are given to him.
3) It encourages memorization of facts which are soon forgotten and therefore, knowledge is rendered useless.

4) This method is unnatural and un psychological for the students who do not possess ability to appreciate ideas in the absence of concrete examples.
5) It fails to develop motivation and interest in learning.
6) It fails to develop self-confidence and initiative in the students.

c) Concept Mapping – Meaning, Steps and significance, PEOR (i.e. Predict, Explain, Observe and React)

Concept Mapping:- Meaning

- A concept map is a type of graphic organizer used to help students organize and represent knowledge of a subject. Concept maps begin with a main idea (or concept) and then branch out to show how that main idea can be broken down into specific topics.
- Concept mapping is a diagram showing hierarchy and relationship among concepts.
- Concept mapping is a graphical tool for organizing and representing knowledge.
- They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts.
- Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts.

Steps of Concept mapping

1. Brainstorming phase
2. Organizing phase
3. Layout phase
4. Linking phase
5. Finalizing concept map

1. Brainstorming Phase:

- Identify the topic for which concept map is to be prepared. Teacher conducts brainstorming session to get students to identify facts, terms, and ideas that are in some way associated with the topic. Teacher notes down these facts, terms or ideas
- For eg topic- measurement -

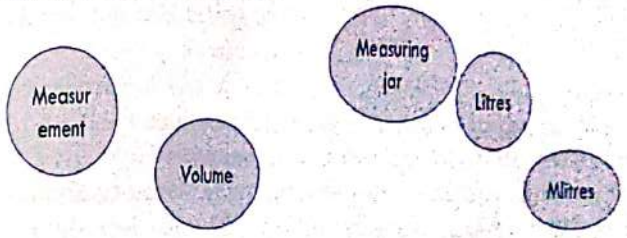
- Time, volume, temperature, length, mass, thermometer, balance, ruler, tape, watch, measuring jar, kms., m, Kgs, seconds, hours,

2. Organizing Phase:

- Students work to create groups and sub-groups of related items. At times items are grouped to emphasize hierarchies. Identify terms that represent those higher categories.
- For e.g.
- Volume instruments measuring jars, units liters , milliliters

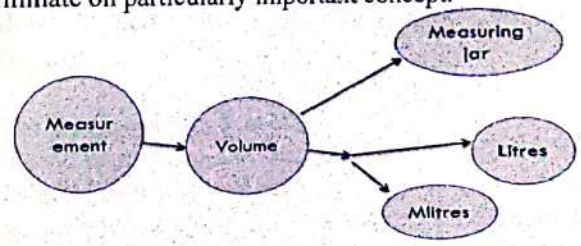
3. Layout Phase:

- On a large sheet of paper or large chalkboard or power point or internet free tools (exploratree / mind mister), teacher with help of students tries to come up with an arrangement (layout) that best represents collective understanding of the interrelationships and connections among groupings.
- Use a consistent hierarchy in which the most important concepts are in the center or at the top. Within sub-grouping, place closely related items near to each other.



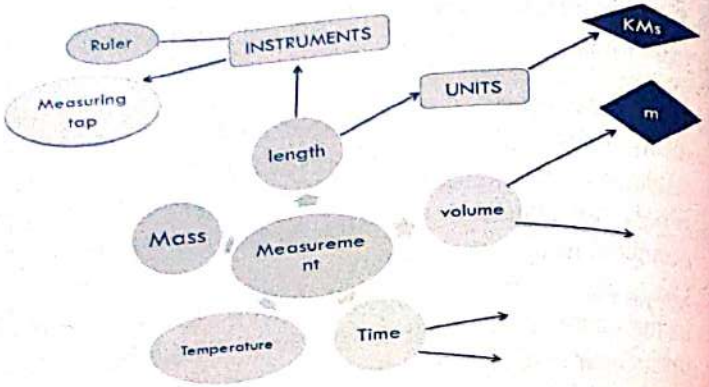
4. Linking Phase:

- Teacher with the help of lines with arrows connects and shows the relationship between connected items. Write a word or short phrase by each arrow to specify the relationship. Many arrows can originate or terminate on particularly important concept.



5. Finalizing the Concept Map:

- After group has agreed on an arrangement of items that coveys their understanding, convert the concept map into a permanent form that others can view and discuss. Use of colors , thick, narrow lines, shapes can be made



Advantages:-

1. Child centered
2. Helping students brainstorm and generate new ideas
3. Encouraging students to discover new concepts
4. Helping students integrate new concepts with older concepts
5. Help identify incorrect ideas and concepts

PEOR (i.e. Predict, Explain, Observe and React)

Unit 5 Learning Resources and Activity

a) Science Text book: Characteristics of good Science textbook
b) Science Club and Science Field Visit – Concept, Organization and Significance
c) Improvised apparatus and E – resources (Virtual Lab and Simulation)

a) Science Text book: Characteristics of good Science textbook

Science Text book:-

A teacher gets print resources in different forms. The textbook is the most familiar print resource for the teachers and the students. It is developed on the basis of guidelines provided in the curriculum.

- Textbooks occupy control and prominent place in teaching and learning process
- Help teachers and students to be acquainted with limits and boundaries of subject matter, learning experiences to be gained.
- Helps in saving time and energy of teachers.
- Helps in maintaining uniformity of standard.

Characteristics of Good Science Textbooks:-

In the teaching-learning process, the text-book occupies an important place. There is a saying "As is the text-book, so is the teaching and learning". A good text-book can even replace class-room teaching. The science text-book should aim at aiding the pupils in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely stuffing their minds with facts.

Characteristics of a good science text-book

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

2. Mechanical features of the text-book

(a) The print and paper used and the binding of the text-book should be attractive. It should be hard and durable.
(b) The printing should be clear, legible and appropriately spaced.

(c) The book should be well-illustrated with diagrams, sketches and pictures.
(d) The size of the print, the language and experiments discussed should suit the age of the child and standard of the child.
(e) Photographs should be clearly reproduced
(f) Diagrams should be carefully made attractive

3. The subject matter-its nature and organization:

(a) The subject-matter should be developed as far as possible in psychological sequence. Care must be taken of the mental growth and interest of pupils.
(b) There should be consistency of the subject-matter and the text-book should satisfy the objectives of science teaching.
(c) Each chapter should begin with a brief introduction and end with a summary.
(d) Subject-matter should lead to the inculcation of scientific attitudes, disciplinary and cultural values.
(e) Each chapter should contain assignments at the end.
(f) During treatment of subject-matter, numerical examples should find place where necessary.
(g) Headings and sub-headings are given in bold letters.
(h) Each text-book should contain detailed Table of Contents and an index.
(i) The language of the book should be simple, clear, lucid, scientific and precise. The English equivalents of the terms should be always given in brackets.
(J) The text-book should give suggestions for improving scientific apparatus.
(k) Examples in the text-book should be given from local environment and from life experience.
(l) During the treatment of science subject in the text-book, care should be taken to see that it is correlated with other subjects like craft, social environment and physical environment.
(m) Each text-book should be accompanied by a laboratory manual.
(n) The subject matter should cover the whole syllabus
(0) Subject matter should be developed in psychological sequence
(p) The text book has to be organized into units which are based on student interests and probability of use
(q) Inductive approach is to be used whenever possible in introducing new topic

(r) At the end of each units there should be assignments informing to the following
(s) Application to life situations
(t) Self-assessment test

Besides these characteristics, the UNESCO Planning Mission has given some principles of writing text-books in U.S.S.R. and other countries. They are as follows:

(i) It should be first of all according to the requirements of the syllabus. It should also help in the improvement of the syllabus.
(ii) The facts, concepts etc., should be modern and within the comprehension of the pupils.
(iii) The contents should contain not only the established facts but also the problems which are being researched and thereby, arousing the interest in the pupils in these problems.
(iv) It should help in linking up science with life and practice. The pupils should be equipped with 'know-how' utilizing the knowledge in everyday life.
(u) The whole content of the text-book should be aimed at shaping the integrated modern scientific outlook which ensures success in mastering scientific knowledge and solution of the problems of vital issues. The content should be simple, brief, exact, definite and accessible.

b) Science Club and Science Field Visit – Concept, Organization and Significance

Science Club:-

What is a science club?

- A science club is an out-of-school-hours club that offers children the chance to do science-related activities that extend and enhance the science they experience in the classroom.
- Each science club is different, as the club program reflects the interests of the children, the club organizer and the facilities available. Most clubs use the opportunity to explore areas of science not covered by the curriculum and to give the club members plenty of opportunities to do practical science.
- A science club can be run in a lunch break or after school. Some organizations are able to offer special Saturday clubs.

- A science club session typically lasts for about 45 minutes. In this time, the members might complete a challenge, plan a science project or have a special scientific visitor.
- Science clubs channelize the energies of students and make use of their skills and talents, which satisfy their instincts and urges and helps in their overall personality development.
- Science clubs work in association with classroom instruction of science subjects.
- Therefore we can define science club as "an organization, which helps in the development of scientific attitude, and develop genuine interest in science and scientific activities, supplements the work of the classroom and the laboratory and parts the syllabus on a practical bias".

Objectives of Science Club:-

1. To develop scientific attitude among the students.
2. To provide training in scientific method of problem solving.
3. To create interest in scientific facts and events related to one's surrounding.
4. To enable the students to select and actively participate in the scientific activities and hobbies suited to their special interests and aptitudes.
5. To provide opportunity for the development of the constructive, explorative and inventive faculties of the students.
6. To help them in learning the art of organization and taking initiative for individual and collective work.
7. To provide opportunities for bringing school close to the society and to acquaint the people with the services and contribution of the science in their life.

Who runs clubs?

- To start a science club, you need at least one, preferably two or more organizers. This way, you can share the planning and delivery of the club and your club will be more adventurous and creative, as you bounce ideas off each other.
- Remember, it's just as important that the organizers enjoy the club, as it is that the children enjoy the club.

- Science club organizers can come from many backgrounds, within and without school. You don't need to be a super scientist in order to run a club, and there are sets of resources designed with that in mind. It can be an opportunity for the club organizers to extend their knowledge and skills, in a less pressured setting.
- Club organizers and helpers can be found in many places:
  - interested parents
  - local university postgraduates or graduate students
  - retired scientists or engineers
  - teachers and
  - classroom assistants

Organization of Science Club:-

A. Preliminary Organization.

- Principal of the institution
- Science Teacher

B. Structural Organization.

- Patron.
- Sponsor.
- Office Bearers:- President, Secretary, Asst or Joint Secretary, Treasurer, Publicity Officer, Class representatives.

C. Functional Organization: - (Activities undertaken in a Science Club)

- ❖ Arranging talks and lectures of distinguished speakers and subject experts.
- ❖ Arranging debates group discussions, seminars and paper reading.
- ❖ Arranging short trips for members of scientific interests.
- ❖ Collecting objects related to scientific subject.
- ❖ Decorating walls of the classroom, library and laboratory with paintings and posters of science subject.
- ❖ Improvising and preparing handmade apparatus.
- ❖ Arranging scientific film shows.
- ❖ Helping in the proper organization of science library and laboratory in the School.

Significance Science Club:-

1) Provides opportunities for the self-realization and self-expression.

2) Helps in generating genuine interest in the study of science.
3) Provides means and ways for the proper utilization of leisure time.
4) Provides opportunities for satisfaction of the instinctive urges.
5) Helps in linking the school studies more firmly with the outside world.
6) It helps in inspiration and energizing the students.
7) Provides opportunities to experience a wider range of science topics, hence broadening their enthusiasm for science.
8) Provide multiple ways for learners to engage with concepts, practices, and phenomena within a particular setting
9) Promote and support participants to interpret their learning experiences in the light of relevant prior knowledge, experiences and interests
10) Developed through partnerships with appropriate expert(s)/ agencies and wherever possible be rooted in scientific problems and ideas that are relevant for the local community.
11) All educational tools and materials should be developed through iterative processes involving learners, educators, designers, and experts in SMT through appropriate field trials.

Field Visit

A field Visit is a journey by a group of people to a place away from their normal environment. When done for students, it is also known as school trip and school tour.

The purpose of the Visit is usually observation for education, non-experimental research or to provide students with experiences outside their everyday activities, such as going camping with teachers and their classmates. The aim of this research is to observe the subject in its natural state and possibly collect samples. Field Visit are also used to produce civilized young men and women who appreciate culture and the arts. It is seen that more-advantaged children may have already experienced cultural institutions outside of school, and field trips provide a common ground with more-advantaged and less-advantaged children to have some of the same cultural experiences in the arts.

Meaning:-

- Field Visits are out of classroom activities that students deliberately engage into to improve or enrich science program and which at same time, place emphasis on science as process of enquiry.
- Out of classroom activities where pupils observe, experiment, investigate, explore and interpret the natural phenomena or any occurrence.

Organization of Visit:-

Field Visits are most often done in 3 steps: preparation, activities and follow-up activity. Preparation applies to both the student and the teacher. Teachers often take the time to learn about the destination and the subject before the Visit. Activities that happen on the field Visits often include: lectures, tours, worksheets, videos and demonstrations. Follow-up activities are generally discussions that occur in the classroom once the field Visit is completed.

Generally in school, Organization of Visit is done in following manner.

1. Choice/selection of place.
2. Relevance to subject, topic, Derivation of relevant educational benefits, Feasibility in terms of expenses, season, time etc.
3. Preparation for Visit.
4. Permission from Head, consent from parents, arrangement of transport, reservation, concession, correspondence, aims and objectives, instructions to students.
5. Conduct of Visit.
6. Agenda, working in groups, recording in notebooks, collection of articles.
7. Follow-up-Discussion of experiences, deposition of collected articles, classifying and labelling, correlation with actual teaching.

Popular field trip sites include zoos, nature centers, community agencies such as fire stations and hospitals, government agencies, local businesses and science museums. Not only do field trips provide alternative educational opportunities for children, they can also benefit the community if they include some type of community service. Field Visits also provide students the opportunity to take a break from their normal routine and experience more hands on learning. Places like zoos and

nature centers often have interactive displays that allow children to touch plants or animals.

Significance:-

1. Provides new learning situations to students and creates interest in scientific work.
2. Provides rich experiences to pupils about ecology and other aspects of environment and their relationship.
3. Develops scientific attitude.
4. Generates spirit of cooperation, learning in social setting
5. Helps in collection of materials.
6. Opportunity to learn practical applications of science.

c) Improvised apparatus and E – resources (Virtual Lab and Simulation)

Improvised apparatus (Meaning and significance)

Meaning:-

Apparatus and equipment's made out of no cost or low cost raw material with help of students under guidance of teacher are referred to as homemade or improvised apparatus.

Resources needed

Match sticks, wires, cardboard, seeds, beads, matchboxes, cans, bottles, etc.

Many schools are not well equipped and face financial constraints in buying materials and equipment's for carrying out activities, demonstrations and experimentation due to availability of limited funds. But this does not mean that there is no way out. An enterprising teacher can critically look at local resources and find possibilities of carrying out innovative activities for teaching- learning of science using local, low cost, easily accessible materials. She can encourage and help students in making improvised apparatus. With a bit of creativity and imagination, a teacher with the help of students can convert day-to-day usable articles, household wastes or discarded materials and materials collected from immediate environment into valuable learning resources. Such learning resources, while being interesting and effective, do not result in financial burden on school. This is, however, possible when the experiment is of qualitative nature and does not require too much precision. Students can also be involved in collecting locally available materials and improvising

apparatus. This will enthuse the children to explore new things. It will provide them an opportunity of creativity, self-expression and self-development. They will be able to connect learning of science to their environment. In the long run, it would help to inculcate scientific temper in them. The learning resources from the immediate environment can be used at all stages of school education. At primary and upper primary stage of school education, almost all science activities and demonstrations can be done using resources from immediate environment. At secondary and higher secondary stage, many activities, demonstrations and some experiments also can be performed in physical science by using such improvised apparatus. Let us see some examples.

Examples of improvised apparatus:-

- Model of Lungs.
- Periscope.
- Plant cell.
- Spring balance.
- Insect catching device.

1. Centripetal Force: Take the body of a ball pen, through this; slip a strong string of about 50 cm to 100 cm length. Tie packets of sand on the two sides of the string as shown in Hold the pen body along with the string vertically in your hand. Now start whirling it with your hand. The packet of sand at the top starts rotating and the string starts moving up. Try with different-sized sand packets and with different speeds. What makes the lower packet move up? What is the effect of changing the speed and why? This simple improvisation would help you learn about the force that comes into play when objects undergo rotational motion.

2. Surface Tension: Take a metallic U-clip. Place it on a small piece of newspaper. Fill a cup full of water. Carefully put this newspaper along with the U-clip horizontally on the water surface, so that the U-clip does not get wet. If kept undisturbed for a few minutes, we observe that the newspaper absorbs water and sinks while the U-clip keeps floating on water. Discuss why it keeps floats. Why does the U-clip sink if disturbed?

3. Magnetic Compass: Magnetize an iron needle using a bar magnet. Now, insert the magnetized needle through a small piece of cork or foam. Let the cork float in water in a bowl or a cup. Make sure that the needle does not touch the water. Your compass is now ready to work. Make a

note of the direction in which the needle points when the cork is floating. Rotate the cork in different directions with the needle fixed in it. Note the direction in which the needle points when the cork stops rotating. Does the needle always point in the same direction when the cork stops rotating?

Significance:-

1. Social value: - The construction of these materials follows the principle of learning by doing. The habit to work together without any disporting in formed and the child molds himself according to the needs of society and moves towards the goal of socialism.
2. Educational and psychological value: - The improvised apparatus provide opportunities for the exercise and development of ingenuity and the resourcefulness. The pupil fined new way of applying their knowledge. They learn to think critically and scientifically. Coordination of hands and heads develops as sense of confidence and constructive and creative instincts of pupils are satisfied. The energy of the child is channelized in a proper way.
3. Economic Value-these items are prepared art of materials which are considered to be waste or low cost. Thus they have great economics value "Best art of waste"
4. Recreational Value: - Students do the work on their own they keep themselves occupied and utilize their leisure time. Thus, it has got recreational value
5. Practical Value: - While constructing apparatus, they became; organized. They themselves discovered new apparatus, can produce according to the needs, repairs old apparatus can also take interest of doing more.
6. Scientific Value: - The students develop interest in scientific activities and in turn they gain scientific knowledge.
7. Entertainment value
8. Search of scientific talent.
9. Development of creative instincts.
10. Expression of ideas.
11. Conservation of waste.
12. Nurture ideas of preparing relevant aids.

E – Resources (Virtual Lab and Simulation)

Virtual Lab:-

Educational professionals consider the importance of integrating information and communication technology in science learning, as to facilitate studying many scientific phenomena that cannot be studied experimentally due to its danger, high cost, or lack of time to complete the experiment. Furthermore, it will help the student in investigation and searching, which are considered the main aims of teaching science. The fields of internet-based learning are diverse, including virtual laboratories of science, which are considered the main underpinning in practical electronic learning, seeing that virtual labs closely resemble real labs. Moreover, a technology-enriched environment would greatly enhance students' motivation and develop positive attitude towards the course. Subsequently, the academic achievement would be enhanced. Several studies emphasized the vital role of virtual labs in developing academic achievement, providing awareness of scientific concepts, and modifying misconceptions.

Definition:-

- Virtual labs can be defined as a simulated interaction encompassing the contributions of technology, educational theory and individual human influences (Prieto-Blazquez, Herrera-Joancomarti & Guerrero-Roldán, 2009).\
- "The Virtual Laboratory is an interactive environment for creating and conducting simulated experiments: a playground for experimentation." (The Virtual Laboratory Environment @ Algorithmic Botany retrieved 11:48, 30 June 2006 (MEST))
- "A Virtual Laboratory is a heterogeneous distributed problem solving environment that enables a group of researchers located around the world to work together on a common set of projects." (LESTER, retrieved 12:52, 30 June 2006 (MEST))
- It is defined as "laboratory experiment without real laboratory with its walls and doors. It enables the learner to link between the theoretical aspect and the practical one, without papers and pens. It is electronically programmed in computer in order to simulate the real experiments inside the real laboratories." Harry & Edward, 2005).

- It is defined as "A virtual studying and learning environment aims at developing the lab skills of students. This environment is located on one of the internet pages. Usually, this page has main page & many links, which are related to laboratory activities & its achievements (Zaitoon, 2005, 65).

Through the above mentioned definitions, the virtual lab can be defined as virtual studying and learning environment that stimulates the real lab. It provides the students with tools, materials and lab sets on computer in order to perform experiments subjectively or within a group at anywhere and anytime. These experiments are saved on CDS or on web site.

The Components of Virtual Lab

The main components of the virtual labs are determined to have the following:

1- The lab sets & equipment's

The virtual lab is considered integral to the traditional lab but not an alternative to it. The existence of the traditional lab is very necessary, but in lower numbers and requirements, which help in the possibility of using it by several users outside the lab.

2- Computer devices.

They are represented in personal computers, which are linked to the local net or to the international net so that the student can work directly in the lab, or distantly at anywhere and anytime.

3- Communication network & the related hardware.

In case of performing experiments electronically, all the sets should be linked to the computer, because the link between the users with lab will be through digital communication.

4- The Programs of the Virtual Lab:-

These programs are represented in the simulation programs, which are designed by professionals. It is necessary to design this program in an interesting and attractive form; as these programs were designed to attract students' attentions and urge them to complete the experiment. This is maintained by the animation techniques, video, and the three dimensions pictures.

5- Co-operation Programs & Management.

These programs are concerned with the method of managing the lab and the ones who perform the experiment, including students and researchers. These special programs register students in the lab program

and determine the kinds of access that should be provided to each user in the different experiments.

6- Technical Staff.

It is important to have a technical team to support educators in preparing and assessing scientific materials, in addition to evaluating the program to determine its efficacy.

But what are the differences between real life experiences and those formed by representations in a computer screen?

- With virtual labs, students acquire a tool with which to experiment without limitations of space or time. They are available all year, as opposed to school laboratories, limited to a specific place and for a limited time.
- The use of virtual environments makes students acquire better computer skills, which can be considered skills for lifelong learning. The use of these technologies also bring together different STEM subjects and provides with great resources for more inclusive workshops.

Benefits of using virtual labs in teaching and learning Science

Virtual labs can be very useful in the teaching of Science, particularly in cases where:

- The experimental activities are to be done quickly and do not easily allow observation and safe measurement,
- The experimental process is very slow and / or complex and not compatible with the teaching time available,
- The experiments involve risks to the health and physical integrity of learners and/or
- The learning activities require modeling.

Advantages:-

- By performing a virtual lab on the material before a "real world" lab it allows students to make mistakes without fear of not getting the experiment done right.
- Furthermore, virtual labs can present abstract ideas that may not normally be easily viewed. For example, when learning about gas laws it may be hard to visualize what is actually occurring at the

microscopic level, but with use of a simulation the interactions can be made visible and tangible.

- Virtual labs need to be accessible because they provide students that are not physically able to be in the classroom a chance to learn content in a meaningful way.
- Flexible access:- Perhaps the most often cited benefit of any online learning is that it can be done at the student's convenience and when he or she learns best. The same is true of virtual laboratories if the experiments are on the student's own time. In some cases, a virtual lab may be used during regular class time which narrows this benefit but still allows flexibility for the teacher who is not limited by using resources within a strict timeframe.
- Instant feedback:- Students can redo experiments on the spot while they are still in a critical thinking mode. All the results are recorded, making communication between teachers and students more efficient too. Experiments no longer have a "one chance" option and students can analyze what went wrong immediately and give it another shot.
- Lower costs: - There is a fee associated with using virtual labs but the capital and maintenance costs are drastically reduced. Instead of one school footing the bill for resources, the cost is split among the clients of the particular virtual lab. This allows school to provide a better learning experience for students at a fraction of the cost.
- It intends to develop a complete Learning Management System where the students can avail the various tools for learning, including additional web-resources, video-lectures, animated demonstrations and self-evaluation.
- There is also a component wherein costly equipment and resources are shared, which is otherwise available to only a limited number of users due to constraints on time and geographical distances.

Simulation:-

Simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

Definition:-

- Simulation is the act of imitating the behavior of some situation or some process by means of something suitably analogous (especially for the purpose of study or personal training) - **The Dictionary.**
- Simulation means to imitate conditions of (Situation etc.) with a model, for convenience of training – **Oxford Dictionary.**
- "Simulation is the use of a model to conduct experiments which convey an understanding of the behavior of the system modeled." – **Gogg and Mott 1993**

What is needed to use simulations?

- Integrating simulations into the traditional classroom practice does not require sophisticated equipment. The basic equipment consists of a computer, a LCD projector and availability of an Internet connection, though this is not necessary if the simulations are in a CD-ROM. Students can also access simulations individually in a computer lab or in a laptop environment.
- The most common requirements for using simulations are free plug-ins like Flash, Shockwave, and QuickTime. Your browser must support Java for some simulations.
- Most simulations are in the form of a Java Applet, a short program written in Java that is attached to a website and executed by a web browser.
- Many simulations include general directions; an audio clip and the most refined include multiple representations (vectors and graphs) and let the user modify the parameters to collect data.

How do I implement simulations in the science classroom?

- Digital technologies require us to rethink our approach to the educational process.
- The real challenge is not the actual technology, but finding pedagogies that use these digital tools to give our students an improved learning environment.
- The following are some ideas about using simulations in the science classroom:
  - Lectures - To help students visualize abstract concepts: the use of simulations, To initiate a discussion on a reading

assignment: simulations open up avenues of thought and discussion that are not typical of a textbook question.

- Interactive Demonstration - Simulations can be used to ask students to make predictions and then discuss the observations made.
- Pre-Lab Exercises - Simulations can serve to introduce the ideas and equipment of the lab experiment allowing the students to work through the laboratory faster and with less confusion.

Advantages to using simulations in Science Teaching:-

1. Simulations can help students translate among multiple representations:- Simulations contain physical systems represented in many different ways in two or three-dimensions: pictures, graphs, words, equations, diagrams, data tables, contour maps, etc. The students can make sense of the concepts by seeing the connection between the representations and how one variable affects another.
2. Simulations can help students build mental models of physical, chemical or biological systems:- Simulations allow students to visualize concepts that appear on textbooks or hear from their teachers in lectures. By using the simulation they can see a concrete situation that helps them build a mental model.
3. Simulations can give students engaging, hands-on, active learning experiences:- Simulations give students control when exploring scientific concepts and phenomena.
4. Simulations can help students understand equations as physical relationships among measurements:- Simulations are great tools to help students recognize how equations relate observations and measurements. Using a simulation where the students are able to vary parameters and see the effect of these variations, the role of equations is powerfully enriched.
5. Simulations can serve as a vehicle for collaboration:- Students working in groups can use a simulation to explain and describe their understandings to each other.
6. Simulations can allow students to investigate phenomena that would not be possible to experience in a classroom or laboratory:- Students can have access to investigations and equipment not commonly available in the classroom like studying a nuclear reactor.

Unit 6 Science teacher

a) Science teacher - Need and avenues of professional growth
b) Science Laboratory - Planning and Maintenance, Laboratory Method
c) Diagnostic Testing and Remedial Teaching in science

a) Science teacher - Need and avenues of professional growth

What Is Professional Development?

As the name suggests, professional development is training that is completed by current professionals in order to continue development as a teacher. Excellent teachers never feel that they have completely 'arrived' at the pinnacle of education, and they realize that there is room for improvement. The best teachers never stop growing as professionals. Due to the importance of continued training, a majority of states require teachers to complete a certain number of hours or earn a number of professional development credits in order to renew their teaching licenses.

Professional development is the enrichment training provided to teachers over a period of time to promote their development in all aspects of content and pedagogy.

Ideas for Professional Development

There are many different types of professional development available for science teachers, from free to costly and from quick to time-consuming. While any experience that helps educators grow in their teaching skills can be considered professional development, credit for recertification will only be given if the experience meets the state's guidelines.

Many programs marketed to teachers will provide a description stating the number of credits to be awarded, while more obscure experiences, such as shadowing a scientist for the day, may need special approval. It is essential that the teacher checks the state requirements before beginning any professional development. Usually the school principal or district recertification specialist will be able to assist the teacher in this. Below are some examples of professional development for science teachers.

Need of professional development for a Science teacher

Though the pre-service professional training is very important, the professional training received by a teacher during a pre-service teacher

training program is not always sufficient for her entire career. When a teacher starts her teaching career, the situation faced by each teacher is unique. 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 science to the learners.

1. New developments in science and pedagogy of physical sciences are occurring continuously. Unless teachers are facilated to keep themselves abrest of these developments, they are bound to show resistance to new ideas no matter how sound they look to educationists. Therefore, in-service training program is conducted by many organizations and institutes that can contribute significantly to the professional development of new teachers as well as experienced teachers. Teachers can identify the areas related with learning of physical science where they feel the need of training, and send them to such organizations for consideration of their participation.
2. 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. The society is also changing with time and this has a great impact on education. The teacher has to adapt her teaching-learning strategies to these changes.
3. To achieve all this, a science teacher will have to continuously strive for her professional development. A sincere and dedicated teacher can have to devote extra time and efforts beyond school hours for her professional development.
4. Science teachers need to develop their abilities to align the teaching-learning experiences to learners' environment, to find learning resources from their environment, locally available resources and the community.
5. 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
6. 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.

7. Science teachers also need to understand the problems of students having special needs such as: Dyslexia, Dyscalculia , Dyspraxia

Avenues of continuous professional development:

Within the scope of a professional growth plan, teachers and school administrators can undertake a range of professional learning activities including reading professional journals, trying out new practices in the classroom and joining professional organizations. Below is a list of professional development activities that can be undertaken individually or collaboratively as part of a professional development plan. In the past, professional development focused on individual development, workshops, in-service and external delivery systems. Today, the emphasis is on school-based activities such as coaching, partnerships and team/group development.

1) Action Research

In undertaking action research, educators begin by asking how current practice might be improved. They then study the relevant literature and research to select an approach that might improve current practice.

Teachers often use their classrooms as research sites. For example, teachers might teach a concept in different ways to determine which had the greatest effect on student learning. Likewise, teachers might experiment to see what approach is most effective in facilitating cooperative learning among students.

Administrators can use action research to address issues related to their leadership role in schools. Action research is a reflective strategy that requires the collection of qualitative and quantitative data, which can lead to enhanced practice.

Teachers can engage in successful mini-research projects in their classrooms, while administrators can use schools, individually or collectively, as research sites. This "action" research often helps identify which techniques work best for particular students. Action research helps teachers to theorize from teaching practice and experience and redefine teaching as an autonomous form of inquiry. For more information on action research, consult the ATA document Action Research Guide for Alberta Teachers.

2) Reading for professional growth

Science teachers should devote time to reading for their professional growth. They should regularly read various books, journals and periodicals

related with science and science education. Reading of these on regular basis can keep science teachers up-to-date on contemporary developments in content and pedagogy of science. For this, they can spend some time in school library. They can subscribe to a few journals also. Teachers should become members of a professional library to get access to science books, educational journals and various curriculum materials prepared by state education departments. They may find such a library at block/district level. They may periodically visit DIET (District Institute of Educational Training). SCERT (State Council of Education Research and Training) and B.Ed. colleges for library reference work. Teachers may request their school authorities to subscribe to some affordable journals. They can try to develop a common library to be shared amongst teachers of many neighboring schools. Science teachers can also visit library of a neighboring science college to enrich their science content knowledge. Teachers can search internet and get lots of ideas for activities, teaching-learning materials, test items, audio-visual (AV) aids, and etc.3)

3) Classroom/School Visitation:-

Teachers visit the classrooms of colleagues to view innovative teaching practices and expand and refine their own personal pedagogy. For classroom visitations to occur, school boards must be willing to engage substitute teachers.

School administrators may benefit from visiting a school in the jurisdiction or another jurisdiction to view the facility, explore alternatives for organizing resources and discuss leadership strategies with the hosting school administrator.

Classroom and school visitations may range from a single day up to two weeks and/or multiple visits over time.

4) Collaborative Curriculum Development:-

Collaborative curriculum development provides a unique opportunity for teachers to delve deeply into their subject matter. Working together, teachers can design new planning materials, teaching methods, resource materials and assessment tools.

5) Conference Audio Tapes:-

Conference audio tapes provide teachers who are unable to attend a national or international conference with an opportunity to learn new ideas from experts. Most organizations make available information on sessions or proceedings through audio cassettes, CD-ROMs, and MP3s.

6) Conferences:-

Conferences can provide very effective professional development opportunities, particularly when they are part of a teacher's ongoing professional development plan. A detailed listing of selected conferences is located on the ATA online events calendar.

7) Community/Service Organizations:-

Community and/or service organizations provide an opportunity for teachers and school administrators to develop leadership skills and gain important knowledge related to their role and community context. Examples of community/service organizations include church, service clubs, 4-H, Scouts, Girl Guides and sporting groups.

8) Curriculum Mapping:-

Curriculum maps are tools to organize teaching. They outline a sequence for delivering content and provide a clear scope for what must be taught to all students as specified in the provincial curriculum. Curriculum maps, which can be aligned both horizontally and vertically, organize content, skills, assessments, and resources over time. A curriculum map can also serve as a tool for collecting data about the implemented curriculum in a school and in a district—the instruction that students are receiving. By mapping what's actually taught and when and aligning it with assessment data, teachers can modify instruction (Educational Leadership, December 2003/January 2004).

9) Examining Student Work:-

Student work provides teachers with a critical source of information about how a student is learning, developing, acquiring new knowledge and applying new skill sets. Student work includes such items as writing samples, projects, oral reports and pictures. Thinking analytically about the work can give teachers greater insights into teaching and learning. The information can also be used in study groups.

10) Hosting a Student Teacher:-

Hosting a student teacher is a form of mentoring, except that the experienced teacher has an obligation to focus on supporting the development of standards related to interim certification. All Alberta universities provide a handbook and orientation workshops for host teachers that outline the expectations for field experiences. Host teachers are ultimately responsible for their students and therefore must closely supervise what the student teacher does with respect to lesson planning, classroom instruction and student evaluation. Student teachers do not have

teaching certificates and, therefore, should not, under any circumstances, be allowed to act as substitute teachers.

11) Internet, Research:-

The Internet provides access to a wealth of information on countless topics contributed by people throughout the world. On the Internet, a user has access to a wide variety of services: vast information sources, electronic mail, file transfer, group memberships based on interest, interactive collaboration and multimedia displays. However, Internet research has a number of limitations. Because the Internet is a self-publishing medium, anyone with minimal technical skills and access to a host computer can publish content. Furthermore, Internet sites change over time according to the commitment and inclination of the creator. Some sites demonstrate an expert's knowledge, while others are amateur efforts. Some may be updated daily, while others may be outdated.

12) Journaling:-

Journaling is a technique for recording observations and reflections. The entries may be related to teaching, student growth, the implementation of a new initiative or any subject for which a teacher may want to develop a record. The journal can provide a rich, qualitative record of events and activities.

13) Networks:-

Effective professional development initiatives use a variety of communication networks and strategies. The vertical and horizontal boundaries at the school and system level must become interrelated and mutually supportive.

Electronic networks can respond to educators' needs to communicate with a larger and more diverse group of educators beyond the staff at their own schools. A computer, a modem and access to a telephone line can link teachers to the electronic village. Open systems can connect teachers to existing online libraries, databases, list servers and other communication systems. Participants can discuss such issues as evaluation and assessment, technology across the curriculum, environmental and global education, second language instruction, conflict resolution, school leadership and school-based research.

14. Attending in-service teacher training programs and workshops:-

Many teacher training programs and workshops are conducted round the year, all over the country, by various organizations such as NCERT, SCERTs, DIETs, KVS (Kendriya Vidyalaya Sangathan), NVS (Navodaya

Vidyalaya Sanghtan), Teacher Education Colleges, Teacher Associations,University Education Departments and NGOs. In-service training programs and workshops are conducted by experts to take care of the particular needs of teachers. Some of the areas in which teacher training programs and workshops are conducted regularly in Physical sciences are Designing improvised apparatus, Developing Low 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. Whenever teachers feel a need for training in a particular area, they may request the authorities to provide them opportunity to attend such a training or workshop.

15. Webinars

A webinar is basically a seminar conducted over the internet. You can listen and see a speaker's presentation live, and some even allow the listeners to participate by asking questions and answering polls. Webinars are excellent sources of professional development because they do not require you to travel beyond your home computer. You can hear from speakers around the world and participate in seminars covering a variety of subjects. Learn about specific science education topics like climate change or participate in more general webinars focused on techniques and practices.

16) 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.

17) Membership of professional organizations

There are many national and international professional organizations which 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. A list of some such organizations is given below. You may add on the names of some more associations by searching the websites and collecting information regarding the activities carried out by them. You can also become a member of such organizations.

18) 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 programs. Some schools allow their teachers to take study leave/sabbatical leave to obtain an advanced degree. Teacher should apply for study leave well in advance so that the school management can recruit a replacement, for the teacher proceeding on leave. If obtaining study leave is not feasible, teacher may pursue these programs through open universities.

Acquiring higher 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.

b) Science Laboratory - Planning and Maintenance, Laboratory Method

Science Laboratory - Planning and Maintenance

Designs of Laboratories:-

The overall philosophy of the design could be fixed or flexible

Fixed Design Laboratories

Traditionally the labs are of fixed design i.e. all benches, cupboards and services are rigidly fixed.

Flexible Design Laboratories

Flexible lab design adopts the strategy of keeping furniture, benches and services free-standing so that they can be easily moved. Many labs show a continual pattern of change in usage, and 'flexible' design helps to overcome the potential inherent disruption. Flexible design is quite suitable for private multipurpose labs.

Planning and organizing laboratory work:-

Science teachers must plan laboratory work well in advance for making best uses of available materials and time. A teacher can plan on thinking along the following lines:

- Is the objective of activity/experiment/project work clear to the students?
- How will I facilitate them to perform the experiment?
- Are materials/apparatus available in the laboratory?
- How will I involve learners in setting up the experiments?
- Have I performed the experiment myself to check the functionality of all apparatus?
- Is the procedure simple and can be performed within the allotted time period?
- How will applications of their findings enhance their learning?
- How will I integrate the laboratory experiments with classroom teaching-learning experiences?

The learning experiences in the laboratory should provide some challenge to the students to learn. They get interested if they understand the purpose of the experiment and are made to realize the application of it to their everyday life. Students can be involved in planning and organizing various works of laboratory.

Following guidelines for planning and organizing experiments in physical science may be considered.

- It should be ensured that students have a sound theoretical knowledge required for handling the apparatus and performing the experimental work. For this, theory and practical teaching learning situations should be properly integrated and coordinated.
- Students should come prepared for the laboratory work. They should be encouraged to refer laboratory manual and other supplementary materials. They should be facilitated to find answers to their own questions.
- Enough apparatus should be set up to provide opportunity to all learners on hands-on activities. It should be checked that the apparatus are in proper working condition.
- During the laboratory work, extensive and critical discussion on the theoretical aspects of the experiments with the students and

continuous assessment of their performance are of utmost importance. This helps the teacher to know their misconceptions and naive concepts and she can then facilitate them in the construction and reconstruction of their knowledge.

- A noticeboard to display safety rules of the laboratory, time- table, list of experiments, group patterns, etc. can be maintained and kept up to date.
- Good discipline is necessary for smooth functioning of the laboratory work.
- Maintaining all possible standards of safety in the laboratory and inculcating safety conscious attitude in students are important.
- Safety kits such as fire extinguishers, sand bucket, rubber gloves, separate dustbins for dry and wet waste materials, etc. should be kept handy.
- First-aid box must be kept ready and timely replenishment of medicines must be ensured.
- Remember that safety of the students and teachers is more important than the safety of the apparatus.

Generally, in the beginning of the session, the teacher takes the students around the laboratory to familiarize them with the general facilities, equipment, apparatus, chemicals, glassware, etc. available in the laboratory and informs them about certain do's and don'ts while working in the laboratory.

Setting of Science Laboratory:-

- Dimensions.
- Walls and floors.
- Doors and windows.
- Seating arrangement and furniture in Laboratory.
- Lecture room, Teachers working place and students working place.

Planning and Maintenance of Laboratory:-

- Space
- Provision of elements of flexibility for effective teacher demonstration, individual and small group work.
- Ample physical and material facilities.

- Ample storage facilities for chemicals and equipment's.
- Good lighting and ventilation.
- Regular supply of water and gas.
- Shelves, cupboards, notice boards.

The essential requirements of a typical Laboratory:-

Laboratory space:-

A lab could just be a single room or a large building with provision for separate rooms for specific work. The size depends upon the purpose for which it is required. Single owner personal pathology or microbiology labs used for some routine tests are generally very small. The physics, chemistry, botany and zoology labs of school/college are larger in size. Public and private research institutions have several big labs. Labs are variously designed. For instance, the biology lab of a college is different from chemistry, physics or computer labs. Often the main lab in a teaching institution is rectangular. The typical size is somewhere between 40 and 80 square meters. It is of utmost importance that any lab has adequate space within which lab workers can work. Ample space is required for the safe conduct of lab work and for efficiency and maintenance.

Benching, surfaces, furniture:-

Often labs are rectangular, since in most cases benching is firmly fixed and drainage is only available along walls, this is what we shall assume for this lab also.

In this lab what could be the arrangement for drainage? The drainage might be restricted to the perimeter. This design may allow a large number of people to use the lab. Besides it provides a considerable quantity of under-bench storage. But in a school lab, the supervision of the pupils, particularly those with their backs to the teacher, may be a problem.

These benches would be rather long and sufficient distance would have to be allowed between each so that people at the ends nearest the wall could have safe access to their work area. This is a typical modular approach with each U-section forming a module.

Many other designs could be devised, but before you decide, you must find out what your requirements are.

The dimension of the work surfaces- the height and width of benches is generally standard for a discipline though most people are of differing height and build. Once the position of benches is decided one must

consider suitable work tops, cupboards and other storage units, shelving and so on.

Bench tops should be sealed to the walls, impervious to water and resistant to disinfectants, acids, alkalis, organic solvents and moderate heat.

Two main factors in the choice of work tops to be considered are:

1. The cost of the material, and
2. The nature of the lab work.

In a school lab, for example, wood or laminated surfaces are likely to be used. In a biology lab the important factor is to be able to sterilize the surface easily in which case a formica surface is probably the best. For wood surfaces, teak is the best type of wood, but it is expensive. The suitability of other types of wood can also be explored.

Keeping in view the type of work to be performed a variety of materials are used for bench surfaces. These are timbers (solid wood), PVC, quarry tiles, Kota stone, granite, glazed tiles, Formica and metal.

The selection of lab furniture is very important. You should make sure that it is sturdy. The furniture can be purchased from some standard firms, which provide a catalogue also. In case you have some specific requirement you can get it made from a local dealer.

Storage:-

Storing facilities are also taken into account while planning a lab. Generally, the storage units are 'hung' underneath a bench and shelving units and cupboards hung from a rail around the room. Commonly the units are of wood or steel. They are demountable and can be easily removed.

Store space must be adequate to hold supplies for immediate use and thus prevent clutter on bench tops and in aisles. Additional long-term storage space conveniently located outside the working area should also be provided. As far as storage in the lab is concerned only equipment and consumables required for day-to-day use should be stored. Obviously an exception would be specialized large equipment, which may have to be housed in the lab even though it is used only occasionally.

Many labs have totally inadequate storage space. Here under-bench storage assumes a far greater importance. Indeed, it can become the major method of storage. Under-bench storage is inconvenient, with low shelves making access difficult. If you want to use under-bench storage then some

of these units will need to take trays, which slot into units or are fitted with movable shelves.

Services:-

All labs require water, gas and electricity to be freely available as well as a drainage system. Some labs (such as chemistry) may also require specialized services such as steam, vacuum or compressed gases and fume extractors. The provision of these services has been the subject of much heart searching for they are the principal factors that limit the flexibility and adaptability of a lab.

Services, traditionally, are almost always provided by way of the floor and run along benches to outlets fixed to the benches, forming an integral part of the furniture.

Some labs are equipped with movable service stations that are supplied via the floor but allow a considerable degree of flexibility in that the supply of services is no longer an integral part of the furniture.

Drainage points have to be set into the floor. The right choice of material for the pipe line is necessary. For example, in a polytechnic chemistry lab the drainage system consists of a network of borosilicate tubing set into the floor, with drainage points at intervals of 2.4 m set over the entire area of the floor. The borosilicate tube is used as it is particularly resistant to corrosion and is readily cleaned with a solution of hot washing soda. Safety should also be borne in mind when providing services.

Ventilation, lightning, heating and cooling:-

Ventilation, lighting, and heating are often treated as related and will be considered as such here. Proper ventilation in a lab is necessary for health and safety and for efficient working. Lighting which is too bright or too dull may lead to tired eyes, headaches, and again an increased incidence of accidents. Also, working conditions that are too hot or too cold, too, dry or too damp are unpleasant to work in and may result in accidents. Thus control of all these factors is important for a safe and comfortable working environment.

Windows provide an uncontrollable flow of air, and although louvered windows are better, they tend to be draughty. Excessive draughts must be avoided on safety grounds, as Bunsen burners may be extinguished or delicately poised apparatus disturbed. Mechanical or forced ventilation can be provided by extractor fans, which at the time of installation can be set high up thereby reducing any draughts. Extractor

fans provide a more constant flow of air and avoid the problems of open windows.

Adequate lighting is necessary for any kind of work. Natural lighting is most acceptable to the lab worker.

Flooring:-

The floor should be smooth but slip-resistant. The choice of covering for the lab floor is governed by a number of considerations, which include:

1. Cost;
2. Safety;
3. Chemical resistance;
4. Wear; and
5. Environmental factors, e.g. comfort, ease of cleaning, noise reduction and warmth.

Most lab floors have a concrete base. Floors should include watertight upstands around all services that enter through floors, and along the walls, particularly floors above ground level.

Access to and from Laboratory:-

Any lab design must take into account that the lab worker must be able to gain access to and from the experimental area. Sufficient distance must be allowed between benches for the safe movement of people, so that colleagues are not disturbed.

As even in the best run establishment accidents can happen, all laboratories and preparatory rooms should be provided with at least two escape routes as widely separated as possible. If an accident occurred near one of these doors escape would still be possible using the other door.

Likewise, the design of the whole building should allow for various escape routes. For example, more than one set of stairs should be provided and these should preferably be constructed throughout with non-combustible materials.

Planning: -

List of apparatus and Chemicals, prepared by careful consultation, provision of annual budget, quantity of equipment's and materials depending upon number of students.

Method of Procurement

Budgetary provision, specification of needs of various experiments and replacement of obsolete or unserviceable equipment's.

Preservation and maintenance of Lab materials:- storage of scientific materials, lab registers, management of safety.

Importance of Science Laboratory:-

1. Realization of objectives of teaching science.
2. Development of Scientific concepts and principles.
3. Improving and understanding of various methods and procedures of science inquiry.
4. Development of scientific attitude, interest, appreciation.
5. Training in Scientific method.
6. Science Lab ready for use of observations and experimentation as and when required. Apparatus, Instruments, Chemicals kept safe.
7. Encourage students to perform carefully in congenial environment.
8. Development of sense of co-operation and spirit of healthy competition.

Laboratory Method

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

For this, provision of a well- equipped laboratory is made by the teacher. Along with such materials and facilities, proper instructions are being provided by the teacher to the students by which they can carry out their experiments self-independently. They carry on the experiments and record the observation properly, on -the basis of which they infer their results or draw conclusions.

Entire work of the students is being supervised and controlled by the teacher, as a result of which, probability of meeting with any kind of accident reduces to considerable extent. Not only this, with this, students perform their work without conducting any kind of mistake.

Principles of Laboratory Method:-

1. It follows the principle of learning by doing.
2. It follows psychological principle, where students age, lord and interest is taken into consideration.
3. The work should be Pre-organized and Pre-selected.

4. Teacher must see that, students are allowed to work independently without much interference.
5. The teacher must ensure that apparatus and equipments should be checked pair hand.
6. Teacher must see that students are able to follow in struction and record their observation properly

ROLE OF TEACHER:-

1. Teacher must be a facilitator of the process of doing experiments by students.
2. Teacher must check the apparatus previously, so that it goes on smoothly.
3. The practical work must be Pre-organized and Pre-selected.
4. The skills of handling apparatus, drawing, diagrams, careful observations taking necessary precautions, must be developed among students.
5. The teacher must be that, the student is doing experiment properly by following proper procedure.

Merits of Laboratory Method:-

1. It makes students active and alert.
2. This method follows child-centered approach
3. It helps in developing higher order this king capacities like reasoning, analyzing, synthesizing etc.
4. It inculcates good virtues like, honesty, truthfulness, dignity of labor etc.
5. It paves way for exploration experimentation and verification of scientific facts and principles.
6. Different skills are developed.
7. It helps in developing sprit of enquiring.
8. It gives scope for learning by doing and students do a lot of thinking themselves.

Limitations of Laboratory Method:-

1. It is time consuming as it takes much time in some experiments to come to conclusion.
2. It is expensive and uneconomical.
3. It expects a lot from students and teacher.
4. All students cannot be expected to be skilled workers.

5. It does not guarantee that, students would be equally efficient in solving problems outside laboratory.
6. Most of the students are either not ready or lack to ability to undertake original work.

Suggestions to improve:-

1. The practical work must be pre-planned.
2. This method should not be considered independently but should form a part of the total science program.
3. It is imperative that same individual laboratory work must be done by every student.
4. Before experiment in performed the purpose must be clarified to the students.
5. Instead of performing the experiments started in the book should be little modified for better result.

c) Diagnostic Testing and Remedial Teaching in science

Diagnostic Test:-

Educational diagnosis implies the use of more or less technical procedures designed to locate specific learning and instructional difficulties, and to determine their causes. Since students' progress is to be appraised towards desirable educational objectives, it is necessary to identify factors in the teaching, learning situations that may be interfering with optimum growth of individual learner. Apart from an individual's mental or physical differences many deficiencies in the student's achievement are due to the simple reason that once a student is not able to keep pace with the teaching in the class room or misses an important step due to some reasons or other has little or no chance to overcome this deficiency. Such deficiencies tend to accumulate with one deficiency leading to another so that after a stage learning becomes quite impossible and thus the student continues to fall back with the gap widening more and more. It is here that the teacher is required to know the specific weakness of the student both individually and collectively and provide suitable remedial teaching. To locate the specific weaknesses in the learning of his pupils the teacher may use analysis of assignment in periodical and final examinations and also oral work in the classroom. But the more systematic

way is to construct diagnostic tests and administer them for these purposes.

Diagnostic testing is an important tool for educators who want to know where their students are academically in order to bring those students to where they need to be. If you want your students to move forward, you need to identify where they have started; diagnostic testing is the way to do this.

Definition:-

"A diagnostic test is a test designed to locate specific learning deficiencies in case of specific individuals at a specific stage of learning so that specific efforts could be made to overcome those deficiencies".

It helps the teacher in identifying the status of the learner at the end of a particular lesson, unit or course of learning as to what specific teaching or learning points have been properly grasped by the learner. If such a deficiency is located in several students, it become obvious to the teacher to reflect upon whether something went wrong with his method of teaching. After administering a diagnostic test or battery test to students, a teacher takes remedial measures to overcome the deficiencies thus discovered.

Diagnosis stage – Observation, Achievement tests, Specific Aptitude, Tests, Interviewing the child.

Levels of diagnosis

1) Causative stage

- Who
- What
- Why

2) Preventive stage

- How
- What measures

Organization of a Diagnostic Program

- Constant Observation
- Studying Academic Scores
- Effective classroom management
- Checking Basics

- Family Background and General Interaction of students.
- Good relationship between teacher and student

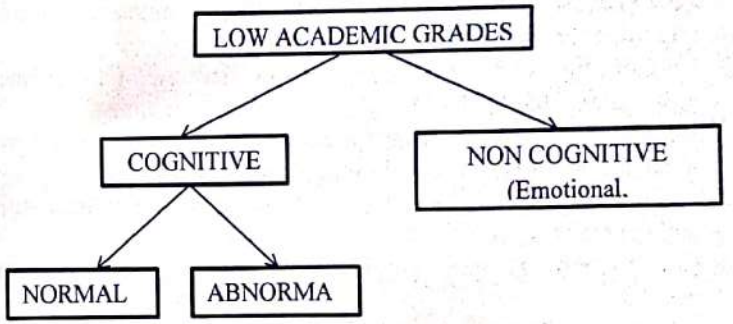
Supporting Activities: Library work, Outings, Survey, Educational Films, Clubs, Projects, Quiz, Games.....

Effective Diagnostic Program

- Philosophy of the school and the teacher
- Sensitizing the classroom
- Sensitizing Parents
- Effective Communication
- Counselling service

Remedial stage –

Curing the child of his deficiencies. Study the class in terms of previous experiences, change teaching methods, and provide adequate attention to individual children by making small groups



Effective remedial Program

- Specific tasks – A specific topic or activity needed.
- Basic Prerequisites – Brush up on topics which are required for current learning
- Basic Skills – Classification, Computation, Observation, Coordination of various skills
- Affective aspects – Interest, Attitude, Beliefs, Disposition.

General Principles guiding a Diagnostic and Remedial Program

- Subject should be taught in small doses, gradual development of content, invite constant feedback.
- Learning should be enjoyable & worthwhile
- Active learning
- Language of exposition - non textual
- Use meta cognitive strategies --- effective communication skills, reflection, keeping a diary……..
- Provide Reinforcement…….Success build Success
- No partiality
- Organize your Remedial Strategies
- Adequate affective strategies and supportive activities.

Science Examples/ Strategies for remediation:

1. Avoid starting with definitions/rules/general statements. Develop them through examples.
2. Give non examples & situations where the given rule or generalization does not apply. Eg; Man as an example for mammals. Highlight the limitations of the given rule.
3. Circumscribe concepts through properties eg: Photosynthesis, Adaptation, Habitat, Light…
4. Compare and contrast related concepts eg: Physical and Chemical changes, Decomposition and Combination reactions.
5. Avoid Stereotype, don't generate misconceptions. Eg: Superstitions and general beliefs without rational thinking.
6. Construction of own problems and developing interpretative exercises.
7. Estimation – Reasonableness of answers, rough order of magnitude, builds confidence. Eg : physics problems.
8. Laboratory skills and observational abilities.

Science examples :

1) Student breaks apparatus in the laboratory always.

Diagnosis: Student is nervous when handling apparatus.

Remediation: Student is helped with how to hold apparatus and how to use them. This is done regularly for a period of time.

2) Student answers, "Plants require carbon dioxide for respiration"

Diagnosis: Student has acquired the wrong concept.

Remediation : Orientation of the following concepts- Respiration, Photosynthesis, Role of Oxygen, Role of Carbon Dioxide, Concept of Living Things.

Mumbai University Question Paper- 2016

(2½ Hours) [Total Marks: 35]

1. Illustrate the various values inculcated through the study of Science in our Socio-Cultural context. 10
2. "External correlation enriches the teaching of Science" Explain with reference to. 10
3. "Constructivism develops higher level of thinking among students." Justify the statement using 7E's of Constructivism. 10
4. Explain the steps of the 'Problem Based Learning' in the teaching of Science with suitable examples. State its advantages. 10
5. Explain the role of the teacher in developing global perspectives through teaching of Science. 10
6. Attempt briefly any one of the following : 5
   (a) Nature of Science
   (b) Use of Maxim 'Particular to General' (2 examples)
   (c) Merits of the Laboratory method

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