Teaching of Science Education

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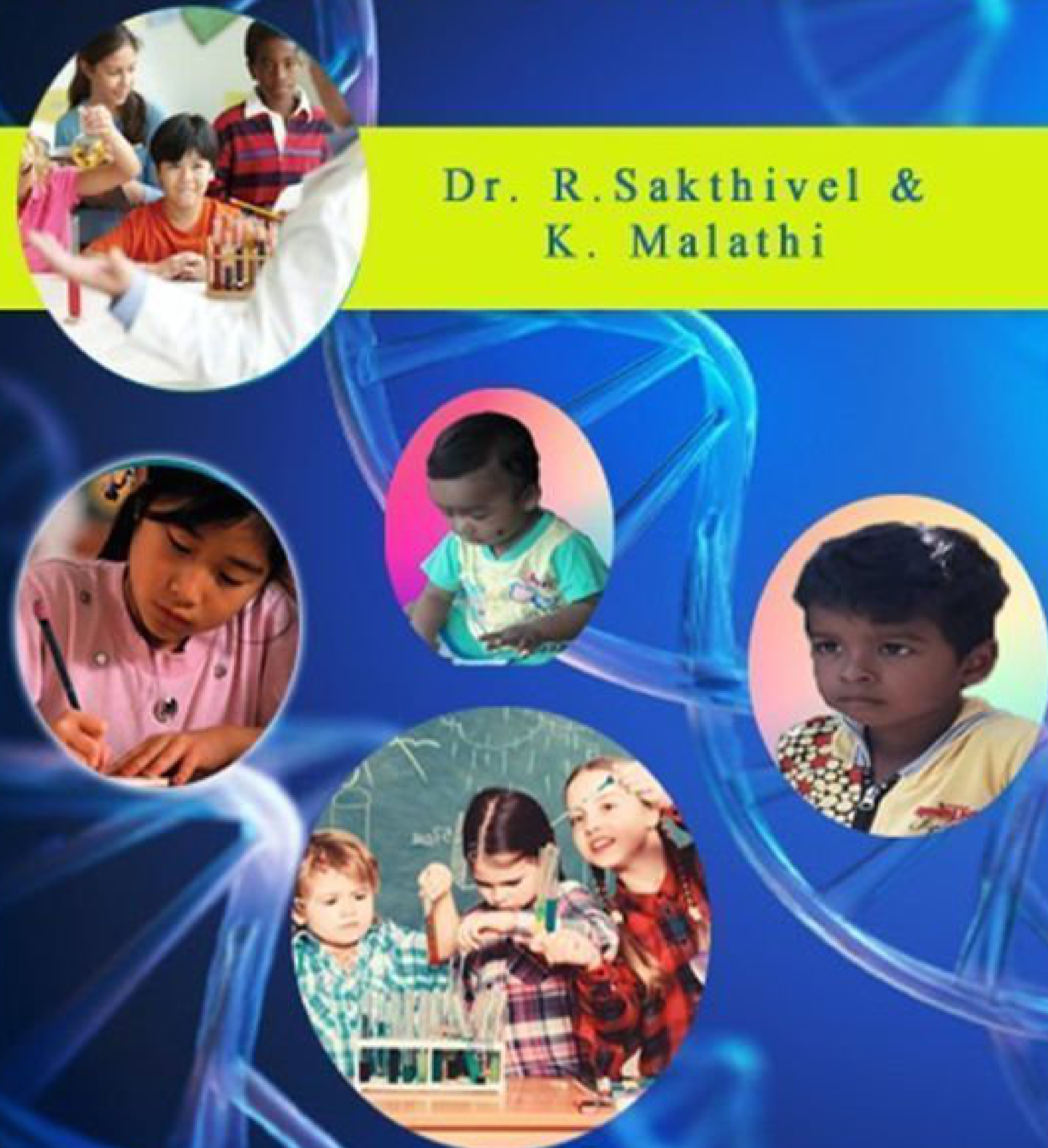
Dr. R.Sakthivel &
K. Malathi



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PREFACE

'Teaching of Science' requires special skill and with the continuing developments and latest researchers, the teaching methodology needs modification.

Teaching is a noble profession. It involves honour, prestige, knowledge-updated information, money and much more. From primary to higher education, a teacher is looked upon as an ideal for students. Students make all efforts to imitate their teacher in every respect. As for knowledge, students regard teachers as a moving store-house of information and erudition, where every question has an answer.

No doubt, there are so many other books on the subject, available in the market, written by worthy authors. However, every writer has his or her own style and way of presentation. The present work also has its own features and characteristics.

This particular book is titled: *Teaching of Science Education.*

We hope that the book will prove its worth by fulfilling the needs of those for whom it has been specifically designed. Any suggestion for its improvement in future will be gratefully acknowledged and warmly appreciated.

- **Dr. R. Sakthivel**
- **K. Malathi**

I. INTRODUCTION

The word science is taken from the Latin word **'Scientia'** which means **knowledge** or **to know.** Science is referred as an organized or systematized body of knowledge. To the founding fathers, the meaning of science was 'To know God better, know His works.' Later the study and exploration of the working (laws) of nature became a passion that has driven all scientists ever since. According to modern thinking, the curiosity of man to know about himself and his surroundings has led to an accumulation of a vast body of knowledge, called as Science. Today, science is an amalgamation of observation, identification and theoretical explanation of the phenomenon that occurs in nature. Man has been studying his environment in an attempt to improve his life right from his primitive days. He began with the observation of things around him and went on to gather information and finally applied it to his daily life.

Great advancement of science and technology and the use of these scientific achievements in promoting the well-being of mankind through their application in the field of industry, communication, transport, engineering, agriculture, medicine has made science more important than ever before.

Today science and technology have become very sophisticated. Our powers of observation are aided by sophisticated gadgets, which allow us to view minute particles with magnifications millions of times its original size. Our vision his extended to the outer fringes of the universe by modern instruments. We can access and record information very rapidly using computers. We are able to communicate with one another by means of spoken and written word. If communication is to be effective, it is essential that the persons involved share a common understanding of the terms.

MEANING OF SCIENCE:

Man is curious by nature. It is curiosity that motivates him to discover new ways to use this powerful key for understanding the mysteries of the world. Therefore, when we consider what science is and make decisions about what to teach children and how to teach them, we must be conscious about the following three parts of what science actually is? The three parts are:

1. **Attitudes:** Science encourages humans to develop positive attitudes, including their powerful curiosity;
2. **Skills:** Science stimulates humans to use their curiosity to construct new ways of investigating and understanding; and
3. **Knowledge:** Science consists of what humans learn-knowledge for practical learning and everyday living-the meaning humans construct for themselves.

WHAT IS SCIENCE?

Science is a methodical approach to studying the natural world. Science asks basic questions. Such as,

i. How does the world work?
ii. How did the world come to be?
iii. What was the world like in the past?
iv. What is it like now, and
v. What will it be like in the future?

These questions are answered using observation, testing and interpretations through logic.

SCIENCE: DEFINITION:

The word `Science ` is derived from the Latin word termed as "***Scientia***" which has the meaning ` ***to Know*** `.

Science has been defined as a **body of knowledge** obtained by scientists. The body of knowledge includes facts, concepts, theories and laws that are subjected to rigorous testing. Scientific information is constantly modified, rearrange and reoriented in the light of recent developments.

Science can be defined in a number of ways. A few definitions are given below.

- ✓ Science is concerned with understanding the properties of external world of nature.
- ✓ Science is a body of knowledge and a method of obtaining it for wider usage.
- ✓ Science reveals that knowledge is tentative and constantly changing.

- ✓ Scientific ideas are the result of experimentation and observation by scientists.
- ✓ Scientific ideas are subject to modification in the light of further empirical observation.
- ✓ Scientific Methods have given trustworthy science through the experimental learning.
- ✓ Science is both a product and a process

IMPORTANT CHARACTERISTICS OF SCIENCE:

From the definitions and we can summarize the important characteristics of Science.

1. Science helps us to understand our environment.
2. Science is nothing but truth.
3. Science means searching for truth.
4. Science reveals that knowledge is tentative and changing.
6. Science is not only classified knowledge but also a method of acquiring it.

Hence the Science is both a product and a process.

TEACHING SCIENCE: – IMPORTANCE AND VALUES

Teaching Science is an important for every teacher also it has its own influence over the personal life of an individual as well as his / her social life. From the Ancient days the Science and teaching and learning science subjects have been an integral part of the human society.

The teaching Science is felt important for the following reasons:

- ✓ The Science helps an individual to be a self-seeker of knowledge and develop curiosity.
- ✓ It satisfies the inquisitiveness of an individual and helps to discipline his character.
- ✓ It is only Science that reveals the use of the natural phenomena.
- ✓ The study of science helps us to understand the most modern gadgets and its proper usage.
- ✓ The impact of science in our civilization and modernization can be appreciated only by studying Science

TEACHING SCIENCE: IMPORTANCE:

The curriculum renewed in the light of NCF 2005, aims at the preparation of committed teachers whose professionalism would enable them to sustain their learning interest throughout their career. The present curriculum has a paradigm shift from the teacher to the learner and from the focus on teaching methods to ways and means of facilitating and enhancing learning by children.

SCIENCE EDUCATION:

Technology is changing every day, and the jobs of tomorrow haven't been invented yet. As a science educator you can prepare your community for that change. Science fields are in high demand, and science teachers are the ones that can meet the demands.

We need intelligent, qualified individuals more than ever. If you have an interest in science, good communication skills, and a passion for learning and growing, then science education may be the right field for you. With one of the best science schools in the state, we can offer science education classes that are second to none. With a teaching certificate from the College of Education at the University of Iowa, you will be one of the most competitive applicants in the job search.

WHAT IS SCIENCE EDUCATION?

Science is a process as well as knowledge. Children learn science by being involved not only with its content, but also with its methodology. The effective science facility accommodates both. Science study requires a variety of unique instructional materials in addition to those materials common to all of education. A science facility must have space to accommodate this variety in combination with hands-on instructional strategies. Science instructional areas have spatial and material needs that are different from those considered in designing a general use classroom. National, state, and local efforts, public and private, are underway to improve science education.

SCIENCE EDUCATION: DEFINITION

Science education is process which involves provide to learner guidance which involves acquiring scientific knowledge, process skills.

SCIENCE EDUCATION RESEARCH:

The test of science programmes and science teaching is an empirical one: 'What do the students learn?' If there is to be continuing improvement of science education, it is important to undertake research. Through research we are better able to differentiate between what we *wish* would happen and what *does* happen.

NATURE OF SCIENCE:

Science can easily make or break the future for mankind. Therefore, a good way to start to examine the nature of science may be to ask what it is that is special about it. What is unique, or at least distinctive, about science when compared with other human activities? A number of possible answers may spring to mind; some of them may seem obvious of first sight but turn out on closer scrutiny to need a great deal of hedging about with qualifications. There is one, however, which seems to be both outstandingly simple and outstandingly significant. It is this-that science has made progress in a sense which is clearer and less disputable than is the case with other fields of human endeavour.

Science as a Body of Knowledge:

Science is often taught as a body of established facts obtained by infallible individuals (scientist) using infallible methods (particularly, the "scientific method"). Actually, scientific knowledge includes not only facts, which are truths and therefore indisputable, but also generalisations and theories which are subject to error and liable to change. To be scientifically literate certain, that which is supported by strong evidence, and that which is merely speculative, he should also be conscious of ever changing nature of science.

Science is based on Observation:

Observation is the primary way to provide information. This does not mean that we benefit solely from watching someone else and listening to someone else and listening to what others think. Students observe by using all their senses. The science teachers stimulate useful observation through the five senses when they ask children questions that cause them to identify properties of objectives, changes and similarities and difference; and to determine the difference between an observation and an inference. An example of observation could be: *the object is hard, gray, round and the size of a baseball.* Instruments such as thermometers, volt meters, balances, and computers help to add precision to observations.

Science is a Part of Knowledge:

Our quest for the meaning and nature of science will start with an acquaintance with knowledge itself. We are using this as a starting point for the very basic reason that science, in its essential form is a part of knowledge. Even etymologically, the term 'science' is derived from the Latin word 'scire' which literally means 'to know'. To understand science then we have to understand the nature and the structure of knowledge as such. Simple-minded as it may sound, our knowledge consists of what we know to be facts about ourselves and the universe in which we live. When, for instance, a person claims knowledge about the military force of a country, or about the structure of the earth, or about the economic and political life of a country, he simply implies that he knows what he may call the facts about all these matters. Human knowledge takes the form of beliefs or judgements formed by an individual about a particular phenomenon.

When a person claims that he knows that the sun arises in the east or that man is a social animal, he makes such claims on the basis of what he believes in. However, human beliefs fall into two broad categories. In the first place, there are certain judgements or belief which are supported by the evidence which justifies them. The evidence may be in the form of individual experiences or perceptions. In other words, one may believe in what one hears, seems, smells or touches or what others are able to present to one with some justification in terms of their own experience and observation. These beliefs may be called *justified beliefs.*

The *justified beliefs of man constitute his knowledge.* Mere beliefs are, therefore, to be excluded from the sphere of knowledge. These are usually described as superstition and differentiated from knowledge. Thus, human knowledge consists of the justified beliefs of man supported by sufficient evidence.

Science is based on Creativity:

We have often heard the statement, "There's nothing new under the Sun." It is said that new inventions are merely new combinations of old knowledge. Even if this be true, does it follow that nothing new is produced.

Chemists have long distinguished between a mixture and a compound. The mixture might represent the combination of old knowledge which gives us nothing new, but should a chemical reaction take place. We have a new substance or a compound which gives us nothing new, but should a chemical reaction take place. We have a new substance or a compound which can't be identified with the mixture of yeast, flavour and salt produces a mound of maternal which to most people is quite unpalatable. However, addition of water and heat results in a savory leaf of bread in which none of the ingredients of the original mixture can be specifically identified. A new substance has been created. From this point of view, we may say there are "many new things under the sun" which have come about as a result of the creativity of particular persons. Such creative persons are the inventors who bring forth novel products in almost any field of endeavour. These persons are the scientists. They contribute for the growth of science.

Science is Organised Knowledge:

Science is based on organised knowledge. But strictly speaking all organised knowledge is not science. Organised knowledge includes both theoretical knowledge and practical wisdom or active skills of different kinds. On one hand is the science of medicine or physiology consisting of theories, laws and principles of a general nature applicable to a large variety of practical situations, on the other, are the practical skills and the techniques used in the practice of medicine and surgery. In a broad sense, both practical and theoretical part of organised knowledge. Sometimes the term 'pure science' is used to refer to that part of scientific knowledge which belongs to the sphere of theoretical knowledge cannot be considered strictly scientific.

SCOPE OF SCIENCE TEACHING:

1. Science Teaching is concerned with Economic Growth:

The ingredients of economic growth, are fairly well known. Among the ingredients are: natural resources, skills and know-how, energy and ingenuity of people, the capital necessary to develop the technology to make the optimum use for skills and energy and some reasonable relationship between natural resources and the human population that must exist on those natural resources. Apparently, all of these ingredients must be present. The lack of one ingredient may be a serious limiting factor to economic growth.

Effective programmes of science education are essential for optimum economic growth. Among the natural resources that can be used for economic growth are soil, fresh water, rocks and minerals, fuels, water power, solar energy, animal and plant life, the oceans, scenic, landscapes and the energy and ingenuity of the human population. Considerable insight and know-how is needed to make the optimum use of these resources.

2. Science is Essential for Healthy Living:

Education, and particularly science education, is essential for the control and reduction of disease. Many diseases are carried by various vectors such as the mosquitoes and files. It is essential for the individual to know how these diseases and spread some details of the life cycles of the insect vectors, and the points in the life-cycles where the insects are often due to ignorance. Malnutrition, for example, is often found in places where the necessary nutrients are available but ignorance may keep them away from those who are in need.

3. Science Helps to Control Population Growth:

The history of twentieth century becomes more and more a race between numbers and the quality of life. If we open the pages of history, we will find that the human race has increased very slowly. It took thousands of years for the world to reach one billion by 1800A.D. when death rate fall the growth of population began to accelerate. From some recent studies it is estimated that it took nearly 130 years to reach two billion in the year 1930. Within a period of only thirty years, i.e., in 1960, it reached three billion. It is surprising that only within a period of fifteen years i.e., in 1976, the number increased to four billion. Thus race between numbers on explosion has become almost a global problem.

BRANCHES OF SCIENCE

There are pure and applied branches of science but for the convenience, science is divided into the following three branches. (However, in recent times many new fields have emerged.)

- **Physical sciences:** These include Physics, Chemistry and Astronomy. Physics is the study of matter, energy and interaction between them. Chemistry is the science, which deals with composition, properties, reactions and structure of matter. Astronomy is the study of universe beyond Earth's atmosphere.
- **Earth Sciences:** These include Geology, Paleontology, Meteorology, and Oceanography. Geology is the science of origin, history and structure of earth, whereas, Paleontology is the science of life forms, which existed in prehistoric or geologic period. Meteorology deals with atmosphere and its phenomenon and Oceanography is the study of oceans. Environmental science is also one of the earth sciences.
- **Biology or Life Sciences:** Botany, the study of plants, and Zoology, the study of animals constitute the life sciences. Thus, science unfolds the mysteries of life and universe and has influenced the existence of man largely, be it vocational, social, political or cultural aspects.

SCIENCE EDUCATION AND ITS NEEDS:

Science is the knowledge and understanding of scientific concepts and processes required for decision making, participation in civic, cultural affairs and economic productivity. People who are scientifically literate can ask for, find or determine answers to questions about everyday experience. The elements of science like developing hypothesis, proposing critical experiments, making observations, collecting data, testing ideas, developing logical conclusions should be woven into every content area and become a part of life. The principal goal of science education is to create individuals who can develop creative and innovative thinking to become capable of doing new things and not just follow the past generations. Further the question: 'Why teach science?' can be answered in the light of the objectives of science teaching.

They are as follows:

- To explore and interpret the physical world. (The three fundamental areas of Physics, Chemistry and Biology help in achieving this objective.)
- To acquire understanding of scientific concepts, principles and laws;
- To develop instrumental, communicational and problem solving skills ;
- To develop scientific temper, attitudes and values such as open-mindedness, intellectual honesty, suspended judgment, courage to question and respect for human dignity;
- To cultivate social, ethical, moral and aesthetic values which exalt and refine the life of the individual and the society;
- To appreciate the contributions of scientists and develop sensitivity to possible uses and misuses of science;
- To develop concern for a clean environment and preservation of the ecosystem.

SCIENCE OUTCOMES:

- ✓ Students will demonstrate their acquisition and integration of major concepts and unifying themes from the life, physical, and earth/space sciences.
- ✓ Students will demonstrate the ability to interpret and explain information generated by their exploration of scientific phenomena.

- ✓ Students will demonstrate ways of thinking and acting inherent in the practice of science.
- ✓ Students will demonstrate positive attitudes towards science and its relevance to the individual, society, and the environment and demonstrate confidence in their ability to practice science.
- ✓ Students will demonstrate the ability to employ the language, instruments, methods, and materials of science for collecting, organizing, interpreting, and communicating information.
- ✓ Students will demonstrate the ability to apply science in solving problems and making personal decisions about issues affecting the individual, society, and the environment.

AIMS OF TEACHING SCIENCE

Educational aims turn the different activities undertaken in schools and other educational institutions into a creative pattern. An educational aim helps the teacher connect her present classroom activity to a cherished future outcome without making it instrumental, and there, give it direction.

The broad aims of science education complementing the aims of general education should be:

- ✓ To make students interested in science
- ✓ To familiarize the students with the important role played by science in their daily life
- ✓ To develop in students a scientific culture
- ✓ To provide a training to students in method of science
- ✓ To emphasize upon students the role of science on social behavior
- ✓ To prepare students for those vocations which require a sound foundation in science with special reference to the concerned subject
- ✓ To increase student's understanding to such a level that he can understand various concepts and theories which unify various branches of science
- ✓ To develop scientific attitude and science related values among students by inculcating scientific temper.

THE AIM OF TEACHING SCIENCE CAN BE SUMMARIZED UNDER THE FOLLOWING CATEGORIES:

a. Acquisition of knowledge and information:

The students studying science should acquire knowledge of scientific facts, principles and events of nature, living and non-living, rules of health and sanitation and other kinds of knowledge of science that will help the learner to live an intelligent and efficient life in a modern society. Such knowledge must be appropriate to the age, stage and ability level of the learners. Knowledge of science should enable the learner to understand, adjust and if necessary change his immediate environment as required.

b. Development of interest and appreciation:

Since study without interest will not be meaningful and permanent, the teacher should therefore conduct his teaching in such a way as to stimulate interest of the learners in the subject. They must develop interest to pursue scientific activities within and outside the school, read scientific news and literature, organize science clubs and science exhibition, science competitions and try to apply scientific knowledge in everyday activities. They should take interest to conserve the beauties of nature.

The students studying science should be able to appreciate the contributions of science for the well-being and comfort of mankind and how the ideas and achievements of science have helped the progress of human civilization. They should be able to realize that the tremendous progress of experimental science, the marvels and wonders of modern science, and the application of science to every field of human activity have marked the present day society as a scientific society. The teachers in their process of teaching should lead the learners to see the impact of science on society and their responsibility as a member of a modern society.

c. Development of favorable habits:

The teachers should see that the desirable need for learning science is instilled in the learners' minds and that such qualities are reflected in their everyday habits. For instance, science is pursuit of truth and its pursuit demands intellectual honesty, mind, unbiased judgment, and objective observation. These qualities also help the learners to become self-confident.

d. Training in scientific method

Through teaching of science, the students should be trained in scientific method of procedure while solving scientific problems. It involves logical steps in the process. It is, in fact, the problem-solving method which involves application of critical thinking and systematic procedure. The scientific method means following certain steps of scientific procedure in sequential order which lead to the solution of a problem. Though there does not appear to be one strictly typical process of scientific method in general, it involves such steps as sensing a problem, defining the problem, analysis, organization and experimentation, collection of data, processing and calculating, formulation, of hypothesis and testing, correct interpretation, conclusion and generalization. The teacher should focus the learners attention on these processes and train them to follow scientific methods to solve problems not only in the area of science but also social problems.

e. Development of scientific attitude:

This is an important component of the aim of science teaching. The constituents of scientific attitude may not automatically develop in the outlook of the learners. The teacher will have to make efforts to point out these aspects in the process of teaching science and try to inculcate this outlook in the behavior pattern of the learners. Scientific attitude refers to critical observation, inquisitiveness, broadmindedness and open-mindedness, objectivity in approach, non-belief in superstition and hearsay, belief in proof, trust in correct evidence, respect for others' opinion, faith in scientific method, unprejudiced judgment, and belief in cause and effect relationship. Such attitudes are warranted not only in pursuit of scientific problems but also in solving problems at home and in the society. These qualities if developed in the minds of the students and instilled in the behavior pattern of the learners, solve many problems of individual and social living. Hence, scientific attitude is considered an important constituent of the aims of teaching science.

f. Development of skills and abilities:

Teaching of science should aim at developing in the learners various skills involved in studies of science, such as skills in drawing diagrams and sketches of specimens and apparatus, constructional skills, experimental skills for arranging and organizing experiments in science as well as for handling instruments and apparatus skill of observation, and the skill for solving problems.

The study of science should develop the ability to identify a problem, ability to analyse and interpret the problem, ability to improvise apparatus if necessary, ability to generalize and predict results and also the ability to locate source of information relating to the problem at hand. Further, the learners of science should develop abilities to express or discuss on scientific problems, the ability to organize science clubs and fairs and the ability to apply scientific principles in problems faced in life.

g. Science studies as a basis of future career:

In the scientific and technological world of today, there are innumerable avenues where science finds its application. Science, in addition to being a part of general education, prepares students for future vocations and forms the basis for specialization in higher sciences. The teacher should be able to select students from his group to be given special training to enable them to pursue specific studies for technical or vocational career, we need enough manpower for schools themselves.

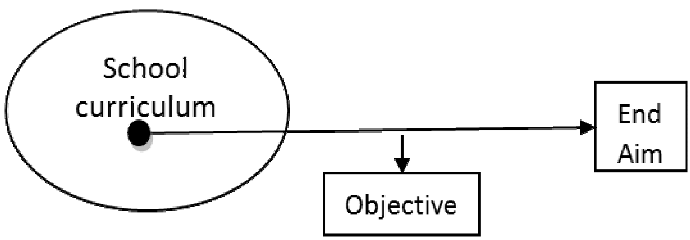
h. Provision for utilization of leisure:

In a industrial and technological society, the use of leisure time poses a problem. Science provides a host of technical and intellectual activities which can provide fruitful engagements for leisure. Such activities may range form production and maintenance activities to intellectual activities pursued for pleasure. While teaching facts and principles of physical and biological sciences, the pupils should be encouraged to prepare simple useful materials like soap, boot-polish, ink, etc., or articles like kaleidoscope, simple camera, simple telescope, magnetic compass etc., or engage themselves in maintenance of aquarium, herbarium, nature corner, preparation of charts, models or slides, observation of animal and bird habits, and repairing articles of everyday use and a wide range of similar other activities. The instruments, such activities provide opportunity for utilization of leisure and fulfil one of the aims of education.

WHAT IS AN OBJECTIVE?

The whole educational system is directed towards aims which lead to an all-round development of the student. For the teacher, it is practically impossible to realize all these aims, for they involve a total programme of education encompassing not only school, but also out-of-school experiences. Thus the school programme is only a part of the total educational programme.

The part of the aims which a school can hope to achieve is called an objective. Hence an objective is a part of an aim-a narrower term when compared to an aim. This can be illustrated by a diagram as shown in figure.



An instructional objective is a statement that describes what the pupil will do, or be able to do, once the instruction has been completed. It is a learning product that the teacher hopes will result from the instruction, whether in a lesson unit, course or curriculum. It is the terminal behavior expected of the pupils at the conclusion of a period of learning.

Objectives of teaching science in Primary Education:

Each and every child should

- Have the creativity.
- Acquire the Interest in learning science
- Have the awareness of the environment
- Analyse and investigate their activities rationally.
- Develop the scientific aptitude and attitude.
- Do individually simple science experiments.
- Actively engage themselves in Project works.

- Collect data from various sources in the given context.
- Have the ability of decision making and problem solving.
- Classify the data in an organized pattern and confirm the results.

Objectives of teaching science in elementary schools:

- To create interest in science.
- To help the children in healthy living.
- To observe carefully objects and events in the nearby environment.
- To analyse and investigate the natural objects and specimens.
- To collect all sorts of objects in the environment, and classify them to draw inference.
- To be curious to know about natural objects and appreciate them.

Classification of Objectives of Teaching:

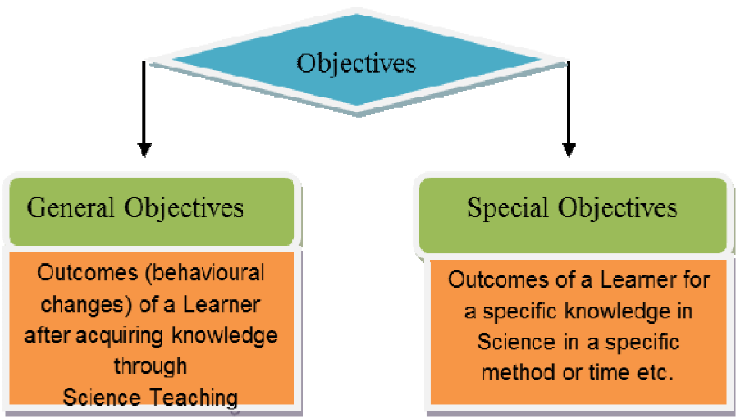
Aim is the ultimate object or action or result to be achieved by the person. It is a broader concept. But the Objective is the trend or roles to be forwarded or implemented to achieve the aim desired.

Objectives are classified in to types, viz:

I. **General objectives** and

II. **Special objectives**.

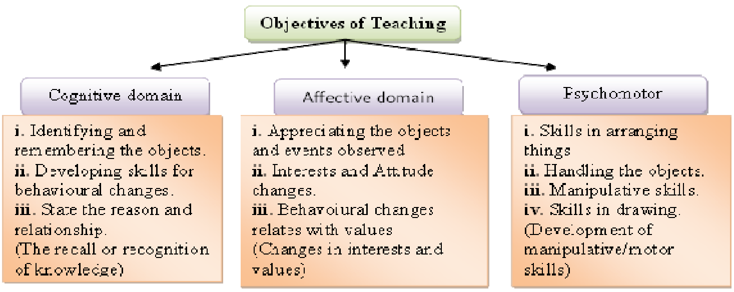
Objectives in Teaching Science



BLOOM'S TAXONOMY OF EDUCATIONAL OBJECTIVES

Although the objectives of teaching science are stated in different ways, the objectives formulated by Benjamin Bloom (1956) and his associates developed a hierarchical classification system or taxonomy, to help teachers gain a better perspective on the behaviours to be emphasized in instructional planning are as follows:

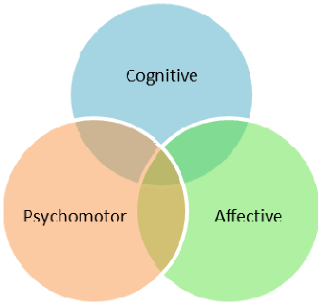
1. Cognitive domain
2. Affective domain
3. Psychomotor domain



Bloom and his associates have attempted to formulate taxonomies of instructional objectives for both the cognitive and affective domains. The three domains of learning do not occur in isolation but rather work together to make up one whole being.

Objectives can be classified into three primary categories on the basis of their instructional focus: **thinking, attitudes** and **physical skills.** These areas of focus represent the three domains of learning: cognitive, affective and psychomotor. In reality, the domains do not exist in isolation. Whereas some behaviors are easily classifiable into one of the three domains, others will overlap a great deal. This overlap is shown in figure.

Interaction between the three types of skills in learning science



The three domains for objectives were designed to form hierarchical taxonomies of students learning-from simple to complex-with each level making use of building on the behaviors addressed in the preceding level.

Example: 1

Teaching / learning the features of living and non-living things.

Cognitive domain	Identification of things given and recalling the similar experiences. Formulating the concept.
Affective domain	Observing the activities of the given things.
Psychomotor domain	Differentiating the animals and plant

Example: 2

Teaching / learning the separation of iron dust from the rice.

Cognitive domain	Selection of appropriate experiment (Knowledge)
Affective domain	Observing and arriving the results from the experiment.
Psychomotor domain	Setting up or conduct of the experiment proposed.

Example : 3

Learning is Titration

Psychomotor domain	Muscles coordinate to pipette and operate the burette
Cognitive domain	Knowledge of level to which one must pipette and the colour of the indicator

Affective domain	Performance of these two activities effectively so that the pupil becomes proficient

COGNITIVE DOMAIN:

This domain includes those objectives which deal with thinking, reasoning ability and problem-solving of students. Because the ability to think can range from simple recall of information to more complex thinking behavior.

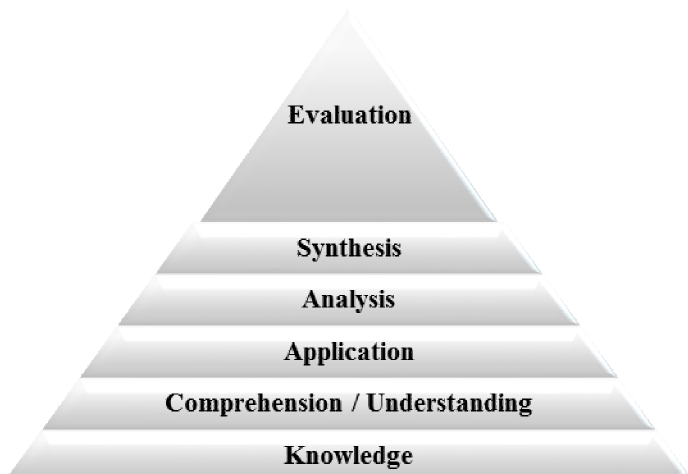
The cognitive domain into three types as follows;

1. Factual knowledge,
2. Conceptual Knowledge and
3. Procedural Knowledge.

The skills to be developed among the learners in the Cognitive domain are classified further into 6 divisions. They are.

1] Acquiring the Knowledge
2] Comprehending the knowledge
3] Application of knowledge and earlier experiences
4] Analysis
5] Synthesis
6] Evaluation and feedback.

Pyramid of skills development in Cognitive domain



Cognitive domain	Knowledge	It is a basic component of Cognitive domain. It just recalls or remembers the earlier experiences. The names, dates, objects, incidents etc. can be remembered with through knowledge.
	Understanding	Comprehends the knowledge of the object observed or the action performed or to be performed. It generally explains or illustrates the principles and laws related to science. Only with the understanding further conceptualization is possible.
	Application	Applies the knowledge acquired and make decisions for problem solving.
	Analysis	This relates or distinguishes the information from the news, objects, activities etc. for the process of Problem solving or decision making.
	Synthesis	Assemblage of the parts or information derived and formulates the new projects and schemes or concepts.
	Evaluation	Feedback of the properties of objects, activities, solutions, methods etc.,

1] Acquiring the Knowledge:

- ❖ The learner acquires the knowledge of scientific facts, principles relevant in day to day life.
- ❖ Acquiring knowledge of relevant facts to understand the scientific literature.
- ❖ Action verbs: Identify, define, list, match, state, name, label, describe, select.

2] Comprehending the knowledge:

- ❖ Understanding cause and effect relationships among the scientific facts and principles.
- ❖ Developing ability for critical thinking and reasons of basic scientific and principles.

- Classifying objects, facts on the basis of some scientific criteria.
- Translating the scientific notations into understandable language.
- Solving scientific problems.
- Elaborating phenomena of sciences.
- Explaining graphs, charts and other scientific concepts.
- Explaining relationship or difference in scientific concepts.
- Examining the validity of scientific principles of law.
- Action verbs: Translate, convert, generalize, paraphrase, rewrite, summarize, distinguish, infer, alter, explain.

3] Application of knowledge and earlier experiences:

- Analysing scientific phenomena.
- Explaining and analysing observations.
- Predicting from the results of analysis.
- Establishing causes effect relationship.
- Involving the basic principles in solving problems.
- Conducting new experiments.
- Using graphs, charts, tables in appropriate situations.
- Action verbs: Use, operate, produce change, solve, show, compute, prepare, determine.

4] Analysis:

- It is breaking down complex material into its component parts so it can be better explained.
- This may involve subdividing something to explain how it works, analyzing the relationships between parts.
- This ability is evidenced when the pupil can distinguish facts from hypothesis or is able to make explicit the interrelationships among ideas in a communication
- Analysis is split into three levels:
    - Analysis of elements
    - Analysis of relationships
    - Analysis of organizational principles
- Action verbs: Discriminate, select, distinguish, separate, subdivide, identify, break down, devise.

5] Synthesis:

- ❖ It is the putting together of elements and parts so as to form a whole.
- ❖ A new and unique form must be produced form available elements.
- ❖ It involves the process of working with pieces, parts, elements and arranging and combining them in such a manner as to constitute a new distinct pattern or structure.
- ❖ The key to synthesis level activities is the incorporation of known ideas to form unique patterns or to create new ideas.
- ❖ Synthesis involves three levels:
    - o Production of a unique communication
    - o Production of a plan, or proposed set of operations
    - o Development of a set of abstract relations
- ❖ Action verbs: Design, plan, compile, compose, organize, conclude, arrange, construct, devise.

6] Evaluation and feedback:

- ❖ Making of judgments about the value, for some purpose, of ideas, works, solutions, methods, materials, etc.,
- ❖ Judgments are both quantitative and qualitative.
- ❖ Students must i. set up or be given appropriate criteria or standards and ii. Determine to what extent an idea or object meets the standards.
- ❖ It involves:
    - o Judgment in terms of internal evidence
    - o Judgment in terms of external criteria
- ❖ Action verbs: Appraise, compare, justify, criticize, explain, interpret, conclude, summarize, evaluate

Anderson and Rathhole proposed the **Metacognition** as an additional type of Cognitive domain. The restructured general objectives of *metacognition* are as follows:

Metacognition	General Objectives	Activities concerned
	Remembering	Define, list out, recall, give an account of
	Understanding	Compare, distinguish, note briefly, guess
	Application	Make models, discuss,
	Analysis	Differentiate, arrange, classify, illustrate with examples
	Evaluating	Experiment, evaluate, test,
	Creating	Plan, modify, formulate, derive

Example:

" Find out the amount of vitamin contents in the food supplied to a person in his / her family environment "

If the general explanation of Vitamins and their availability and list out the functions are given for activities proposed in teaching the learners have received the data only. Such like activities force the learner to memorize the data and remembering skills only. With the activities proposed above the following activities can be done individually or in group activity.

By providing the diagrams and ask the children to classify the food constituents based on vitamins.

- By providing actual objects / specimens or models or diagram the learner should classify according to the specific vitamin.

- Learner is asked to list out their daily food and it's nutritious values.
- To prepare a diet table of a family (usually the learner's) describing the amount of food intake and its nutritious value. Identify the vitamins in their food and amount of vitamin consumption by a particular person in the family.

Such activities may enhance the learnability and positive feedback of the subject taught.

The following table gives the general objectives and the appropriate action verbs that would clearly indicate the behavioral objectives

General Objectives	Action verbs that would explicitly indicate the behavioral objective
Knowledge	1. State the laws, define concepts 2. List the details 3. Name the objects
Understanding	1. distinguish 2. give examples 3. explain 4. compare and contrast 5. state the relationship
Application	1. state the reason 2. solve problems 3. apply the scientific principles in daily life
Acquisition of skills	1. Set up experiment, using appropriate science apparatus 2. observe carefully and note down data 3. Fabricate the apparatus for the experiment 4. Measure accurately during experiments 5. Draws diagrams for explaining scientific principles 6. Collects scientific objects 7. Point out the different stages of development of objects 8. Classify scientific objects and display them 9. Dissect biological specimens

AFFECTIVE DOMAIN:

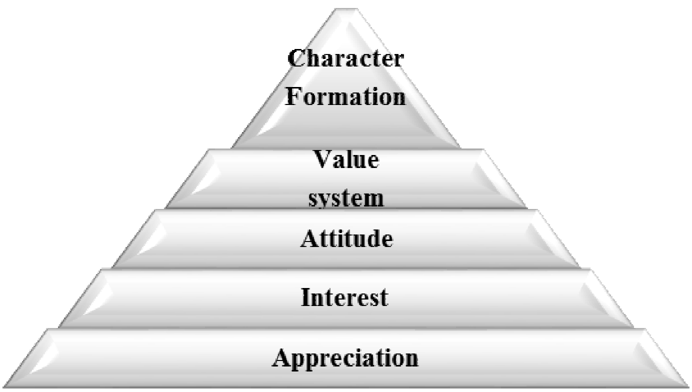
This is concerned with the development of emotions and feeling among students. The following are the objectives in this domain. In teaching science, children have to develop

1. Appreciation
2. Interest
3. Attitudes
4. Value system and
5. Character formation

Usually these are long term objectives. The behavioral changes in this domain are not explicitly evaluated. A continuous effort in teaching and the follow up activities alone can change or modify the behavioral changes. The moral values can be inculcated in this domain.

Example: Disposal of degradable and non-degradable wastes in its appropriate places.

The stages of Affective domain:



The kernel of this teaching objective is to make the learner to manage the wastes in a proper way. It is very difficult to illustrate the solid wastes management, the oral instructions and the lectures make tired of the learner also arouse no interest towards the topic dealt. The illustration through the drama or puppets make effective. The good characters and the goodwill be appreciated in these will give a positive effect.

Appreciating the activities of sincere learner enhances the motivation of teaching objective. The learners themselves trained to classify the wastes as degradable and nondegradable. The activities assigned (The degradable wastes must be kept in green colored bin and the non-degradable wastes to be placed in red colored bin) to the learners need be followed and appreciated. The proper appreciation makes the learner to achieve the long term goal or objective. The appreciation can be done among the other children motivates them to continue their activity.

1. Appreciation:

A student of science develops sense of appreciation for scientific inventions and discoveries. Development of sense of appreciation is a psychological phenomenon. This can be developed in the learner if he is exposed to such situations and trained to judge its importance critically. Such a sense of appreciation is manifested through the learner's behavioural charges like tendency to appraise the influence of scientific contribution for the human society, to value high the scientific inventions and the like.

2. Interest:

Through science education the learner develops interest in scientific matters. He automatically involves himself in discussions related to science. He develops a liking for reading like history of great.

3. Attitudes:

Through the study of science the learner has to follow a systematic scientific approach in all the related activities like observation, analysis, classification, experimentation, drawing of inference and the like. In course of time he develops the habit of performing all such activities in that systematic approach. In other words, an attitudinal change takes place in the logical and scientific way. Such scientific attitude is also exhibited when the attempts to solve any problem in his day to day life situation. This attitudinal change is characterized by certain mental qualities.

4. Value system:

Valuing refers to voluntarily giving worth to an idea, a phenomenon, or a stimulus. Students not only accept the worth of a value, but they also internalize that worth.

5. Character formation:

If behaviors reveal an individual has developed a value system and acts consistently with the internalized values, then characterization by a value or value complex has been established. At this stage, a student displays individuality and self-reliance.

PSYCHOMOTOR DOMAIN:

The purpose of this psychomotor domain is to develop the mind and muscular skills.

The following are the objectives:

1. Skill in arranging experiments
2. Skill is arriving at accurate results
3. Skill in drawing the sketches and diagrams
4. Manipulative skills

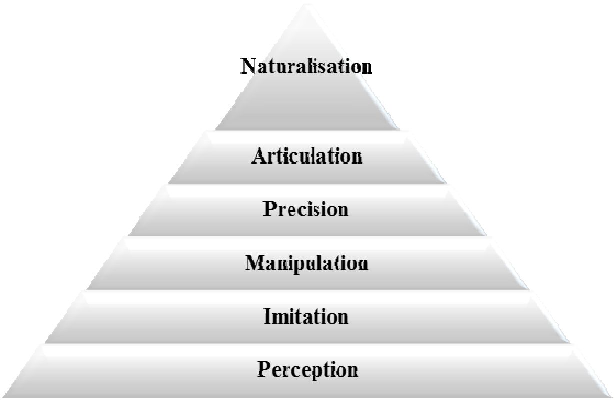
The above stated objectives are called general objectives. The attainment of these general objectives can be observed and measured only when they are stated in the form of behavioural objectives. Before teaching any lesson to the students, it is absolutely necessary to state clearly the learning outcomes in terms of general objectives and behavioural objectives.

Benjamin Bloom had not given much attention and gave little explanation to this Psychomotor domain. The Psychomotor domain is explained and classified its objectives by Harey (1972) as follows:

1. Perception
2. Imitation
3. Manipulation
4. Precision
5. Articulation
6. Naturalization

The creativity of child is developed by the behavioural changes of psychomotor domain. The keen observation and the active participation only develop the creativity. The teacher should demonstrate and give the hands on experience while learning science. The projects and experiments develop the creativity of the children. The activity based learning is also an one of the method allows the behavioural changes among the children and fulfill the main objectives of teaching Science.

Objectives of Psychomotor domain:



Example: The demonstration of the experiments related to transformation of energy.

1. Teacher demonstrates the concept through simple experiments: making models for wind energy. Mechanical energy to Electrical energy etc.
2. Giving low cost materials to build fan, anemometer, wind mill etc., and demonstrating them for children.

1. Perception:

Perception is our sensory experience of the world around us and involves both the recognition of environmental stimuli and actions in response to these stimuli. Through the perceptual process, we gain information about properties and elements of the environment that are critical to our survival. Perception not only creates our experience of the world around us; it allows us to act within our environment.

Perception includes the five senses; touch, sight, taste smell and taste. It also includes what is known as proprioception, a set of senses involving the ability to detect changes in body positions and movements. It also involves the cognitive processes required to process information, such as recognizing the face of a friend or detecting a familiar scent perception is equated with reality for most practical purposes and guides human behavior in general

Possible verbs: listen to, look at, touch, smell, taste, hear, sound, feel

2. Imitation:

Observe a skill and attempt to repeat it, or see a finished product and attempt to replicate. Patterning behavior after someone else.

Possible verbs: Attempt, carry out, copy, duplicate follow, imitate, mimic, move, practice, repeat, try

3. Manipulation:

Perform the skill or produce the product in a recognizable fashion by following general instructions rather than observation.

Possible verbs: Complete, follow, play, perform, and produce

4. Precision:

Independently perform the skill or produce the product with accuracy, proportion, and exactness; at an expert level.

5. Articulation:

Modify the skill or produce the product to fit new situation; combine more than one skill in sequence with harmony and consistency.

Possible verbs: Adapt, alter, customize, originate

6. Naturalization:

Completion of one or more skills with ease and making the skill with ease and making the skills with ease and making the skill automatic with limited physical or mental exertion.

Possible verbs: Naturally, Perfectly.

II. SCIENTIFIC METHOD

SCIENTIFIC METHOD AND SCIENTIFIC ATTITUDE:

WHAT IS SCIENCE?

A discussion on scientific methods and attitudes presupposes the concept of what science is. Science has been defined in different ways by different authors. It has already been mentioned elsewhere that science is not just a body of knowledge as it used to be considered in earlier times; it is a static view presenting science as a hot of facts, principles, laws and theories along with the vast lot of systematized information used for interpreting the events in our environment and universe at large. It is true that ever since men tried to understand nature, and to adjust themselves for existence and survival, human knowledge for convenience. But under the current wider context, science is much more than this. Science is dynamic. It is knowledge as well as the process of its continuous development and refinement. Science is thus both a product as well as a process. It is an endless process of observation, exploration and acquisition through empirical and conceptual means. The characteristic of this process is growth through continuous acquisition, generalization and refinement.

In science, generalisations often have exceptions. Conclusions or theories in science are valid as long as they can explain all the known events and behaviours in nature. In this sense, generalisations are tentative. Many laws of science used in experiments hold good within temperature constraints. A theory of one time proves invalid at a different time when it fails to explain newly found facts of nature. For instance, Newton"s Laws of motion, which are applicable in case of macroscopic bodies with limited velocity, fail application in case of sub-atomic bodies; or his concept of gravitation was not found to be accurate enough to be utilized by Einstein in his field theory of gravitation. The history of science is full of such instances where even long-accepted notions or concepts about nature, living and non-living, were replaced by new ideas and newly found laws, to explain new discoveries and inventions. Science, with the development of accurate technical appliances and invention of improved techniques, has become more numerical, quantitative and objective with time.

THE SCIENTIFIC METHOD:

One of the most significant outcomes of the study of science is training in scientific method now considered as one of the aims of teaching science. The modern educationists, particularly Dewey, advocate scientific method and scientific attitude as objectives of formal education. This is essentially the method that scientists follow or should follow while solving a problem of science and thus, it is also referred to as problem solving method. In fact, the terms "scientific method", "method of science", "critical thinking", "reflective thinking", "scientific enquiry", "problem solving method" refer to the same process; that is, the method or procedure of solving problems scientifically. Scientific method involves critical thinking, logical reasoning, systematic organization and understanding at each step of the procedure. The rudiments of scientific method in their crudest from can be traced back to the beginning of human race. They can be seen in the immature attempts to do something or make something by trying various ways and means until success was achieved. But the critical discussion and systematic analysis regarding the components of scientific method are of recent origin. Modern scientists have stressed the importance of this aspect of science learning, revitalizing the foundations set by a few earlier scientists, especially Bacon, Galilio and Newton. But some modern critics express doubt over the interpretatior of scientific method consisting of a set of definite steps to be followed in sequential order to solve a problem of science. It is contended that there can be different ways of solving a problem scientifically. It is, however, agreed by all that scientific method is an efficient way to solve problems of everyday life. The scientific method obviously begins with a problem.

It may be mentioned here simply performing an experiment scientifically does not automatically train the learners in scientific method or develop scientific attitude in them. Research studies have revealed that deliberate efforts are needed to facilitate acquisition of scientific method and scientific attitude. Studies have also indicated that direct teaching for scientific method and scientific attitude is more effective than teaching science without considering these outcomes of science learning. It is therefore essential to provide situations and activities to the learners while teaching the subject so that they receive a continuous training in scientific method during the process of learning. An atmosphere of enquiry and investigation involving analytical thinking should prevail during science teaching both in the classroom as well as in the laboratory, or outside the school activities. The teacher should also provide situations where the learners can apply the knowledge and concepts of scientific method and reveal development of scientific attitude in them. He should ask appropriate and leading questions while encouraging the students to explore the problem at hand. Alternatively, he should encourage the students to ask relevant questions relating to the problem that is being investigated or listen to the various questions raised by the students to ask relevant questions relating to the problem that is being investigated or listen to the various questions raised by the students and discuss the solutions with the learners themselves. Such an atmosphere of exploration should lead the learners to recognize a problem, define and analyse it, collect relevant data, process and interpret them, formulate a hypothesis and test its correctness and generality to draw a conclusion. An attitude of objectivity, intellectual honesty and unbiased judgement should prevail during the process of investigation which can help the learners achieve a training in scientific method and attitude. They will be encouraged to be scientific in their thought and action in everyday life. This aspect of science learning, that is, the development of scientific method and scientific attitude, is more important and more valuable than mere acquisition of knowledge or facts of science.

DEFINITION OF SCIENTIFIC METHOD:

A means of acquiring knowledge scientifically; the system of advancing knowledge by formulating a question, collecting data about it through observation and experiment, and testing a hypothetical answer.

A short definition of scientific method is:

OBSERVE - HYPOTHESIZE - TEST.

How to introduce students to the scientific method:

Students, and sometimes even teachers, often think scientists only use the scientific method to answer science-related questions. In fact, you can apply the scientific method to almost any problem. The key is to use the elements (steps) to reduce bias and help come to a solution to the problem. The scientific method is the standard in the laboratory, but don't be fooled by the name. It is also used beyond the laboratory to solve everyday mysteries and problems. The scientific method is the standard in the laboratory, but don't be fooled by the name. It is also used beyond the laboratory to solve everyday mysteries and problems.

One size does not fit all:

The scientific method consists of a number of different steps, but the order in which we apply the steps can vary. Rather than focus on the order of the steps, students should see the scientific method as a tool that consists of elements they can use to solve problems and answer questions.

One size does not fit all when it comes to doing science or solving everyday mysteries.

While you can reorder the steps of the scientific method, it is important to apply all the steps to reduce the impact of personal bias. This is really the key function of scientific method. The scientific method lays out a process that helps scientists come to a conclusion, but that conclusion is made more valid by virtue of the process scientists used to reach their conclusion. One of the real strengths of the scientific method is that its steps helps users reduce the chance for error and personal bias, making the results of their experiments more trustworthy. **Communicating what is learned:**

The scientific method also serves as an important template for communicating results and the logic behind them. This step is perhaps the most important step in the scientific method, yet it is often a step that is left out of models of the scientific method. If scientists don't share their results or talk about the processes they used to get those results, those results can't become part of our understanding of the world around us. It is, therefore, critical that "communicating results" is part of students' vision of the scientific method.

The students trained in scientific method are expected to solve problems in any situation they may come across. In this connection, **Karl Pearson** wanted to formally describe 'scientific method' in the following steps:

1. A problem is stated.
2. Observations relevant to the problem are collected.
3. An hypothesis consistent with the observations is formulated.
4. Predictions of other observable phenomena are deduced from the hypothesis.
5. Occurrence or non-occurrence of the predicted phenomena is observed.
6. The hypothesis is accepted, modified or rejected in accordance with the degree of fulfillment of the prediction.

The universality of such formal definition of scientific method has, however, been questioned by many educationists and authors. **Keeslar** suggested the following elements of scientific method suitable for high school students:

a. Notice something that makes you think of a question that you would like to answer make up your mind to try to find an answer to it.

b. Decide exactly what the question or problem is and state it clearly in words.

c. Study all the facts and see how they relate to the problem.

d. Make as many possible answers to the problem as you can think of (making hypothesis).

e. Select from these possible answers of hypothesis, the one you think is most likely to be the right one.

f. Make up and carefully plan an experiment to find out whether the answer you selected is the right one.

g. Carry out the experiment with great care according to the plain.

h. Repeat the experiment to see whether you get the same results the second time. The second experiment is called check expeirements.

i. Draw your conclusion.

j. Use the facts you have thus learned when you face a new problem similar or related to this one.

The above indicates the useful steps for exploring and solving a problem scientifically by students while at the same time the process inculcates in them a training in scientific method. An analysis of the various procedures followed by different scientific for solving problems of science, or an analysis of history of events in science, leads us to identify the following common logical steps involved in a scientific method:

a. Sensing a problem,

b. Definition and analysis of the problem,

c. Collection and organization of relevant data,

d. Interpretation of data,

e. Formulation and selection of suitable hypothesis,

f. Testing or experimenting the hypothesis,

g. Drawing conclusions and generalization, and

h. Application to new situations.

STEPS IN THE SCIENTIFIC METHOD

1. Ask a **Scientific Question**
2. Make **Observations** and do **Research** about the question
3. Form a **Hypothesis** predicting the answer
4. Design an **Experiment** to test the hypothesis
5. Collect and analyse **Data**
6. Form a **Conclusion** (report results)

7. Retest

1. Question:

- ✓ Observing means using one or more of your senses to gather information
- ✓ A scientist observes something interesting in the natural world
- ✓ The scientist formulates a question

2. Research:

- ✓ The scientist makes more observations through research.
- ✓ Then the scientist makes an inference.
- ✓ Inferring is when the scientist explains or interprets his observations.

3. Hypothesis:

- ✓ Based on his observations and research, the scientist predicts an answer to the question.
- ✓ Predicting means making a forecast of what will happen in the future based on past experience and evidence
- ✓ The prediction is called a hypothesis.
- ✓ A hypothesis must be testable.

4. Experiment:

- ✓ An experiment is a procedure (usually written in steps) that will prove or disprove the hypothesis.
- ✓ Variable – Any factor in the experiment that can change.

- ✓ An experiment is valid if the scientist changes only one variable at a time.
- ✓ The scientist changes one variable and then observes or measures what happens as a result.

All other variables must be kept exactly the same so that they will not affect the outcome of the experiment. These are called control variables. They are used for comparison.

1. Example of Controls and Variables:

An experiment was done to see if rotted leaves added to soil had an effect on tomato production. One tomato plant was grown in each of four large tubs. The following amounts of rotted leaves were added to the tubs:

Tub A had 15 kg added

Tub B had 10 kg added

Tub C had 5 kg added and

Tub D had no rotted leaves added

Each tub had the same type and amount of soil, got the same amount of sunlight, and was watered the same amount. The total mass of tomatoes produced by each plant was measured and recorded for three months.

What is the Scientific question?

Does adding rotted leaves to soil increase tomato production?

What is a possible Hypothesis?

If rotted leaves are added to soil, tomato plants will produce more tomatoes.

What are the Control variables?

Type and amount of soil, amount of sunlight, amount of water, time.

Is this a valid experiment?

Yes! Only one variable was changed.

5. Data:

Facts, figures, and other observations gathered during an experiment; often organized into tables or graphs

Quantitative data: Quantitative data comes from observations that can be measured in numbers or amounts For examples: Length, time, mass, temperature, etc.,

Qualitative data: Qualitative data comes from observations that can"t be measured For examples: colour, shape, taste, etc., Both types of data are important to scientist!

6. Conclusion:

A summary of what was learned based on the data obtained during the experiment. It should answer the scientific question. A conclusion may: support the hypothesis or prove it to be false.

7. Retest:

In order to verify the results, experiments must be repeated!

Are you and your students science detectives?

Science Detectives Training Room is a fun way to teach students from elementary level to college about the scientific method. It is also a great way to build problem solving skills. Based on a popular “room escape” genre of online games, players enter a dark room and must work through a set of problems to escape. Once the player escapes from the first room, they encounter a summary of the steps they took to escape and how those steps match the steps of the scientific method. At the end of the game the player can print out the results of their training room exercise for review. If used as an assignment, students can submit the printout to their instructor to show how they performed in the activity.

Review first, play later, or play first and review afterwards?

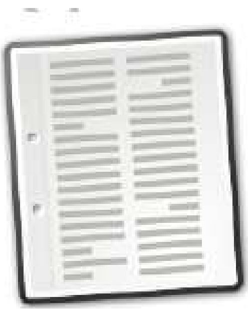
This is a question best answered by each teacher. Depending on the student or class, it might help to review the process involved in using the scientific method to solve problem. Previewing the game allows the student to experience what they have learned as they play the game. Other instructors, however, might choose to have students play the game first and then use the game summary printout as a tool for engaging students in a discussion of the process and parts of the scientific method, such as control, variables, and data. Either method is effective.

Time to play:

The average time to play the game is 5-7 minutes, depending on the grade level of the student.

Multiple game solutions:

The game has multiple options that are randomly selected as the player enters the room. Players are unlikely to have the same experience if they play the game several times. This is handy for instructors who want to have students play the game in a classroom laboratory. Each student is likely to have a slightly different experience.



Using the final report option:

In order to escape, a player will be presented an opportunity to print the output of their training. The final report is personalized and can be used as homework or as an extra credit opportunity. For school-level learners, problems of science may not be evident under ordinary situations. All the students may not possess equal degree of inquisitiveness of mind, enquiring attitude or environmental experience. At school stage, therefore, they need be to provided with situations which generate curiosity in them and lead them to question. Alternatively, the teacher may indicate the problem through a question or two, The topic, an item of their regular syllabus to be covered, should be presented in such a way as to be felt as something new and challenging and as a thing to be explored instead of it being repeated as a routine work to be taught every year to new batches of students. Though many facts of science were discovered by chance, the majority of scientific achievements were the results of enquiry, effort and a deliberate desire to find. Science is a process of endless query and one question leads to another more fundamental question. But a school level, the learners need constant guidance and direction towards discovering a problem of science. The teacher has to lead his students to notice things that provoke their thinking and raise questions in their minds. After discovering and ascertaining the problem, they should be able to define the problem in scientific language and proceed towards a solution. This sensing and defining of the problem serve the „what" part of their question, while 'how' and 'why' parts are yet to be answered. For this, the learner will have to collect relevant data, analyse and interpret them and then formulate a number of hypothesis, select the most probable one among them and proceed to test the selected hypothesis through experiment.

After analysing the problem, the students need to plan the subsequent activities. They should discuss, consult references, use the needed audio-visual aids such as relevant pictures, charts, models, specimens, and do the experimentation carefully to test the validity or otherwise of their selected hypothesis. These activities demand their skill, abilities and reasoning power and on the other hand the whole process provides an opportunity to develop these abilities in them. The collected data need careful organization, tabulation and involve accuracy of calculation. Unnecessary data needs to be discarded. The selection of appropriate hypothesis is a good test of their conceptual understanding and thinking power. After testing the hypothesis, they come to a conclusion and repeat the experimentation to verify the consistency and correctness of the conclusion arrived at. Repeatability is a good test of the quality of the collected data. The students should mark the limitations of conditions during their experimentation and include these limitations in their conclusions. When the same conclusions are arrived at in different sets of experimentation under similar situations, they may go for generalization of their conclusion. The students should then be able to apply generalizations under new situations in their everyday life and be able to interpret similar events happening in their environment. In life situations, the students will come across circumstances that will demand application of their knowledge and ability to predict happenings. As has already been mentioned, training in scientific method helps the learners solve many practical problems of life. But the habit of scientific enquiry or problem solving skill may not automatically be developed in those who may be interested to learn the contents only. The teachers will have to make a deliberate effort to train the learners in scientific method while teaching them science. They must develop a proper attitude of mind to look into the practical problems of their life and their environment scientifically and follow scientific method to solve them.

Introduction to the Scientific Method:

The scientific method is the process by which scientists, collectively and over time, endeavor to construct an accurate (that is, reliable, consistent and non-arbitrary) representation of the world.

Recognizing that personal and cultural beliefs influence both our perceptions and our interpretations of natural phenomena, we aim through the use of standard procedures and criteria to minimize those influences when developing a theory. As a famous scientist once said, “Smart people (like smart lawyers) can come up with very good explanations for mistaken points of view.” In summary, the scientific method attempts to minimize the influence of bias or prejudice in the experimenter when testing an hypothesis or a theory.

I. The scientific method has four steps:

1. Observation and description of a phenomenon or group of phenomena.
2. Formulation of an hypothesis to explain the phenomena. In physics, the hypothesis often takes the form of a causal mechanism or a mathematical relation.
3. Use of the hypothesis to predict the existence of other phenomena, or to predict quantitatively the results of new observations.

4. Performance of experimental tests of the predictions by several independent experimenters and properly performed experiments.

If the experiments bear out the hypothesis it may come to be regarded as a theory or law of nature (more on the concepts of hypothesis, model, theory and law below). If the experiments do not bear out the hypothesis, it must be rejected or modified. What is key in the description of the scientific method just given is the predictive of the hypothesis or theory, as tested by experiment. It is often said in science that theories can never be proved, only disproved. There is always the possibility that a new observation or a new experiment will conflict with a long-standing theory.

II. Testing hypotheses:

As just stated, experimental tests may lead either to the confirmation of the hypothesis, or to the ruling out of the hypothesis. The scientific method requires that an hypothesis be ruled out or modified if its predictions are clearly and repeatedly incompatible with experimental tests. Further, no matter how elegant a theory is, its predictions must agree with experimental results if we are to believe that it is a valid description of nature. In physics, as in every experimental science, "experiment is supreme" and experimental verification of hypothetical predictions is absolutely necessary. Experiments may test the theory directly (for example, the observation of a new particle) or may test for consequences derived from the theory using mathematics and logic (the rate of a radioactive decay process requiring the existence of the new particle). Note that the necessity of experiment also implies that a theory must be testable. Theories which cannot be tested, because, for instance, they have no observable ramifications (such as, a particle whose characteristics make it unobservable), do not qualify as scientific theories.

If the predictions of a long-standing theory are found to be in disagreement with new experimental results, the theory may be discarded as a description of reality, but it may continue to be applicable within a limited range of measurable parameters. For example, the laws of classical mechanics (Newton's Laws) are valid only when the velocities of interest are much smaller than the speed of light (that is, in algebraic form, when $v/c << 1$). Since this is the domain of a large portion of human experience, the laws of classical mechanics are widely, usefully and correctly applied in a large range of technological and scientific problems. Yet in nature we observe a domain in which v/c is not small. The motions of objects in this domain, as well as motion in the “classical” domain, are accurately described through the equations of Einstein's theory of relativity. We believe, due to experimental tests, that relativistic theory provides a more general, and therefore more accurate, description of the principles governing our universe, than the earlier “classical” theory. Further, we find that the relativistic equations reduce to the classical equations in the limit v/c << 1. Similarly, classical physics is valid only at distances much larger than atomic scales (x >> 10-8 m). A description which is valid at all length scales is given by the equations of quantum mechanics.

We are all familiar with theories which had to be discarded in the face of experimental evidence. In the field of astronomy, the earth-centered description of the planetary orbits was overthrown by the Copernican system, in which the sun was placed at the center of a series of concentric, circular planetary orbits. Later, this theory was modified, as measurements of the planets motions were found to be compatible with elliptical, not circular, orbits, and still later planetary motion was found to be derivable from Newton's laws.

Error in experiments has several sources. First, there is error intrinsic to instruments of measurement. Because this type of error has equal probability of producing a measurement higher or lower numerically than the “true” value, it is called random error. Second, there is non-random or systematic error, due to factors which bias the result in one direction. No measurement, and therefore no experiment, can be perfectly precise. At the same time, in science we have standard ways of estimating and in some cases reducing errors. Thus it is important to determine the accuracy of a particular measurement and, when stating quantitative results, to quote the measurement error. A measurement without a quoted error is meaningless. The comparison between experiment and theory is made within the context of experimental errors.

III. Common Mistakes in Applying the Scientific Method:

As stated earlier, the scientific method attempts to minimize the influence of the scientist's bias on the outcome of an experiment. That is, when testing an hypothesis or a theory, the scientist may have a preference for one outcome or another, and it is important that this preference not bias the results or their interpretation. The most fundamental error is to mistake the hypothesis for an explanation of a phenomenon, without performing experimental tests. Sometimes "common sense" and "logic" tempt us into believing that no test is needed. There are numerous examples of this, dating from the Greek philosophers to the present day.

Another common mistake is to ignore or rule out data which do not support the hypothesis. Ideally, the experimenter is open to the possibility that the hypothesis is correct or incorrect. Sometimes, however, a scientist may have a strong belief that the hypothesis is true (or false), or feels internal or external pressure to get a specific result. In that case, there may be a psychological tendency to find "something wrong", such as systematic effects, with data which do not support the scientist's expectations, while data which do agree with those expectations may not be checked as carefully. The lesson is that all data must be handled in the same way.

Another common mistake arises from the failure to estimate quantitatively systematic errors (and all errors). There are many examples of discoveries which were missed by experimenters whose data contained a new phenomenon, but who explained it away as a systematic background. Conversely, there are many examples of alleged "new discoveries" which later proved to be due to systematic errors not accounted for by the "discoverers."

In a field where there is active experimentation and open communication among members of the scientific community, the biases of individuals or groups may cancel out, because experimental tests are repeated by different scientists who may have different biases. In addition, different types of experimental setups have different sources of systematic errors. Over a period spanning a variety of experimental tests (usually at least several years), a consensus develops in the community as to which experimental results have stood the test of time.

IV. Hypotheses, Models, Theories and Laws:

In physics and other science disciplines, the words "hypothesis," "model," "theory" and "law" have different connotations in relation to the stage of acceptance or knowledge about a group of phenomena.

An hypothesis is a limited statement regarding cause and effect in specific situations; it also refers to our state of knowledge before experimental work has been performed and perhaps even before new phenomena have been predicted. To take an example from daily life, suppose you discover that your car will not start. You may say, "My car does not start because the battery is low." This is your first hypothesis. You may then check whether the lights were left on, or if the engine makes a particular sound when you turn the ignition key. You might actually check the voltage across the terminals of the battery. If you discover that the battery is not low, you might attempt another hypothesis ("The starter is broken"; "This is really not my car.")

The word model is reserved for situations when it is known that the hypothesis has at least limited validity. A often-cited example of this is the Bohr model of the atom, in which, in an analogy to the solar system, the electrons are described has moving in circular orbits around the nucleus. This is not an accurate depiction of what an atom "looks like," but the model succeeds in mathematically representing the energies (but not the correct angular momenta) of the quantum states of the electron in the simplest case, the hydrogen atom. Another example is Hook's Law (which should be called Hook's principle, or Hook's model), which states that the force exerted by a mass attached to a spring is proportional to the amount the spring is stretched. We know that this principle is only valid for small amounts of stretching. The "law" fails when the spring is stretched beyond its elastic limit (it can break). This principle, however, leads to the prediction of simple harmonic motion, and, as a model of the behavior of a spring, has been versatile in an extremely broad range of applications.

A scientific theory or law represents an hypothesis, or a group of related hypotheses, which has been confirmed through repeated experimental tests. Theories in physics are often formulated in terms of a few concepts and equations, which are identified with "laws of nature," suggesting their universal applicability. Accepted scientific theories and laws become part of our understanding of the universe and the basis for exploring less well-understood areas of knowledge. Theories are not easily discarded; new discoveries are first assumed to fit into the existing theoretical framework. It is only when, after repeated experimental tests, the new phenomenon cannot be accommodated that scientists seriously question the theory and attempt to modify it. The validity that we attach to scientific theories as representing realities of the physical world is to be contrasted with the facile invalidation implied by the expression, "It's only a theory". For example, it is unlikely that a person will step off a tall building on the assumption that they will not fall, because "Gravity is only a theory."

V. Are there circumstances in which the Scientific Method is not applicable?

While the scientific method is necessary in developing scientific knowledge, it is also useful in everyday problem-solving. What do you do when your telephone doesn't work? Is the problem in the hand set, the cabling inside your house, the hookup outside, or in the workings of the phone company? The process you might go through to solve this problem could involve scientific thinking, and the results might contradict your initial expectations.

Like any good scientist, you may question the range of situations (outside of science) in which the scientific method may be applied. From what has been stated above, we determine that the scientific method works best in situations where one can isolate the phenomenon of interest, by eliminating or accounting for extraneous factors, and where one can repeatedly test the system under study after making limited, controlled changes in it.

There are, of course, circumstances when one cannot isolate the phenomena or when one cannot repeat the measurement over and over again. In such cases the results may depend in part on the history of a situation. This often occurs in social interactions between people. For example, when a lawyer makes arguments in front of a jury in court, she or he cannot try other approaches by repeating the trial over and over again in front of the same jury. In a new trial, the jury composition will be different. Even the same jury hearing a new set of arguments cannot be expected to forget what they heard before.

VI. Conclusion:

The scientific method is intricately associated with science, the process of human inquiry that pervades the modern era on many levels. While the method appears simple and logical in description, there is perhaps no more complex question than that of knowing how we come to know things. In this introduction, we have emphasized that the scientific method distinguishes science from other forms of explanation because of its requirement of systematic experimentation. We have also tried to point out some of the criteria and practices developed by scientists to reduce the influence of individual or social bias on scientific findings.

THE SCIENTIFIC ATTITUDE:

Through the study of science the learner has to follow a systematic scientific approach in all the related activities like observation, analysis, classification, experimentation, drawing of inference and the like. In course of time he develops the habit of performing all such activities in that systematic approach. In other words, an attitudinal change takes place in the logical and scientific way. Such scientific attitude is also exhibited when the attempts to solve any problem in his day to day life situation. This attitudinal change is characterized by certain mental qualities.

Science encourages humans to develop positive attitudes, including their powerful curiosity.

The development of scientific attitude of mind is one of the objectives of teaching science. It is a very significant outcome of the process of science education. Teaching of science should not only enable the learners to master the facts, concepts and principles of science or develop instrumental and problem-solving skills but also develop scientific attitude of mind is essential to enable them to adjust themselves and live as efficient citizen in a scientific society. The National Science Teachers Association of USA says that a result science education, the learners should be in the "process of developing a personal philosophy based on truth, understanding and logic rather than one based on superstition, intuition or wishful thinking."

A scientific attitude can be developed only through personal experience and keen observation in the process of science learning. The teacher will have to provide situations in the classroom or field environment where the students can experience see and feel the need for developing this attitude. For instance, open mindedness of the learners in necessary in scientific pursuits. They should respect others‟ opinion but at the same time believe only in verified facts. The spirit of enquiry must prevail in a scientific pursuit. They should learn to observe and think critically and accurately. Accuracy and precision are essential in scientific experimentation. The purpose of scientific pursuit is to find the truth. There is no place for bias or prejudice if truth is to be revealed. The student"s observation, therefore, should be unbiased and objective. Intellectual honesty is indispensable in the study of science. While solving a problem, a scientist proceeds carefully and patiently, examines each step logically and holds back judgement until he is satisfied with the proof.

These characteristics of any scientific pursuit should become a habit in the students learning science so that these are developed as a mental attitude in them. The students of science must never believe in superstition or hearsay. They rely in cause and effect relationship and verified facts or proof. In this connection, the *Rethinking Science Education* mentioned the characteristics of scientific attitude as "open mindedness, a desire for accurate knowledge, confidence in procedures for seeking knowledge and the expectation that the solution of the problem will come through the use of verified knowledge." These attributes of the mind are essential for solving a problem scientifically, be it a problem in the area of science or a social problem. It is true that the teacher will have to provide activities and situations where the students get an opportunity to develop scientific attitude. The learners may, in the process of studying science, miss these additional aspects involved in a scientific pursuit. The teacher should point them out to the students. Further, one textbook of science may not be successful in projecting various components of scientific attitude. The teacher should therefore encourage students to read different books on science because research studies have revealed that the students engaging themselves in wider reading inculcate scientific attitude more than those who read one textbook. But students should perform experiments or do projects in science, components of scientific attitude. The development of scientific method and scientific attitude are constituents of the goals of general education and we must strive to attain them through the teaching of science subjects.

A discussion on the importance of honest doubt in science will be relevant here. It is sometimes seen that when a student doubts a statement of the teacher and puts questions to the teacher, he is usually silenced or even rebuked for not accepting the statement of the teacher. This practice is harmful; it thwarts the spirit of enquiry and honest doubt which, in fact, should be developed in the students. Moreover, this is not democratic teaching; it is authoritarianism. When the student is not convinced of some statement and hesitates to accept it, he is considered skeptical by the teacher and he discourages him. Such authoritarian teaching retards the development of critical thinking and objective judgements, so important for scientific investigation. Such teaching imprints fixed ideas on the minds of the students. In science learning it is not wise to accept things blindly and without questioning if doubt arises. But unfortunately, in practice, it appears, the questioning if doubt arises. But unfortunately, in practice, it appears, the questioning student is often branded disobedient or aggressive. This is simply punishing original thinkers and rewarding unprotesting students.

There are many instances in the history of science where skepticism lead to great breakthoughs. Healthy criticism and a skeptical attitude are considered essential ingredients in science by many authors of science education, because without a questioning mind, science will lose its very foundation, that is, dynamism and progressive character. Philip Abelson in 'the need for scepticism' has pointed out that the great shortage in science now is not opportunity, manpower, money or laboratory space. What is really needed is more of the healthy skepticism which generates the key idea-the liberating concept. The teachers should always remember that without a questioning mind and a spirit of enquiry, studies in science will only mean acceptance of dogma and will never lead to development of scientific attitude in the learners. The students should not merely be supplied with information about science; they should be made to practice and observe science so that they get the opportunity to feel and develop the components of scientific attitude in their minds.

The methods and skills used by scientists are intimately connected to a set of attitudes common in the practice of science. A scientific attitude is a disposition to act in a certain way or a demonstration of feelings and/or thoughts. Studies of the actions of scientists have led to lists of scientific attitudes such as displayed below. Some attitudes such as honesty would be expected in any human endeavour, but other attitudes such as tolerance of uncertainty are more characteristic of scientists. Note that scientific attitudes are different from attitudes about/towards science.

Scientific Attitude	Characteristics
critical-mindedness	. looks for inconsistencies · consults a number of authorities · challenges the validity of statements
suspended judgment (restraint)	· recognizes the restrictions in generalizations and theories · generalizes only to the degree justified by available evidence
respect for evidence	· looks for evidence (empirical approach) to support or contradict statements · demands interpretations that fit the evidence · collects as much evidence as possible
Honesty	· reports all evidence even when it contradicts hypothesis or expectations · acknowledges the work of others
Objectivity	· considers all pros and cons · considers all evidence available

	· considers and evaluates statements by others
willingness to change opinions	· recognizes all hypotheses, generalizations and theories as being tentative · evaluates evidence which contradicts prediction · alters hypotheses when necessary to accommodate empirical evidence
open-mindedness	· considers several possible options when investigating a problem · considers and evaluates ideas presented by others
questioning attitude	· looks for inconsistencies · challenges the validity of unsupported statements · asks many questions starting with who, where, when and how
tolerance of uncertainty	· accepts that there is always some uncertainty · strives for greater and greater certainty

THE MEASUREMENT OF ATTITUDES TOWARDS SCHOOL SCIENCE:

The following sections draw on a range of attitude studies to discuss issues of how attitudes are measured, what attitudes are found, and what factors influence attitudes. When general references are made to studies of „attitudes towards science‟, these studies focus on attitudes that are a product of students‟ experience of school science and, unless otherwise specified, refer to their attitude to school science. Recognition of the difficulty of measuring attitudes towards school science comes in the diversity of methods researchers have taken in its measurement, which we review beneath.

Subject preference studies:

Some measure of attitudes towards school science can be obtained by asking pupils to rank their liking of school subjects. Their relative popularity then gives some indication of students' attitudes towards the subject. Physics and chemistry were two of the least popular subject's and that these were distanced in pupils‟ minds from biology. The latter study was innovative in its use of focus groups to explore 16-year-old student's views and attitudes towards science in depth. Perhaps surprisingly, chemistry was found to be less appealing than physics. A student with an extremely positive attitude to all school subjects to still rank science as the least popular, and yet still have a much more favorable attitude than another student who has a strong dislike for all subjects and ranks science first. Neither is it suitable for the measurement of attitude change as its blunt nature may not expose changes in attitudes as a student's attitude to other subjects may change as well. However, this would suggest that it is an instrument not to be used in isolation rather than discarded totally. The simple nature of this technique still provides an effective answer to the question that is essentially that asked by teachers and schools – 'How popular is science compared to other subjects?'. It is therefore surprising that such surveys have not been repeated more often.

Attitude scales:

More commonly, attitudes have been measured through the use of questionnaires that commonly consist of Likert-scale items where students are asked to respond to statements of the form:

- ✓ Science is fun.
- ✓ I would enjoy being a scientist.
- ✓ Science makes me feel like I am lost in a jumble of numbers and words.

Each item is a component in a summated rating scale that consists of a number of opinion statements reflecting either a favourable or unfavourable attitude to the object (construct) being studied. The subject is then normally offered a five-point choice consisting of „strongly agree/agree/not sure/disagree/strongly disagree‟ to indicate their own feelings. Such items have normally been derived from the free response answers generated by students, which is the major justification for their validity. These open responses are then reduced to a set of usable and reliable items that have been piloted and further refined by statistical analysis to remove those that fail to discriminate. Such scales have been widely used and extensively trialled, and are the major feature of research in this domain.

The problem of interpreting the significance of these multiple components of attitudes towards science has been clearly identified by Gardner, who comments:

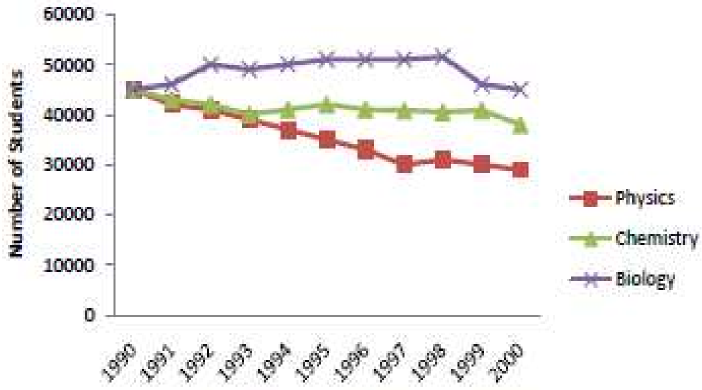
An attitude instrument yields a score. If this score is to be meaningful, it should faithfully reflect the respondent's position on some well-defined continuum. For this to happen, the items within the scale must all be related to a single attitude object. A disparate collection of items, reflecting attitude towards a wide variety of attitude objects, does not constitute a scale, and cannot yield a meaningful score.

Interest inventories:

Less suspect, but more restricted, are interest inventories that attempt to measure science interest. A common technique is to present respondents with a list of items and then ask them which ones they are interested in. However, such inventories are generally restricted to their specific focus, yielding only a limited view of what may or may not be formative on attitudes to science.

Subject enrolment:

Another major source of data – and a source of increasing concern – are the data on enrolments to subjects. *In England and Wales, for instance, physics has been the subject of a continuing 15-year decline in numbers enrolling and passing the A-level.* However, any attribution of significance to such data as a sole measure of interest in science is questionable, and subject choice can be highly affected by changes in society that affect the structure of economic opportunities, the desire not to foreclose opportunities, the perceived difficulties of the subject and, particularly in the case of boys, the association of subject with gender identity – all of which may well be independent of interest in science.



Data for numbers of students examined in
Physics, Chemistry, Biology from 1990 to 2000 in England

Qualitative methodologies:

Attempts to measure attitudes towards school science have, in the main, shown are liance on quantitative methods based on questionnaires. A common criticism of all attitude scales derived from such instruments is that, while they are useful in identifying the nature of the problem, they have been of little help in understanding it, which has led, more recently, to the growth of qualitative methodologies. Even then, in all of the research so far published, only a few studies have attempted to explore the issue of student attitudes through the use of clinical or group interviews. Interview data from approximately 70–100 students to assist in interpreting and explaining their findings. While such studies are subject to restrictions of their generalizability, the richness of data does seem to give more insight into the origins of attitudes to school science than quantitative methods indicating that both methodologies have value. For instance, it is difficult to see how the following perception of the nature of science could ever be elicited through survey methods:

Cassie: With science it's solid information and you've got to take it down.
Cheryl: . . . so when they teach you science you know that this is it, okay? There is nothing, you can't prove it wrong,
Leena: In what way does that make it different to other subjects though?
Shakira: I mean you just have to accept the facts don't you?

School science and the nature of the problem:

A strong feature of the literature is the apparent contradiction between students" attitudes towards science in general and their attitudes towards school science. Many surveys show repeatedly that students" attitudes towards science itself are positive. For instance, the following data (table) from a large-scale survey conducted by the English Assessment of Performance Unit (1988) into why students chose to study science, showed that the majority of 15-year-old pupils find science both 'interesting' and 'useful for jobs', even though it is not considered 'easy'.

Similarly, a large-scale market research survey conducted in the UK for the Institute of Electrical Engineers (The Research Business 1994), based on a sample of 1552 students aged 14–16, found that students saw science as useful (68%) and interesting (58%), and that there was no significant distinction between genders. Again a large proportion saw the relevancy of science as a reason for studying it (53%) and that it offered better employment prospects (50%). Moreover, 87% of students rated science and technology as 'important' or 'very important' in everyday life. What this latter survey reveals is a clear disparity between the students" notions of science, where it is perceived in terms of technological developments in the world around them associated with personal computers, television/video/ telecommunications and developments in space, and that presented by school science, which in contrast sees the most important aspects of science as a series of milestones represented by the most significant discoveries of the last century (e.g. DNA, penicillin, splitting the atom). Perhaps most fascinating was that, if asked to name famous scientists, the overwhelming majority of students identified Einstein, Newton and Bell, demonstrating a total lack of any contemporary role models.

Data showing 15-year-old pupils' views about science (as opposed to school science)

Subject	Sample size		'Interesting'		'Useful for jobs'		'Easy'	
	Boys	Girls	Boys (%)	Girls (%)	Boys (%)	Girls (%)	Boys (%)	Girls (%)
Physics	3551	1433	48	46	63	52	4	2
Chemistry	2224	1767	53	49	51	53	5	1
Biology	1329	4617	73	72	32	36	8	4

WHAT FACTORS INFLUENCE STUDENTS' ATTITUDES TOWARDS SCIENCE? Gender:

The most significant is gender for, as Gardner comments, 'sex is probably the most significant variable related towards pupils' attitude to science'. Boys have a consistently more positive attitude to school science than girls, although this effect is stronger in physics than in biology. The introduction of „balanced science" or integrated science courses during the past decade has had a similar effect in increasing the separation between boys' and girls' attitudes to science.

Environmental factors:

Structural variables:

Actual experience with science at school does not seem to be related to attitude towards science as a worthwhile societal enterprise and involvement in extra-curricular scientific activities. This supports the notion that science at school and science out of school should be treated as distinct and separate entities.

Classroom/teacher factors:

Common aspects of teaching that were perceived to be effective by both teachers and pupils. These were:

- ✓ clear goals for pupil learning;
- ✓ clarity of communication of lesson goals and agenda to pupils;
- ✓ use of preview and review of lesson content;
- ✓ helping students to contextualize content in terms of their own experience and knowledge, as well as in terms of other teaching goals and learning experiences;

- ✓ some willingness to allow pupils to have input into goal and agenda setting;
- ✓ an ability and willingness to allow for different cognitive styles and ways of engaging with the learning process among pupils, through multiple exemplification, and the use of different types of illustration and mode of presentation, and offering pupils a choice from a menu of possible ways of engaging; and
- ✓ a willingness to take into account pupil circumstances and to modify/pace/ structure learning tasks accordingly.

Teachers did not have the content knowledge, errors of fact were made and opportunities to elaborate on student understandings and to diagnose misunderstandings were missed. In some instances, flaws were evident in attempts to explain concepts with which students were having difficulty and, in other cases, analogies were selected which compounded student problems in understanding concepts. The net result of teachers" lack of content knowledge in high school classes was an emphasis on learning of facts and a sewing of seeds for the development or reinforcement of misconceptions.

Curriculum variables:

The science education literature contains hundreds if not thousands of reports of interventions designed to change attitudes. Development of programs to influence the likelihood of certain science-related attitudes is important because it is assumed that changes in attitude will result in changes in behaviour. Unfortunately, few simple and straightforward generalisations can be made about how and why science-related attitudes change. The fundamental nature of the problem is negative attitudes towards school science, useful insights could be obtained by focused studies of classrooms where effective teaching of science, as judged by students, was to be found.

Perceived difficulty of science:

Students' perception of science as a difficult subject as being a determinant of subject choice. Science is only taken by students who do well and not as an incidental or additional subject. Whether this is a self-imposed restriction or a selection criterion imposed by schools is essentially irrelevant – the fact that only able pupils do physical sciences reinforces the notion that it is for the intelligent and therefore difficult. Studying science is perceived as a risk. Some insight into the effect of such perceptions on subject choice at the point of choice. Their study found that when the negative aspects of a course of action were emphasized, people preferred to risk the choice that leads to the definite avoidance of loss rather than risk an opportunity that may have no loss whatsoever. Thus, school students confronted with a choice that is high risk, although potentially with high financial gain (i.e. doing science with its concomitant risk of failure) and one of lower risk (i.e. the greater certainty of success with arts based courses), will choose the low-risk option even though the financial rewards may be less. Attempts to persuade students to pursue science would be more successful if they sought to emphasize lost career and educational opportunities rather than emphasizing the benefits of careers in science. Hence, rather than selling the positive aspects of being, for instance, an engineer or research scientist, teachers should emphasize the certain loss – that without science qualifications the student can never be a doctor, an engineer, etc.

Enhanced subject choice:

Psychology, economics, business studies, sociology, theatre studies, and sports studies are a few of the new and growing number of A-levels that are on offer. Some of these contain aspects of science within them. No research has identified what effect the increasing range of choice has had on individual student choice. In part, such research is difficult to do because of the difficulty of gathering meaningful data retrospectively. Within the English system, students‟ choices from this range were, until recently, limited to three subjects. Students' attempts to achieve a balanced selection from the wide range of choice may well account for the growth of mixed A-levels and the drift away from science.

Cultural attitudes towards the study of science:

Asian parents have a particularly important affect on student career choice. Within Asian families, career decisions will generally tend to favour longer term advantages compared with the more individualistic and immediately attractive choices made by students within contemporary Caucasian cultures in which personal enjoyment and/or perceived ability may play a more significant element. Moreover, within mainstream English society, the valuing of professions above trade is deep seated, reinforced by the financial disparities between arts-related careers and the sciences. A negative attitude to science is correlated with pupils coming from middle-class families. However, if science-based careers are less economically profitable, why are they the predominant choice with the Asian community? As Woodrow points out, all the research has done so far is show that different groups hold different perspectives on the value of science-based careers and possibly science itself.

III. LEARNER CENTERED AND TEACHER CENTERED METHODS

Which is best: Teacher-Centered or Student-Centered Education?

When considering their approach to instruction, teachers are always looking for the method that is most beneficial for all of their students. Teachers want their students to enjoy the learning process, and they want the classroom to be orderly and controlled. As a result, the debate of teacher-centered vs. student-centered education has been in the forefront of educators' minds for many years. Though many people have a specific idea of which type of education is best, there are both advantages and disadvantages to each approach. Below is a description of each approach, along with some pros and cons.

In the traditional approach to school teaching, most class time is spent with the teacher lecturing and the students watching and listening. The students work individually on assignments, and cooperation is discouraged.

TEACHER-CENTERED EDUCATION:

In teacher-centered education, students put all of their focus on the teacher. The teacher talks, while the students exclusively listen. During activities, students work alone, and collaboration is discouraged.

Advantages:

- When education is teacher-centered, the classroom remains orderly. Students are quiet, and the teacher retains full control of the classroom and its activities.
- Because students learn on their own, they learn to be independent and make their own decisions.
- Because the teacher directs all classroom activities, they don't have to worry that students will miss an important topic.

Disadvantages:

- When students work alone, they don't learn to collaborate with other students, and communication skills may suffer.

- Teacher-centered instruction can get boring for students. Their minds may wander, and they may miss important facts.
- Teacher-centered instruction doesn't allow students to express themselves, ask questions and direct their own learning.

STUDENT-CENTERED INSTRUCTION:

When a classroom operates with student-centered instruction, students and instructors share the focus. Instead of listening to the teacher exclusively, students and teachers interact equally. Group work is encouraged, and students learn to collaborate and communicate with one another.

Student-centered teaching methods shift the focus of activity from the teacher to the learners. These methods include active learning, in which students solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class; cooperative learning, in which students work in teams on problems and projects under conditions that assure both positive interdependence and individual accountability; and inductive teaching and learning, in which students are first presented with challenges (questions or problems) and learn the course material in the context of addressing the challenges. Inductive methods include *inquiry-based learning, case-based instruction, problem-based learning, project-based learning, discovery learning*, and *just-in-time teaching*. Student-centered methods have repeatedly been shown to be superior to the traditional teacher-centered approach to instruction, a conclusion that applies whether the assessed outcome is short-term mastery, long-term retention, or depth of understanding of course material, acquisition of critical thinking or creative problem-solving skills, formation of positive attitudes toward the subject being taught, or level of confidence in knowledge or skills.

Weimer explains that in order to be **learner-centered, instructional practice needs to change in five key areas**: the balance of power, the function of content, the role of the teacher, the responsibility for learning, and the purpose and processes of evaluation. In this, however, she assumes that student-centered pedagogy is the most appropriate. Maybe it is. Maybe it isn't. Many variables come into play when we try to determine which teaching style is "best":

- discipline
- class size
- subject within the discipline
- room layout
- environmental factors in the room (temperature, for example)
- teacher personality
- classroom dynamic (between students)

Five Characteristics of Learner-Centered Teaching:

1. Learner-centered teaching engages students in the hard, messy work of learning:

I believe teachers are doing too many learning tasks for students. We ask the questions, we call on students, we add detail to their answers. We offer the examples. We organize the content. We do the preview and the review. On any given day, in most classes teachers are working much harder than students. I'm not suggesting we never do these tasks, but I don't think students develop sophisticated learning skills without the chance to practice and in most classrooms the teacher gets far more practice than the students.

2. Learner-centered teaching includes explicit skill instruction:

Learner-centered teachers teach students how to think, solve problems, evaluate evidence, analyze arguments, generate hypotheses—all those learning skills essential to mastering material in the discipline. They do not assume that students pick up these skills on their own, automatically. A few students do, but they tend to be the students most like us and most students aren't that way. Research consistently confirms that learning skills develop faster if they are taught explicitly along with the content.

3. Learner-centered teaching encourages students to reflect on what they are learning and how they are learning it:

Learner-centered teachers talk about learning. In casual conversations, they ask students what they are learning. In class they may talk about their own learning. They challenge student assumptions about learning and encourage them to accept responsibility for decisions they make about learning; like how they study for exams, when they do assigned reading, whether they revise their writing or check their answers. Learner-centered teachers include assignment components in which students reflect, analyze and critique what they are learning and how they are learning it. The goal is to make students aware of themselves as learners and to make learning skills something students want to develop.

4. Learner-centered teaching motivates students by giving them some control over learning processes:

I believe that teachers make too many of the decisions about learning for students. Teachers decide what students should learn, how they learn it, the pace at which they learn, the conditions under which they learn and then teachers determine whether students have learned. Students aren't in a position to decide what content should be included in the course or which textbook is best, but when teachers make all the decisions, the motivation to learn decreases and learners become dependent. Learner-centered teachers search out ethically responsible ways to share power with students. They might give students some choice about which assignments they complete. They might make classroom policies something students can discuss. They might let students set assignment deadlines within a given time window. They might ask students to help create assessment criteria.

5. Learner-centered teaching encourages collaboration:

It sees classrooms (online or face-to-face) as communities of learners. Learner-centered teachers recognize, and research consistently confirms, that students can learn from and with each other. Certainly the teacher has the expertise and an obligation to share it, but teachers can learn from students as well. Learner-centered teachers work to develop structures that promote shared commitments to learning. They see learning individually and collectively as the most important goal of any educational experience.

Advantages:

- Students learn important communicative and collaborative skills through group work.
- Students learn to direct their own learning, ask questions and complete tasks independently.
- Students are more interested in learning activities when they can interact with one another and participate actively.

Disadvantages:

- Because students are talking, classrooms are often busy, noisy and chaotic.
- Teachers must attempt to manage all students' activities at once, which can be difficult when students are working on different stages of the same project.
- Because the teacher doesn't deliver instruction to all students at once, some students may miss important facts.
- Some students prefer to work alone, so group work can become problematic.

Making a Decision:

In recent years, more teachers have moved toward a student-centered approach. However, some students maintain that teacher-centered education is the more effective strategy. In most cases, it is best for teachers to use a combination of approaches to ensure that all student needs are met.

When both approaches are used together, students can enjoy the positives of both types of education. Instead of getting bored with teacher-centered education or losing sight of their goals in a completely student-centered classroom, pupils can benefit from a well-balanced educational atmosphere.

Teacher vs. Learner-Centered Instruction

Teacher-Centered	Learner-Centered
Focus is on instructor	Focus is on both students and instructor
Focus is on language forms and structures (what the instructor	Focus is on language use in typical situations (how students will use the language)

knows about the language)	
Instructor talks; students listen	Instructor models; students interact with instructor and one another
Students work alone	Students work in pairs, in groups, or alone depending on the purpose of the activity
Instructor monitors and corrects every student Utterance	Students talk without constant instructor monitoring; instructor provides feedback / correction when questions arise
Instructor answers students' questions about Language	Students answer each other's questions, using instructor as an information resource
Instructor chooses topics	Students have some choice of topics
Instructor evaluates student learning	Students evaluate their own learning; instructor also evaluates
Classroom is quiet	Classroom is often noisy and busy

TAKE STUDENTS ON FIELD TRIPS:

Class field trips that are directly related to the curriculum can make learning more meaningful and real for students. They can also serve as the basis for developing instructional units. Trips to community and regional science museums and ecological sites can offer direct experiences and authentic tasks related to what students are learning. In addition, many field trips provide hands-on experiences that promote the learning not just of factual information, but also of processes. "Virtual field trips" to various museums and scientific sites can be done via the Internet.

To help teachers and students benefit from field trips, many museums provide teacher training programs, model curricula and teaching strategies, special tours, exhibits, and materials for school groups and traveling exhibits that prepare students for and build upon experiences at the museum. Prior to taking their classes on trips, many teachers make pre-visits to familiarize themselves with various aspects of the facility (e.g., available exhibits and activities, admission costs, facility and restroom accessibility, rules on photography, whether there are lunchrooms and coatrooms, etc.). Teachers may also meet with the facility's staff concerning the size and unique needs of their classes and the availability and scope of guided tours. Field trips also can be enhanced by giving students a variety of pre-trip learning experiences to prepare them, explaining expectations regarding their behavior on the trip, giving them notepads on which to take notes and make sketches, eliciting and answering questions on the ride to the site, and discussing positive and negative aspects of the trip with them on the ride back to school. Teachers can also prepare trip chaperones by giving them information about the facility and their responsibilities.

The educational benefit of field trips can be enhanced by videotaping them. These videos can subsequently be viewed and discussed in class and can serve as a basis for lessons to help students understand important information presented on the trip. Students can show the video and discuss it with other classes or students who were not able to make the field trip.

These are purposeful visits to places of scientific interest and provide valuable experience in the process of science learning. A science teacher should arrange such field trips or visits to local centers such as factories, gardens, farms or museums. In every place, the community resources provide immense possibilities for educative experience in science. Field trips or visits should therefore be organized to enable the pupils to gain a firsthand knowledge of science and its application. Field trips motivate the pupils to learn science and stimulate their interests. In addition to gaining knowledge, the pupils get an opportunity to collect materials for the school museum or zoo. The scientific information, facts and principles become more realistic to them and they see the relation between science and the society. In short, they learn to appreciate science. Through a field trip the pupils learn to co-operate amongst themselves and also with the members of the community. They learn to think critically and apply elements of scientific method. A field trip enables the pupils to get a clear idea about the lesson or topic that is being taught. It provides an excellent opportunity for correlation.

Though a field trip usually means a biological excursion or a nature-study trip, the term can be applied to any activity outside the classroom in which the pupils participate. A field trip is essential for completing a project and to supplement the class-work; it is an excellent method for creating and fostering the spirit of scientific enquiry among the pupils. Such a field trip must, however, be pre-planned and the visit must be purposeful. The value of field experience is greatly increased by providing suitable follow-up work. The pupils should be guided to sum up and organize their learning in the field trip. They should make charts, diagrams and models related to the field trip and arrange to exhibit the collected materials. The bulletin board can be well utilized for the purpose of display of photographs taken during the field trip. They should write on the connected topics, hold discussion on their activities in the field trip (or visit) or on the problems arising out of their experiences during the trip. The teacher should help them solve their problems by suggesting relevant books, journals, and magazines for further reading.

A field trip may vary in duration and organization from one of a few hours to a extensively organized lasting a day or more. For full benefit, a field trip must be carefully planned. The pupils should be involved in planning the trip keeping in view the purpose, conduct of the trip, and the necessary follow-up activities. The field trip should not be taken as a holiday trip; though it is a sort of an enjoyable activity, it should be considered a serious undertaking. The young pupils, however, need guidance. The teacher may prepare a guide sheet, details of which will vary according to the type of the trip. The pupils may also participate in preparing' the guide sheet. It should contain the physical details of the trip such as the route, transport, dress, provision for meals, first-aid box, etc., and the details relating to the learning activities such as apparatus and materials to be taken with them, collection of data, records, reports, books and paper or the pupils' responsibility and conduct. The pupils should be grouped and each group made responsible for one type of work. In short, all the pupils should be actively involved in the organization of the trip.

Without proper follow-up activities, the field trip loses much of its value. The follow-up activity should begin from the first meet after the trip. It may include a general discussion on the trip, writing a report, displaying collected materials and souvenirs, preparation of models, preparation of suggested further reading in the library, arranging film shows relating to the trip or a talk by a qualified person on the area visited.

An unplanned and badly organized field trip without proper follow-up work is nothing but waste of time and energy. The science teacher should survey the available materials or phenomena of scientific interest or any other opportunity for educative experience in the community before arranging a field trip. Some of the places which may be visited are: radio station, telephone exchange, airport, weather bureau, museum, botanical garden, zoo, bird and animal sanctuary, mines and quarries or oil producing centres, electricity generating station, paper mill, cloth mill, rice mill, sugar mill, saw mill, hospital, railway station, dairies, farms, tea-gardens, water works system, chemical or other industrial plants, oil refinery, rubber factory, soap factory, glass or ceramic factory, dams, dykes or irrigation system, gas plant, research laboratories, shipyards and docks (incase of sea-side areas), green fields and forests, stores and markets, ponds, lakes, streams, antiquarian department, fish farms, etc.

There are certain things which cannot be explained to students very effectively without observing them in real setting. This makes it necessary for the science teacher to arrange visits and excursion to the places of scientific interest relevant to the syllabus.

Importance of Field Trips:

- ✓ develop the broad objectives - desired learning outcomes
- ✓ establish local contacts -critical liaison
- ✓ plan the finances
- ✓ inform incoming / applying students of dates, costs and necessary equipment / clothing requirements
- ✓ book accommodation
- ✓ Establish staffing requirements.
- ✓ Disabilities-health requirements (e.g. vaccinations)
- ✓ establish general permissions to key sites

Months before field class:

- ✓ arrange transport

- ✓ review bookings
- ✓ confirm permissions
- ✓ review field locations
- ✓ confirm specific dates with students
- ✓ confirm staffing and expertise (including first aid training)
- ✓ Check any equipment is serviceable.

Weeks / days leading up to the field class:

- ✓ organise any financial advance for the class
- ✓ collate student details (contact information)
- ✓ collate medical information
- ✓ brief students with general aims of class,
- ✓ run preparatory classes to revise specific techniques etc.
- ✓ prepare field guide and other materials
- ✓ organise all technical and health / safety materials
- ✓ brief staff and agree duties
- ✓ confirm transport arrangements with external operators
- ✓ confirm arrival plans etc. with accommodation / sites
- ✓ prepare final student lists
- ✓ leave contact details for the class,

After a field class:

- ✓ report any incidents
- ✓ debrief the exercises with staff involved
- ✓ assess student work – give feedback to students
- ✓ review practices.

The pupils should be aware of the purpose of the tripe. For elementary grade pupils, the purpose may be:

a. To collect various types of seeds;
b. To collect various types of leaves;
c. To study birds;
d. To study flowers;
e. To collect rocks;
f. To study animal behavior; or
g. To study the life-cycle of toad or frog, etc.

The teacher should decide the type and standard of the purpose in accordance with the level of the pupils and the demand of the circumstances. Some activities that are suitable for higher classes are mentioned below.

Student discussion:

This is another procedure for effecting better understanding and broadening the experience of the pupils in the field of science. Though discussion means talking over a subject, actually a purposeful discussion is much more useful and effective educative experience than mew talking. Through discussions the pupils learn from each other. A discussion may be taken as a bond between other methods and procedures or as a medium of transition from one method to another. In a discussion pupils get an opportunity to exchange opinions.

A discussion provides for individuals thinking and the pupils gain an insight into the problem of discussion. It is not only an intellectual process, but a social process too. All the pupils in a group can freely join in the discussion. But if the discussion is not well directed, it may digress too far. For this reason, the pupils should be made aware of the purpose of the discussion. The teacher plays an important part in the discussion; he should guide and give direction to the pupils to discuss, stimulate them to add vitality to the discussion, help them to keep the discussion lively, interpret on some occasions, organize and summarise the essential points of the discussion, and lead the pupils to draw conclusions. A discussion may be organized before or after a field trip, a class lesson or a film show or an arranged talk on some scientific topic. But while beginning a discussion before an actual activity, such as a class lesson or a field trip, the teacher should be careful lest it becomes uninteresting and unfruitful. Since the pupils usually do not possess sufficient background to initiate the discussion, the arrangement for an initial discussion should be made only when the teacher is satisfied that the conditions are suitable. Follow-up discussions are always lively.

The teacher, while conducting a pupils' discussion, has to be tactful in dealing with the situation. He should neither allow a group to predominate over the other nor discourage the others. He should act as a moderate rather than a leader, and at the same time keep the discussion moving. He should acknowledge all suggestions and should tactfully reject the unacceptable suggestion without thwarting or offending their sentiments. He should encourage all the pupils to participate. He should also see that the physical conditions are suitable; all pupils should be able to hear and see each other. During the discussion, the teacher may have to face many questions form the pupils; in such a situation he should enable them to find the answers themselves, instead of telling them the answers directly.

Committee Work:

Pupils' committee, like group discussion, can also add valuable contribution to the process of learning science. The pupils of a class may be put into a number of small groups or committees and the office-bearers elected. The advantage of having a small group is that pupils with similar interests and abilities are brought together. Pupils of similar aptitude can work and gain maximum benefit. There are various needs of the pupils which may be met effectively through a small group activity. Here also, as in class discussions, pupils get an opportunity for exchange of ideas.

After forming a number of small group committees, special tasks may be assigned to them. One committee may be asked to assist the teacher in setting up demonstration, another to take care of the science library or the science museum, still another to serve as an advance party to collect information regarding the place selected for a field trip by actually visiting the area, and so on. Some committees may take up small investigations in the laboratory, while other committees may take up the work of repairing apparatus or preparing visual aids for a demonstration or a class lesson. There may be many types of tasks in the field of school science while the pupil committees can take up. The tasks allotted, however, require careful planning.

Students' Reports:

Pupils, during participation in a field trip or a project, may have different experiences. Each pupil has his own feelings and appreciations. Reports on various aspects of an educative experience by pupils, individually or in a group, should always be encouraged. In preparing a report and reading it out to the class, the pupils re actively involved in the learning process. A pupil or a group may be asked to prepare a report on a particular topic by consulting books and encyclopedias in the library. Obviously, they have to delve deep into that particular field of study. Or a small group or a committee may be asked to observe a particular aspect of a project or a field trip in greater detail and prepare a report on that aspect for the whole class. Similarly, a group or a committee may be entrusted with the responsibility of interviewing an expert, say the head of a power supply center in connection with information regarding the power supply system. This report may be a part of a broader unit of study such as "Electricity and its application to the community".

Uses of Field Trips:

- ✓ It offers first-hand experience
- ✓ It enables intimate contact with environment.
- ✓ It improves the power of observation and exploration.
- ✓ It helps in the correlation of school subjects.
- ✓ It makes pupils active participants.
- ✓ It effects real socialization of school work.
- ✓ It develops problems solving skill.
- ✓ It facilitates collection of specimen for school museum.

Purpose of Field Trips:

The specific purposes for which the field trips may be conducted are

- ✓ Serving as a preview for a lesson and for gathering instructional materials.
- ✓ For creating teaching situations.
- ✓ Serving as a means of arousing specific interest.
- ✓ Supplementing class room instruction and securing definite information for a specific lesson.

Conditions to be borne in mind in Field Trips:

While using field trip as an aid to teaching science following points should be borne in mind:

- ✓ Previewing the place and determine the purpose
- ✓ Making necessary arrangements with school authorities.
- ✓ Preparing the students physically and mentally for the trip.
- ✓ The teacher should be prepared to act as a guide during the trip.
- ✓ To evaluate the trip in terms of specific educational goals.

After the field trip has been successfully completed, the teacher must relate the experience with the particular lesson that the students are studying. Students may also be asked to write an article or a poem or sketch a drawing about the place visited.

FIELD TRIP NATURE WALK:

Materials:

- pencil
- paper
- crayon (with the paper peeled off, for rubbings)
- clipboard (or other surface for writing)
- plastic bag

Activities:

- Look for signs of fall.
- Collect seeds, acorns, leaves, pine cones etc. In the plastic bag.
- Use your crayon and paper and make rubbings of leaves, bark, etc. Label the rubbings so you remember what they are.
- Fill in the chart below.

THINGS I SEE	THINGS I HEAR	THINGS I SMELL

THE PROJECT METHOD:

No method has evoked more discussion than the project method. It is a quite modern contribution to educational theory and practice. It originated as a reaction against dull, monotonous, purposeless, and life-less classroom teaching. The term "project" has got a very wide connotation and has been taken to include any activity like dramatics, pageants, making models, drawing maps and charts, collecting pictures, preparing scrap-book going on field trips or any other constructive and experimental undertakings, which enables the children to learn a significant skill or process. Project may be an inclusive undertaking. Some of these like dramatics are not projects in the true sense of the term. They might form one of the thread of a bigger project. They can't be the 'whole' project. Similar is the case with pageants and mock performances. However, anything accomplished under pupil motivation is a project.

The project method owes it's origin to the American philosopher belonging to the pragmatic school of philosophy. John Dewey perfected the pragmatic philosophy and gave it practical, instrumental and utilitarian bias. The project method is a direct outcome of Dewey's philosophy.

Definitions of Project:

As a method of teaching it was perfected by Dr. J. A. Stevenson. Professor William H. Kilpatrik defined project as "a whole-hearted purposeful activity proceeding in a social environment."

Dr. J. A. Stevenson said, "A project is a problematic act carried to completion in it's natural setting."

Dr. Ballard said, "A project is a bit of real life that has been imparted into school."

From the above definitions, it is understood that the project method lays great stress on the actual action or activity on the part of the pupil. Nothing is imposed on from without. In this method the curriculum content and techniques of teaching are considered from child's point of view. It is better to call this method "learning by living" than "learning by doing."

This method came into existences as a reaction against the former dull, purposeless and monotonous method of teaching science in which there is no link between the knowledge imparted in schools and the activity outside the class-room. A project, if properly planned, can provide various activities, both inside the class-room outside. The method consists in building up a comprehensive unit of connected facts around a central theme which may be some matter of scientific interest, a scientific principle or theory or topics of immediate interest to the pupils. The central theme is so chosen that its pursuit provides all sorts of activities inside the class-room as well as outside. A project is usually defined as a piece of whole-hearted environment. Dr. Stevenson defines a project as a problematic act carried to completion in its natural setting. In case of a group project, the useful task so chosen must be completed in the natural environment working co-operatively.

Essentially, the method is based on the fact that students learn through association, activity and co-operation. The method is psychologically sound. It is commonly experienced that when a fact is presented to us, we usually tend to remember other facts which are either similar to it or connected with it. Because of the principle of association, out interest spreads to matters connected with the original subject and which we would have otherwise ignored. The students also learn related facts besides learning science. The teacher acts as a guide and leads the students, by putting questions at the right hour, to find the facts and principles themselves. Such a project may be chosen from any field of science. The problem may be a constructional type such as building up a school science museum, running a school garden, setting up a simple meteorological station, collecting specimens for science exhibition, arranging a picnic, or it may be of the type meant for investigation such as the power supply or water supply system of the locality, growing seeds in a box or hatching chicks, the study of plant and animal life of the area. Through each project sufficient knowledge and information can be imparted on topics related to the project. For example, in a simple project like growing seeds in a box, an extensive unit on soil, plant, food, manure, sun rays, temperature and other areas of knowledge related to seed growing can be built up. Similarly, in general science, major portions of mechanics can be developed around the topic 'work'. In India probably hydro-electricity and irrigation are two important developments which can provide a number of themes on which projects can be worked out. By careful planning and organization of the connected experiences a wide variety of knowledge can be imparted even through simple projects. For example, around a project on rearing birds or other animals which may provide great number of units of teaching such as food physiology, their behavior, benefit and harm to mankind from them and many other animals habits.

The project method is a suitable method for teaching science in elementary classes. Planning and carrying out a project involves much more work on the part of the teacher than our traditional method of teaching science. The teacher has to be well informed and alert. He must constantly provide encouragement and inspiration so that the original enthusiasm may not slowly fade away. He must be conscious to direct and guide the students to acquire the information they seek and to achieve the end they aim at. The teacher should not only co-operate with the students in their investigation but also see that the students co-operate among themselves and work in groups. To keep their interest alive, the teacher should himself collect articles, reports, illustrations, charts, exhibits, and specimens related to the problem of investigation. He should co-ordinate the activities of the different groups. The school authorities should provide illustrated science journals, teachers' journal and other audio-visual aids to help achieve the end efficiently. The project does not end with mere investigation. The groups should collect specimens relevant to the investigation, make models and prepare charts, scrap books, newspaper cuttings relating to the project and organize an exhibition, to show the materials for inspiration by others. At the end of the project the groups should meet and discuss the problems and their achievements and the leader of each group should read out a written report of his group's activity. The whole class may prepare an article or an essay to be published in the school magazine.

Outstanding Features of the Project Method:

a. The project selected for the teaching of science must be significant and have an educative value. They should be according to the capacity and ability of the students.
b. The planning should be done by the students, must assume responsibility and make decisions.
c. The whole project should be performed by the students.
d. Problems for projects must arise in the classroom teaching and classroom discussion.
e. The teacher should act as the unseen prompter.

Procedure and Plan of the Method:

The project method aims at teaching the students through the carrying out of some projects. A definite procedure has been laid for carrying out the project.

1. Providing a Situation:

The first task for the teacher under the project method is to provide for such a situation wherein the students feel a spontaneous urge to carry out a particular project according to their needs and interest. He is to discover the interest, needs, tastes and aptitudes of the students. Situations may be provided by finding out the food, facts and fallacies in a particular locality and factors responsible for development of such facts and fallacies. Students will be asked to describe their experiences. He may also take out children on excursions and educational tours and trips to enable them to see cloth-mills, an ideal kitchen or bakery, a market place etc. Thus, the students are brought face to face with a situation from all points of view and determine for themselves the choice of the project. It is assented that the problems or situations which are provided to the children should always be preferably related to science only.

2. Choosing the Project:

After the situation has been provided or problem presented, the second step is the choice of the project. An intelligent and alert teacher guides well the students to choose a good project. Dr. Kilpatrik points out, "the part of the pupil and the part of the teacher in most of the school work depend largely on who does the proposing." The teacher may be impatient and in a hurry to choose the project himself for the class. This is totally against the spirit of the method. The most important thing about the project is that the pupils do the proposing. The project is to be chosen and thought over by the students themselves. Self-choice and self-imposition leads to better results and entail real satisfaction. They stimulate better planning an successful early completion. After many situations and problems have been presented and discussed, being stimulated by the teacher through suggestions, the students are led to decide for a topic. Decision is always democratic. The more common interests and needs of the children are the guiding principle for choice. The students discuss the various projects, reject a few, explain others and thus come to a decision.

In the choice of the project the teacher is to keep in view that the projects chosen are always of the greatest utility and satisfy a real need of the children and may be within their capacity to be successfully carried out. The students may sometimes make a wrong choice. The teacher should point out the points for consideration and let the children reconsider their decision and feel that the choice is not appropriate. Hence under the able and well directed guidance of the teacher a project, most suitable and of greatest educational value and satisfying the kneely felt need should be chosen. The class may write in their notebooks for the project-books, as they may be called, the reason for their choice. This will be good device to enable the students to clear up and collect their ideas regarding the choice and selection of the project.

3. Planning:

After the decision about the choice of the project is made, the children are to consider the plans to carry out the project. The children should themselves do the planning and the teacher is only to guide them. The teacher draws the attention of the pupils to the urgent necessity of a good plan. Discussion may be held and each child should be encouraged to express his views and make suggestions. Different proposals may be made. The teacher may point out the difficulties inherent in the working of different plans. Resources are taken into account, limitations are properly weighed and the details of the plan are all discussed. Alternatives are also considered. Thus, after a good deal of discussion, suggestion and counter-suggestions, rejection, and modifications etc., the best of the possible plan is agreed upon. After such lengthy oral discussion the whole plan may be written down by the students in their project book under the careful guidance of the teacher.

4. Executing:

When the plans are ready, students are encouraged to put it into practice. Students themselves distribute the various items of duties among themselves according to individual interests and capacities. The teacher is to see that every child is assigned some duty to do work. Every child must contribute something towards the successful completion of the project. The teacher is not to give too much help in order to accelerate the work of the project. Not too much help, not dictation but guidance only and direction is expected at teacher's hand.

This step requires a lot of work and is the largest of all. A legion of activities is to be performed by the students. They may be busy in collecting information, visiting various place and peoples, looking up maps, writing letters, reading the reference books, observing specimens, studying history, keeping accounts, calculating prices. Inquiring rates, measuring length and areas, seeking help from others, doing and performing a variety of such activities. The teacher's task, here is not an easy one. He is to guide them, suggest books for, and advise them to do particular type of activity and to help them on to right lines.

Thus through co-operatives efforts, the whole project are being carried to his assigned duty, the teacher supervise the activities and watch the progress of the project. A single project may thus provide for a number of activities and a variety of knowledge of mathematics, science, history, and geography etc. the students, while executing the project, gain a varied type of experience and learn a good deal incidentally.

5. Judging:

No project is complete unless the work done in it is critically reviewed. In this step the students assess their activities, whether these have been carried out in accordance with the plan chalked out or not, the mistakes committed are noted, alternatives are thought out and things learnt are reviewed and useful experiences are recounted etc.

They make a critical approach to their work. This is also an important training which is not to be neglected. This step carries great importance for it sets the pupils thinking about the work they have done and to evaluate it in the light of the experiences gained.

6. Recording:

For the effective learning process, the students must maintain a complete record of all activities connected with the project. In the project book everything is to be put down regarding the choice of the project, the discussion held, proposals accepted, duties assigned, books consulted, information sought for work undertaken, difficulties felt and experiences gained etc. Self-criticism is also to be entered and important points for future references and guidance are to be jolted down.

If the project book is well maintained it can serve a very useful purpose. The teacher must see that records are complete and regularly kept.

Role of the Teacher in Project Method:

A teacher under the project scheme is a friend, guide and philosopher of the students. He is not being a dictator but a director only. He is to be a practical psychologist to understand the interests and needs of the young children. He is to have emotional maturity and intellectual patience to guide the children. He is tactfully to direct their activities though himself keeping in the background. Help is to be given only when it is sought for and not to be imposed upon for speedy execution of the project. He is to repose confidence and goodwill in the children so that the children are encouraged to come forward to discuss, to propose, to plan and to take up the work.

The teacher is to be wide awake, act as a store house of information and knowledge so that he can help the students efficiently when the help is needed. He is to check and supervise the work of individual children and to see how ably they are pulling on with their duties. The progress of the project is always to be reviewed. The students are to be kept on the right lines and modifications suggested if occasions demands. The teacher is to have thorough knowledge of each student's interest and tastes so that duties allotted to him are according to his nature and interest.

The teacher must have knowledge of different subjects, for the project method is based on correlated teaching of different subjects. The teacher is to guide the execution of the project in such a way that the maximum of subjects concerned are learnt by the students. The teacher is to fill the gaps in the knowledge picked up by the students. He should aim that not only practical knowledge is to be imparted but also it should be complete and not sketchy.

Merits:

The project method has numerous merits. They are as follows:

i. The method is in accordance with the psychological laws of learning:

It provides the best conditions under which the child can learn well. The three favour laws of learning are well kept in view in this method.

a. Law of Readings:

This law demands that in order that this law is effective, mind must be ready to take it up. The project method prepares for this readiness by providing for the situation and proposing by the students.

b. Law of Exercise:

The law states if the learning is to be effective, the knowledge learnt must be put to practice, i.e., learning must be exercised. Children should practice what they are taught. The project method is based on not only learning by doing but also learning by living. Ample useful practice accompanies each learning unit.

C. Law of Effect:

This law requires that learning to be forceful must be accompanied by satisfaction and happiness. In this project method, the children manipulate their own activities towards success and they derive immense satisfaction.

ii. The Method of Economical:

It gives the best of material with least of wastage and in the shortest of time. There is an atmosphere of freedom and the children pick up knowledge without strain. The work of their own choice and hence it is speedily gone through. As pointed out by Dr. Kilpatrik we never simply, there is always concomitant learning. Learning science carries with it likes and dislikes for it, habits of industry on lethargy and similar such attitudes. In the project way of teaching, the unit experience consisting of varied activities and subjects leads to enlarged concomitant learning.

iii. Dignity of Labour:

The method keeps up the dignity of labour as well as the students are required to do work with their own hands, they develop a taste for all kinds of work. Self-reliance and responsibility are engendered among the pupils. They make their own discussions and enjoy the product of their labours.

iv. Education is imparted according to the real conditions of life:

Projects have vital connections with the everyday needs and experiences of the child. At every step in the project the pupil draws upon his own past experiences. Knowledge imparted is real, practical and useful. Superfluity of redundant knowledge is avoided. Subjects are taught to the extent these are applicable to everyday practical life. There is correlation of different subjects and the knowledge is gained as a whole and in it's natural setting. Cramming of memory work is no more there. Learning is effective because it comes as a by-product of useful activity. There is the problem-solving attitude and exercise of thinking and reasoning power of the child. From the process to the product, learning is real and it is lived.

v. It Trains for a Democratic Way of Life:

Co-operative activities and group interaction promoted children are trained to think and work together for common purpose. The pupils have a say in the activities they choose, plan and execute useful social habits are learnt and the students get real training in citizenship. Primary virtues e.g., tolerate, self-respect resourcefulness, etc. are encouraged.

Difficulties and Considerations:

i. The teacher is to be careful that all the expressed interests of the students are not of equal value. The child has not yet attained maturity of thought and action and his tastes and interests are to be refined. It is a fallacy to think that the interests of the children should be equally weighed. Careful selection is necessary.

ii. While filling in the gaps of knowledge, the teacher should not unnecessarily stretch the project to include particular type of activity. This brings in artificiality. The project as far as possible should be confined to its natural setting.

iii. There is widespread misconception that project method is nothing but training the children in hard work. Intellectualism is bad and manuism is still worse. The spirit of the method lies in the purposeful intellectual enquiring and experience, through the achievement of task and not merely the manual work that it entails. The teacher should not reduce the project method to doing hard work the whole day.

iv. Some children are very assertive. They may like to do all the work themselves and keep others at leisure. The teacher is to be very careful that all the students is to be checked. Some students may take up alike duties in every kind of project. This is not a desirable practice. The teacher is to see that a student's gets training in all kinds of activities in rotation.

Defects and limitations:

i. No proper and simultaneous development of all the subjects can take place. Knowledge of particular subjects always comes in this method in a half-hazard and discontinuous manner. There may remain wide gaps in knowledge. To stretch the projects beyond the natural limits is worse than the remedy. The project method may disturb the psychological agreement of particular subjects, and it may be difficult for the child to pick up knowledge which is based on other knowledge which the child has not yet learnt. Thus the ideas gained by the students may not be clear to him. It may encourage cramming e.g., unless the student has learnt addition and subtraction, he can't follow multiplication and division and to reverse the process is unpsychological.

ii. Knowledge is not be confined to the perpetual level. Our goal is conceptual level. The project method limits the knowledge to the perpetual level only. To start with is all appreciable, but to carry it on to all levels of child growth is sometimes harmful. Children lose interests in projects in the higher classes and they crave for more intellectual food.

iii. Expensive. The project method requires a lot of materials which may not be easily available sometimes. The method is expensive and ordinary schools may not afford to adopt it. To say that a project should be according to local needs and local situations carried out with the locally available materials is no solution of the problem. In the beginning it may work well but knowledge is not be confined to the locality. Knowledge is to grow with the growth of children. More costly projects may be required.

iv. Project method will disorganize the school time-table and the curriculum. No fixed periods can be followed if school is to be run on project method.

There can be no fixed curriculum. The students may take up quite different projects in which subject correlation, as desired in the curriculum, may not be possible. To fix a number of projects for each class will be against the spirit of the project method where the students themselves are to decide the choice.

v. The method expects too much of the teacher. Every teacher can't be expected to be different in each subject. At the same time the principle of correlation is not easy to work out. Too much strain is put on the teacher's resourcefulness and intelligence. No suitable textbooks written on the project method lines are available. An average teacher can't be so intelligent as to suggest suitable projects and to impart knowledge in a correlated manner. Paucity of literature strikes at the roots of the project method.

List of Some Projects:

1. Cacti and Succulents, 2. Microscopic plants, 3. Factors affecting and germination of plants, 4. Flower or fruit, 5. How plants reproduce, 6. Vegetative reproduction in plants, 7. Collection and recognition of poisonous mushrooms, 8. Plant Parasites, 9. Carnivorous plants, 10. Study of rocks, 11. Locomotion of animals, 12. Ways of preserving food, 13. Spiders and their ways, 14. Butterflies and moths, 15. A study of nests and nesting habits of birds, 16. Bird migration, 17. The ecology of a pond, 18. Maintaining an aquarium, 19. Recording and reproduction of Sound, 20. Generation of electricity, 21. Radio, 22. Transistor, 23. Crystal set, 24. Telephones, 25. Wireless transmission

HOW TO DESIGN AN EXPERIMENT:

Have you ever thought about what goes into a real scientific experiment? Most of us get to do science investigations when we're young. School experiments are easy and fun. But what about real scientists, like chemists, physicists, and medical researchers? What kind of work do they have to do? How do they go about designing their experiments in the laboratory?

Experiments, remember, are one of the key components of the scientific method, which is a set of procedures that scientists follow to gain knowledge about the world. Other components of the scientific method are questions, hypotheses, observations, analyses, and conclusions. While experiments are only one part of a scientific investigation, they end up being accountable to the other elements.

What an Experiment Needs:

A scientific experiment is an ordered investigation that attempts to prove or disprove a hypothesis. So its primary purpose is to test whether someone's prediction is correct. In designing experiments, scientists have to answer some pretty complicated questions, like: Does my experiment answer the question I'm trying to solve? Does it adequately test my hypothesis? Can I make observations about the results of my experiment, and will I be able to analyze those results? Finally, if I run this test, will it allow me to come up with some kind of conclusion?

Scientific experiments are different from other kinds of tests because they are required to fit in with the scientific method. Another important factor is peer review by the science community. A scientist's work isn't generally recognized unless he follows the standards set by other scientists around the world. A few basic rules apply to the design of a good experiment. Let's take a look at what a science experiment needs.

Rule 1: The experiment must show that a hypothesis is either supported or not supported. In science, we try to avoid using terms like 'right' and 'wrong,' and we don't say that hypotheses are 'proven' or 'disproven' until we're really sure about it. A single experiment is not enough to prove anything with 100% certainty.

Rule 2: The results of an experiment must be measurable and objective. Scientists use standard units to measure different properties like length, time, volume, mass, and speed. Sometimes we need special equipment to observe things in a measurable way. For example, we can't see ultraviolet light or hear infrasonic sounds. We need special devices to detect and measure those properties for us.

Rule 3 for scientific investigations: The experiment must be repeatable by other scientists. Peer reviewers want to make sure that other scientists can run the same experiment and get similar results. This is one of the reasons we standardize our measuring tools and equipment. Scientists must be able to read anyone else's report, follow the steps exactly the same way, and compare their findings to the original test. In science, new ideas aren't taken seriously until many scientists have tested them many, many times. So it's important that scientists share their techniques and confirm each other's findings.

Theories and Laws:

So how do scientific ideas become part of the community knowledge base? If everyone's always double-checking each other's work, how do hypotheses become theories? How do theories become scientific law? Well, first of all, keep in mind that theory in the world of science is not the same thing as a theory in everyday language.

In science, a theory is a statement that is generally accepted as a summary for a hypothesis or a group of hypotheses. You can also call a theory an accepted hypothesis. When one hypothesis has been tested by many different scientists and most of them have come to the same basic conclusion, then we can start calling the hypothesis a theory. There isn't any 'grand master of science' who makes the final decree about a theory. It's more like a general consensus. And a theory can still be disproven if further research reveals enough evidence to refute it.

A law is different from a theory in that it is viewed as a universal fact. A scientific law is a general statement about a group of observations that has no exceptions to the rule. Most laws can be stated as mathematical equations, like Boyle's Law and Pascal's Law. Laws in biology are statements about how living things work - for example, Mendel's Laws. To explain the results of his experiments with peas, Gregor Mendel developed the Law of Segregation and the Law of Independent Assortment. No genetics experiment has ever disproven Mendel's laws, and so his statements are still viewed as laws today.

Controls in Experimental Design:

But even Gregor Mendel had to design a valid experiment in order to receive credit for the work that he did. The use of a control is one element that really makes an experiment scientific. When scientists are trying to test one factor, they have to make sure there aren't any variables going on that could mess up their results.

For example, let's say you wanted to see whether sunflowers or daisies grow faster from seed. You'd plant a sunflower seed in one pot, a daisy seed in another, and then put the pots in a window and water them every day. But what if you put the sunflower pot in a sunny window and the daisy pot in a shady window? Your findings would be skewed, right? You wouldn't know for sure whether sunflowers always grow faster than daisies or if it was just your sunflower growing faster because it got more sun.

In science, a control is a means of ensuring that only one factor is being tested at a time. In order to make yours a controlled experiment, you would need to place both flower pots in the same window. You'd also give each plant the same amount of water, make sure the seeds were planted in the same type of soil, and plant both seeds at the same time. The more you controlled the variable factors in your experiment, the more confident you'd be that the results would accurately address your experimental question.

While we're on the subject, let's check over this flower experiment to make sure it follows the other rules. Remember, our peers in the scientific community are scrutinizing our every move! So first of all, is our experiment designed so that it either supports or refutes our hypothesis? Well, we need a hypothesis. Let's say our hypothesis is 'Sunflowers will grow faster than daisies when grown in similar conditions.' Our experiment is designed to test and compare the two growth speeds, so we've got that rule covered.

Next, do we have a means of generating measurable, objective results? Our results are related to plant height over time, so we'll need to measure the plants' heights in millimeters and the time in days and hours. We'll probably make a chart that shows how much each plant grew over increments of time.

Finally, can other scientists repeat our experiment in the same way we designed it? Well, obviously anyone can grow plants in their window. But as scientists we need to specify every detail about our experiment. How much soil are we putting in the pots? What will the average temperature be? How many hours of light will each plant receive? Exactly how much water will we give to the plants? What kind of potting soil will we use? How often will we measure the heights of the plants? How long will we continue our experiment? I know this seems like a lot of questions, but these are the rigorous requirements that scientists face in their work. If they don't defend their experiments with detailed information, then their work isn't recognized in peer review.

Lesson Summary:

As you can see, scientific experimentation is no walk in the park. In order to receive credit for their work, scientists have to design and implement experiments with great complexity and precision. In fact, some scientists publish hundreds of pages of work for every study they perform! It may seem like overkill, but the challenges of the scientific community help ensure that only valid, reliable science gets fully recognized and used.

It takes a lot of work to design a good experiment. To fit in with the scientific method, experiments have to be relevant to the questions, hypotheses, observations, analyses, and conclusions of the investigation. Experiments are designed so that they support or refute a hypothesis and give results in terms of measurable, objective data. An experiment must be repeatable by other scientists so that it holds up in peer review.

When a hypothesis becomes generally accepted by the science community, it becomes a theory. Scientific principles that are viewed as fact become laws. In designing their experiments, scientists must incorporate controls to ensure that only one variable is tested at a time. Experimental design and implementation is tough, but these challenges help to keep science moving forward.

Example of Designing Experiment:

Name:________________________________

Date:______________________

Class:________________________________

Teacher:__________________

Day 1

Background information:

Designing an experiment and carrying out the plan are what scientists do. Developing the ability to design an experiment is critical to understanding of the scientific process and in promoting critical thinking skills. This skill can be developed if students are allowed to work like scientists. In order to be successful in designing an experiment, understanding it is necessary. After developing basic understanding of the scientific methods, the next process is designing steps in performing investigation. Here are some of the sample problems that can be explored:

· How do we investigate the properties of nylon? Explain the reason for the development of this polymer.

· How do we construct a mobile of organic molecules that illustrates molecular symmetry?

· How do we test several foods for the presence of protein?

Procedure:

1. Break into assigned teams consisting of four members. Assign each other the following roles.

Role Your name

· Team leader or facilitator - ____________________

· Secretary or note taker - _______________________

· Material manager - ___________________________

·Observer/researcher -___________________________

1. As a team address the following scientific processes when designing an experiment:

· Develop your own problems dealing with organic chemistry - What do you want to find out?

· Formulate your hypothesis to be tested-Based on previous knowledge and information; what educated guess do you want to test?

· Design a procedure and list the materials needed- What procedure should be followed to test your hypothesis?

What measurements and observations are necessary to determine whether your hypothesis is correct?

· Make measurements, or observations or a model.

· Collect and analyze the data - Review the recorded data, such as observations or measurements to determine what happened during the experiment. Compare the observations between the control and the experiment.

· Draw a conclusion with respect to the hypothesis -Determine whether the data that was collected by the observations and measurement supports the hypothesis. Review the steps in organizing an experiment by arranging the events in a chain concept map. Work in-groups to develop and set up each of the steps involved.

1. Write an outline of your experimental design for teacher's evaluation. Your outline should include the following:

Sample Experiment:

Problem: How many drops can fit on a penny before the liquid overflows?

Hypothesis: Fifty to eighty drops can fit on a penny before the liquid overflows.

Materials: Penny, dropper, and water

Procedure: Organize groups, assign roles, classify objects distributed, discuss and describe the medicine dropper. What are its uses? Practice putting 1 drop on wax paper-describe what happened. Put a drop on the paper towel-describe what happened. Predict how many drops will fit on a penny before the water overflow. Write down the number. Test. Use three trials for this experiment. Were the prediction correct? What were the variables? Record results-- try two other variables and record. How do you get the drops off of the penny using the dropper?

Observations: Record the number of drops that can fit on a penny before the liquid overflows. The variables that affect the number of drops are the size of the hole of the eyedropper, shape of the surface of the coin and the force exerted when squeezing the eyedropper.

Trials	*Number of Drops*
1	80
2	75
3	85

Draw Conclusion: Analyze the observations and accept or rejects the hypothesis. The average number of drops that can fit on a penny is 80 drops.

Day 2, 3 and 4 Teacher evaluates, approves or suggests to modify your experiment. Collect all materials needed for the experiment once approved. Read appropriate journal or literature related to your experiment. Write a journal entry on how is the literature related to your work.

Day 5 Perform the experiment.

Day 6 Write the final report of your experiment. Your report must include:

Topic

Problem
Background information
Hypothesis
Materials Methods
Data/Observations
Analysis
Conclusion

Day 7

Present your experiment including your findings, data, and conclusion to the class. Prepare any visual aids that will help your classmates understand better your experiment.

Evaluation:

Outline of an Experimental Design- 20%
Performing the Experiment -20%
Final Report of the Experiment -20%
Oral Presentation -20%
Group Effort-20%

INDUCTIVE TEACHING AND DEDUCTIVE TEACHING:

INDUCTIVE TEACHING:

Definition:

Inductive teaching (also called discovery teaching or inquiry teaching) is based on the claim that knowledge is built primarily from a learner's experiences and interactions with phenomena.

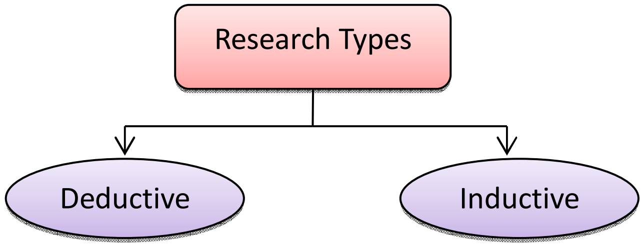
Inductive method or induction is a procedure to generate a universal law by showing that if it is true in particular case, it is also true in other similar cases.

In this method we proceed from concrete to abstract, from a specific example to the universal law or from particular to general.

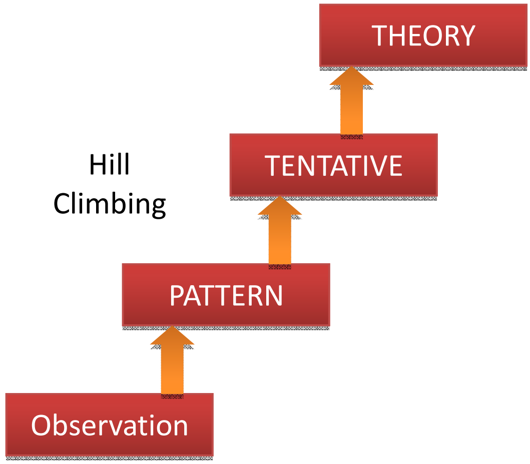
It is a very suitable method for the teaching science since all the conclusions or principles are the result of inductions. A few examples will clarify the point.

Research Methods:

In research, we often refer to the two broad methods of reasoning as the deductive and inductive approaches.



Inductive Research Approach:



- Inductive reasoning works the other way, moving from specific observations to broader generalizations and theories.
- Informally,, we sometimes call this a "bottom up" approach
- Conclusion is likely based on premises.
- Involves a degree of uncertainty

Inductive Teaching:

- ✓ An instructor using an inductive approach begins by exposing students to a concrete instance, or instances, of a concept.
- ✓ The teacher's role is to create the opportunities and the context in which students can successfully make the appropriate generalizations, and to guide students necessary.
- ✓ In inductive method of teaching the pupils are led from particular instances to general conclusion. Concrete examples are given and with their help students are helped to arrive at certain conclusions are principles. In this method, the child is led to discover truth for himself. Inductive method is a very suitable method for the teaching of Sciences, Mathematics and Grammar.

Example of Inductive Teaching:

Example I: Effect of Litmus on Bases

- ✓ Add red litmus solution to sodium hydroxide an alkali, it is turned blue.
- ✓ Add red litmus solution to Calcium hydroxide it is turned blue.
- ✓ Add red litmus solution in Potassium hydroxide, it is turned blue.
- ✓ These three particular cases lead us to generalize that all bases turn red litmus blue.

Example II: Formation of water

- ✓ Two parts of hydrogen and one part of oxygen are filled in the eudiometer tube. On passing current through platinum terminals, hydrogen and oxygen in the given proportion react to form water.
- ✓ It leads us to generalize that whenever hydrogen and oxygen are allowed to react in particular proportion water is formed.

Example III: Gravitational Force

- ✓ We drop a mango, it falls on earth.
- ✓ A book falls from the hands of a boy it is attracted by the earth.

- ✓ A milk bottle is tilted a little, the milk flows towards the earth.
- ✓ These instances lead us to generalize that all substances are attracted by earth.

Merits:

- ✓ It is a scientific method and helps to develop scientific mindedness.
- ✓ It develops critical thinking and habit of keen observation.
- ✓ This method is logical as well as psychological.
- ✓ The children develop genuine interest since they move from known to unknown.
- ✓ Students may draw approaches
- ✓ Inductive approach can increase the creativity
- ✓ Inductive approach showed better long-term retention ability
- ✓ Meet the challenges of the new world
- ✓ This method helps to develop ***Scientific attitude*** among students.
- ✓ Knowledge is self-acquired an it soon transformed into wisdom.
- ✓ Inductive method is a Scientific method and helps to develop scientific mindedness.
- ✓ This method is logical as well as psychological. Learning by doing is the basis of this method.
- ✓ It develops critical thinking and habit of keen observation.
- ✓ The method affords opportunities to the students to be self-dependent and develops self-confidence.
- ✓ It develops the habit of intelligent hard work.
- ✓ It makes the lesson interesting by providing challenging situations to the students.

Limitations:

- ✓ Students may draw other meaning from the examples
- ✓ The inductive approach may also take more time and be less "efficient" then a deductive approach
- ✓ certain ideas do not lend themselves easily to an inductive-teaching

- ✓ Inductive method is not good in the case of lengthy conclusions. Moreover it is said that the pupils might not be able to active at complete generalization.
- ✓ The method is very show and lengthy.
- ✓ It is not possible to apply this method in solving and understanding of all the topics of science.
- ✓ It is lengthy and time-consuming method.
- ✓ The method can be considered complete and perfect if the conclusions are verified through deductive method.
- ✓ It is possibility that the students may draw conclusion very hastily and these may be based on insufficient data and, therefore, may be wrong.
- ✓ Inductive logic is not absolutely conclusive. In certain cases it develops probability to some extent, which increases with the amount of data available.

DEDUCTIVE TEACHING:

Definition:

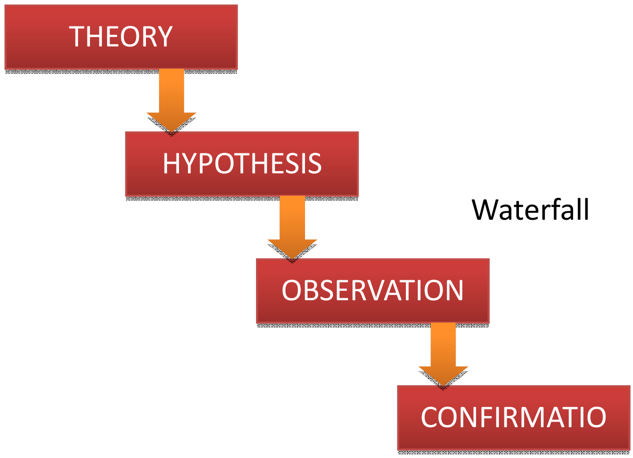
Deductive teaching (also called direct instruction) is much less “constructively” and is based on the idea that a highly structured presentation of content creates optimal learning for students.

“Deduction is the reverse of induction, Hence the facts are deduced or analyzed by the applications of established formulae or experimentation. Here the approach is confirmatory and not explanatory.”

In this method, the students proceed from general to particular, from unknown to known, from abstract to concrete or from established principles to their application.

A few examples will clarify the point:

Deductive Research Approach



- Deductive reasoning works from the more general to the more specific.
- Sometimes this is informally called a "top-down" approach.
- Conclusion follows logically from premises (available facts)

Deductive Teaching:

- ✓ The instructor using a deductive approach typically presents a general concept by first defining it and then providing examples or illustrations that demonstrate the idea.
- ✓ Students are given opportunities to practice, with instructor guidance and feedback.
- ✓ Deductive method is reverse of Inductive method. In this method rules, generalizations and principles are provided to the students and then they are asked to verify them with the help of particular examples. We proceed from general to particular and from abstract to concrete. The teacher's work is much simplified by giving a rule and asking the pupils to verify it by application to several concrete examples.

Example of Deductive Teaching:

Example I:

Water is H_2O. It can be confirmed by the electrolysis of acidified water, using a water voltameter.

Example II:

All bases contain hydroxide. It can be confirmed by reacting different bases one by one, with a particular acid and then verifying with the help of other acids.

Example III:

Cooling is caused by evaporation. This fact can be confirmed by the observation of its numerous, such as, by wearing wet clothes, feelings after taking bath, by spreading a few drops of spirit on the hand etc.

Merits:

- ✓ It is very suitable method for lower classes since they are provided with established principles.
- ✓ As compared to inductive method, it is time-saving since the students will not have to go through the anlaysis or explanation to carve out a universal truth.
- ✓ In this method, the teacher feels happy and secure since his work is simplified. He only gives the scientific principle and the students are asked to apply it in certain situation.
- ✓ It supplements induction and thus helps to complete the process of Induction-Deduction.
- ✓ Some educators have suggested that deductive teaching can be critically important for students with learning disabilities
- ✓ Some learn best through a deductive approach.
- ✓ Deductive learners like to have the general principles identified
- ✓ This method is very suitable for small children who can't discover truths for themselves. The get readymade material.
- ✓ The teacher's work is simplified. He gives general principles and the students verify them.
- ✓ It is a time saving method since the students will not have to go through the analysis or explanation to crave out a universal truth.
- ✓ It is a speedy process and the syllabi can be easily covered.

Limitations:

- ✓ It is unscientific in the sense that the approach is confirmatory and not explanatory.

- ✓ This method is unpsychological since the children do not find out the facts or principles themselves.
- ✓ In encourages rote memory.
- ✓ It doesn't allow for divergent student thinking.
- ✓ It also doesn't emphasize students reasoning and problem solving.
- ✓ Deductive approach can not increase the creativities.
- ✓ This method is rather unnatural and unpsychological since the children do not find out the facts or principles themselves.
- ✓ The method doesn't impart training in Scientific method.
- ✓ This method does not help to develop Scientific attitude.
- ✓ The method fails to develop self-confidence and initiative in the students.
- ✓ This method encourages memorization of facts, which are soon forgotten.

Deductive vs. Inductive method

- In *deductive* (*rule-driven, top-down*) teaching the teacher introduces and explains the concept and the rules relating to it. Then the teacher lets students to practice the new concept.
  GENERAL RULE > EXAMPLES > PRACTICE
- In *inductive* (*example-driven, bottom-up*) teaching the teacher gives students the data and lets students draw their own conclusions from the data. The students notice how the concept is used and figure out, and verbalise the rule.
  EXAMPLES > PRACTICE > GENERAL RULE

Difference between Inductive and Deductive Methods:

S.NO	Inductive Method	Deductive Method
1.	In this method we proceed from concrete to abstract, from a specific example to the universal law or from particular to general.	In this method, we proceed from general to particular, from unknown to known from abstract to concrete or from established principles to their

		application.
2.	Here, the students themselves explore the principles and laws.	Here, the principles and laws are made known to the students and their work is only to verify those principles and laws.
3.	As the students make laws and principles themselves, it develops the power of critical thinking among them.	Here, in this method, the students are dependent upon the teacher.
4.	It is psychological method.	It is un psychological method.
5.	With this method, teaching process becomes interesting and enjoyable.	Teaching process is monotonous and does not become challenging.
6.	This method encourages the students to discover new knowledge.	This method does not encourage the students to discover new knowledge.
7.	It is suitable for lower classes.	It is suitable for higher classes.

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.

This is the usual class-room 'chalk and talk' method. It is not a scientific method at all and not quite suitable for teaching science, especially at the school stage. It is advisable to use it sparingly and when the occasion demands. But the method is still widely used in most of our schools for teaching general science. It rarely creates interest or draws attention of the young people. Here the teacher talks and the class listen; thus the teacher is the only active individual in the class and the pupils are passive listeners. The pupils do not have the patience to listen to the lectures all the time. A long, tedious lecture mars the liveliness of the pupils. But a dull lecture is still more harmful; it creates an averse attitude towards the subject. The greatest drawback of the lecture method is that it ignores experimentation – the basis of modern scientific knowledge – and student participation essential for learning science. In a lecture method class, very little is permanently retained by the pupils and there is practically no understanding.

An interesting lecture may, however, be successful in drawing the attention and interest of the pupils or may help in memorizing facts but the essential qualities in learning science, such as independent thinking, power of observation and reasoning, are never developed. The method may be effective for superior pupils in the class but fails to benefit the average or the below average pupils. Some authors contend that the method acts as a sort of spoon feeding to the pupils whose faculties are never exercised. The method is usually recommended for use in higher classes where more able pupils are prepared for college courses. However, the method becomes most effective when as many pupils as possible are drawn into discussion or when accompanied by a good use of the blackboard, other audio-visual aids, and well-planned class-room demonstrations related to the topic. A judicious use of questioning simultaneously may contribute towards its effectiveness.

It cannot be denied that there is still scope for using this method in teaching science. It may be used by experienced teachers in the general procedure. An expert teacher may often use this method to relate thrilling biographical and historical incidents in science. He has to resort to this method, while he speaks of the lives and achievements of the great men of science. It is convenient and speedy for covering the course quickly and to summarize the essential points of the previous works or to give the class relevant information before the actual beginning of the lesson. In fact, the method is used to introduce a new topic, to state the aim of teaching it, and to open discussions on the result of pupils' practical work. It can also be used for revision of the previous lessons and to refer to books and periodicals in the library. It is the easiest but least advisable of all methods. It lays no strain on the teacher.

Characteristics of a good Lecture:

- ✓ Impart new information
- ✓ Explain, clarify and organize difficult concepts.
- ✓ Summarize a topic
- ✓ Provide supplementary information
- ✓ Model a creative mind at work or the problem-solving ideas
- ✓ Inspire a reverence for learning
- ✓ Challenge beliefs and habits of thinking
- ✓ Breed enthusiasm and motivation for further study

When to use Lecture?

There are three main reasons to use the lecture method.

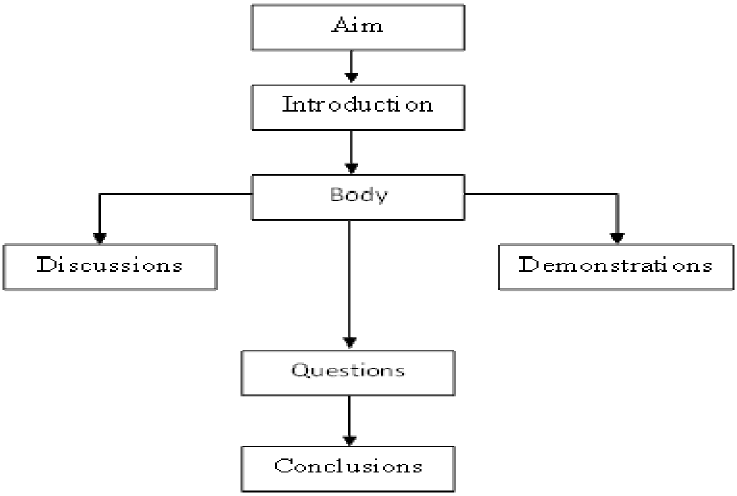
i. To transmit information.

ii. To create interest.

iii. To promote understanding (affect).

Components:

While planning for the lecture one has to be well aware of the components of the lecture. The lecture contains three main components or parts, the introduction, body and conclusion.



Advantages:

- ✓ It provides an economical and efficient method for delivering substantial amounts of information to a large number of students.
- ✓ No teaching aids are required.
- ✓ Knowledge can be imparted to the students with a short period.
- ✓ It is a simple method for the students with a short period.
- ✓ It is a simple method for the teachers; he/she will feel comfortable and satisfied.
- ✓ The teacher does not have to worry about demonstrations, experiments, etc.,
- ✓ Good lectures by teachers could motivate and inspire students.
- ✓ Can be used to put the subject into its context.
- ✓ It can present material that is not yet available in print or books.
- ✓ It is efficient.
- ✓ It can complement some individual learning preferences.
- ✓ A good lecture can be used to arouse interest in a subject.
- ✓ It can complement and clarify text materials.
- ✓ It is very attractive concise and very easy to follow. The teacher feels secure and satisfied.
- ✓ Lengthy syllabi can be covered in short time by this method.

- ✓ It is economical because no laboratory is needed and one teacher can teach a large number of students at a time.
- ✓ Factual information and historical anecdotes can be easily imparted by this method.
- ✓ The logical sequence of the subject can be easily man tied.
- ✓ In this method there is no student activity, no project therefore there is hardly and wastage of time.

Disadvantages:

- ✓ Students are passive learners.
- ✓ Students' previous knowledge and behavior are usually not taken into account.
- ✓ Students cannot be provided with individual feedback.
- ✓ It is difficult to adapt to individual learning differences.
- ✓ It is difficult to cater to the individual grasping capacities.
- ✓ A teacher needs to prepare in advance for the lecture.
- ✓ It usually does not allow the opportunity for students to ask questions.
- ✓ It does not promote individual learning.
- ✓ The teacher can ignore the students' interaction.
- ✓ The teacher may overload the material.
- ✓ It falls to develop critical thinking and reasoning power, so essential for democratic living.
- ✓ It does not help to inculcate scientific attitudes and training in scientific method among pupils.
- ✓ There is no place for learning by doing in this method
- ✓ This method is undemocratic; the pupils are encouraged to depend upon one authority.
- ✓ When the teacher lectures, there is no guarantee whether pupils are concentrating and understanding.
- ✓ It lay too much stress on memory work.

LUCTURE-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 method 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 a good demonstration.

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, and 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 procedure 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 wills 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

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.

TEAM TEACHING:

Team teaching can be considered an innovative procedure in organizing teaching rather than a method or technique. It is an instructional design which involves a group of teachers jointly responsible for planning and instruction of particular course content. The way in which the team of teacher operates constitutes team-teaching. A teaching team is a unit of a small faculty group jointly responsible for teaching a distinct group of students to whom the teacher-group will teach and also other non-professional persons who assist the teachers and the students. The number of teachers in the faculty group may vary from two to six or seven and the team cooperatively prepares and develops the instructional programme. The different grades of teachers in the team may have different responsibilities. There may be a team leader, senior teachers and the team teachers. The team-teacher has direct contact with the learners as he actually teaches has direct contact with the learners as he actually teaches the students in small or large groups depending upon learners' common 'entering behavior'. The senior teacher supervises and coordinates teaching activities. The team leader has the overall administrative, supervising and coordinating responsibility. The description above indicates that the team-teaching approach is an advantageous model for training new teachers and for in-service training of working teachers. The purpose of team-teaching is to help teachers solve their own teaching problems. The scheme also provides the less skilled or less experienced teachers to observe highly skilled or more resourceful teachers at work. This helps improve their competence. The group working system helps behavior modification of individual teachers. Further, the team-teaching arrangement provides opportunity for utilizing the capabilities of each teacher as he gets the opportunity to plan instructional programme and also to teach in the area of his specialization. Since aptitude and knack varies with teachers, one teacher may be more skilled in presentation through verbal deliberation or through group discussion, and the other may be better in laboratory work or in presentation through verbal deliberation or through group discussion, and the other may be better in laboratory work or in presentation through use of audio-visual aids while still another may be more interested in testing and evaluation. A good team-teaching programme must consider this fact and utilize the individual teacher's talents to an advantage.

A team-teaching programme is based on the teaching objectives, need of the students, their entering behavior and the techniques proposed to be used in teaching. The size of the class and duration of the teaching period can vary accordingly. A team-teaching programme gives emphasis to joint team work in planning, teaching and evaluating rather than the individual teacher. Yet, the professional autonomy of each teacher is always protected by the team and the opportunity of using the special ability of each teacher is never missed.

As in all other instructional programmes, there are difficulties faced by the team. For instance, it may not be easy to find an appropriate team leader or teachers who could function harmoniously and maintain the common philosophy of the group. A team-teaching programme may face difficulty of organization and adjustment in the routine work-schedule of an institution, or may even create new administrative problems. Some authors believe that it is impossible that a creative teacher may be forced to follow the common interest of the team and hinder his creativity.

The Education Commission, 1964-66, advocated the use of team-teaching approach for promoting elasticity and dynamism in teaching situations. The Commission felt that the practice of team-teaching "breaks down the isolation of teachers, increases his sense of assurance and makes it easier for him to adventure. It is the basis for all real reform in teaching practice. No worth-while advance is possible in teaching method unless the individual teacher understands what he is doing and feels secure enough to take the first new steps beyond the bound of established practice. It is easier for a teacher to do so in a small group than when he is working alone. The success of team-teaching in introducing new teaching techniques into some American schools is based on the fact that it is not the individual but the team that is responsible for planning and execution of new methods."

The present system of education demands too much from a teacher by curtailing his freedom. He has to teach same subject matter every year and he is forced to teach the same content to two or three sections of the same class. It is very boring for him and stifles his interest in the subject. Sometimes he is assigned to teach the subject in which he has no interest to teach but he is forced to do so. More-over the present day classrooms are appropriate only for the average students.

In these, circumstances, when teachers and students have to work under so many constraints, we feel an urge to use team teaching.

Origin of Team Teaching:

The concept of "Team-Teaching" has its origin from America during the mid 1950. It reached England in the 1960. J. Freedom's team teaching in Britain gives an account of its growth in the country. It has occupied a place for itself in schools and colleges.

Harvard University is the first institution which has initiated an internship plan in 1955. The second mile stone in team teaching is the project in Lexington (1957-64) which has been influenced by the Harvard programme.

Francis Chase of the University of Chicago has developed the need of team teaching to use the best teachers more effectively.

J. Leyod Trump made valuable contribution for the success of team-teaching. Team-Teaching was not only confined to educational institutions but its use was extended to armed forces for teaching purpose during second world war.

It is difficult to trace the origin of team teaching because so many individuals and organizations have been conducting studies in their own areas for last two decades all over the world.

In India many educationists are aware of this system; but they are not confident to implement it even though it will best suit to our teaching learning situation.

Meaning and Definition of Team Teaching:

The term "team teaching" has been defined by several persons because they have designed and conducted experiments to understand the nature of team teaching. Warwick has tried to define the term more comprehensively. According to him

"Team-teaching is a form of organization in which individual teachers decides to pool resources, interests and expertise in order to devise and implement a scheme of work suitable for the needs of their pupils and the facilities of their schools."

Carlo-Olson has defined team-teaching as:

"An instructional situation where two or more teachers possessing complementary teaching skills cooperatively plan and implement the instruction for a single group of students using flexible scheduling and grouping techniques to meet the particular instruction."

Another definition of team-teaching is:

"An arrangement whereby two or more teachers, with or without teaching-aids cooperatively plan, instruct and evaluate one or more class groups in an appropriate instructional space and given length of time so as to take advantage of the special competencies of the team members."

It may be inferred from the definitions of team-teaching that it has the following characteristics:

- ✓ It involves two or more teachers to teach a class.
- ✓ In this type of teaching, a group of teachers is responsible rather than an individual teacher.
- ✓ A team or group of teachers of the same subject work together to deal a significant content to same group of students jointly.
- ✓ It can be termed as co-operative teaching. In which individual teachers plan to pool resources, interests and

their expertise for teaching content for the same group or class of students.

- ✓ Every individual teacher gets appropriate instruction space and length of time so as to use special competencies of teaching content to a group of students.
- ✓ A group of teachers shares responsibilities of planning, organizing, teaching, controlling and evaluating the same class of students.
- ✓ In team-teaching the group of teachers has to consider the needs of their pupils and they should teach jointly to satisfy their needs and remove the difficulties of their students.

Types of Team-Teaching:

There are different styles of organizing team teaching in schools. One of the common methods adopted is that the teachers teaching the students of same standard and subject join together, collaborate and perform the task. The whole team can plan the lecture and discuss which teacher is best suited to lecture, for small group discussion, for guiding library work, for setting up demonstrations and visual aids that can be used in presentation in large groups and for preparing evaluation materials. Each of the members in the team has a specific assignment.

All the students of four sections meet at the large hall for large group instruction. One teacher gives a lecture and another teacher demonstrates. This lecture is arranged after thorough preparation in consultation with the other teachers in the team. The purpose of the lecture is to motivate the students and initiate them in the learning activity.

Team teaching can be effective only when this lecture in a large group is immediately followed by small group discussions under the guidance of all the teachers in the team. The large group is split up into small groups of homogeneous abilities and the teachers' pay individual attention and work as counselor or can be accomplished on the basis of students' abilities, interests, needs and achievement.

Another style of team teaching can be that the team members join together, discuss the topics, plan the work, prepare the teaching aids and then go to their respective classes and teach the subject matter.

In yet another approach, when a topic of common concern to different disciplines is to be discussed, teachers of these subjects after proper planning together, can go to the same class is followed by another teacher and the discussion is completed from each one's point of view. This may bring about the interrelatedness of knowledge through discussion by different subject teachers.

Objectives of Team-Teaching:

The teaching strategies have been designed to achieve certain objectives. The team-teaching has been evolved to realize the following objectives:

- ✓ To make the best use of expertise of teachers under team-teaching.
- ✓ To improve the quality of teaching. The services of the expert teachers are shared by a large number of students.
- ✓ To develop the feelings of co-operation or group work in teaching-learning situation.
- ✓ To help the students, to satisfy the needs and difficulties relating to the special content.

Procedure for Organizing Team-Teaching:

The team-teaching serves several purposes of teaching and it has different forms or types. Therefore, it is difficult to provide a general procedure for organizing team-teaching, but it involves the following steps:

Step 1 – Planning,
Step 2 – Organizing and
Step 3 – Evaluating.

The details of activities of these steps have been given in the following paragraphs:

Step 1 – Planning for Team-Teaching:

This step involves the following activities which are decided by the team members.

Deciding the topic to be taught:

- ✓ Writing the terminal objectives in behavioral terms.

- ✓ Identify the entering or initial behavior of the learners of the group.
- ✓ Preparing a tentative schedule of teaching.
- ✓ Assigning duties to teachers, considering their interest and competencies during lead lecture, follow-up work and supervision.
- ✓ Fixing up the level of instruction.
- ✓ Selecting appropriate teaching aids and demonstration equipment's for generating learning environment; deciding ways and means for evaluating the students' performance: oral or written questions for practical work, etc.

These activities are finalized by the team of teachers who are taking part in the team-teaching. In planning of team-teaching expertise of every teacher must be fully utilized. There should not be imposition of activities on them.

Step 2 – Organizing Team-Teaching:

The organization of team-teaching is decided by considering the purpose or needs of the learners of the group. The following are the general activities which are usually performed by team of teachers:

- ✓ Determining the level of instruction: Some questions are asked to explore the background of the learners.

- ✓ Presentation of lead lecture by a competent teacher of the team: other teachers listen to the lecture and note down the elements of topic which are not easily understood by the learners or not appropriately presented.
- ✓ Follow up work, the other teachers have to supplement the lead lecture by explaining the elements of the topic in a more simple way so that learners can understand easily.
- ✓ Providing motivation or reinforcement by teachers to the learners in both the situations: lead lecture and follow up work.
- ✓ Supervision of students-activities which are assigned in lead lecture or group work or follow-up work. This stage is considered to be important for assimilation.

Every member of the team should be conscious about time schedule and about the duty assigned to him.

Step 3 – Evaluating Team-Teaching:

The evaluation is an important aspect of any type of teaching. It is helpful to measure the performance of learners which determines the level of achievement of the objectives. It also provides the reinforcement to team members. Thus, it involves the following activities:

- ✓ Asking oral questions, writing questions and practical work. Each question should measure a particular objectives of team-teaching.
- ✓ Taking decision about the level of performance and realization of the objectives.
- ✓ Diagnosing the difficulties of the learners and provide the remediation.
- ✓ Revising the planning and organizing phases of team-teaching on the basis of evaluation of the students.

Advantage of Team-Teaching:

The team-teaching is a perspective and economical device of teaching to cater to the needs of the students. It is highly flexible. It has the following major advantages:

- ✓ The team-teaching utilizes the competencies of the teachers.
- ✓ It creates the learning environment for better comprehension and mastery over the subject among the learners.
- ✓ It provides an opportunity for free discussion in the small group work.
- ✓ It provides an opportunity to the teachers to develop the professional status and competency in teaching by mutual sharing of ideas.
- ✓ It develops the team spirit and the team members utilize the best use of multimedia.
- ✓ Time and energy are saved by the team teaching. It maintains the discipline in the class and creates a conductive environment of learning.

- ✓ It is highly flexible method of teaching while traditional methods of teaching are rigid.
- ✓ It enables the students to become more aware of their own approach, knowledge of content and simultaneously to the other experts of the same area. It brings excellence of teaching in them.

Limitations of Team-Teaching:

- ✓ It is very difficult to seek co-operation among teachers to work jointly in teaching-learning situation. There is no mutual regard and respect among the teachers. Every teacher considers himself expert of the subject. Every teacher has his own style of teaching.
- ✓ The teachers do not like to deviate from the routine method of teaching and they do not prefer any change in system of education.

ACTIVITY ORIENTED APPROACH:

Activity-oriented approach or AOA describes a range of pedagogical approaches to teaching. Its core premises include the requirement that learning should be based on doing some hands-on experiments and activities. The idea of activity-based learning is rooted in the common notion that children are active learners rather than passive recipients of information. If child is provided the opportunity to explore by their own and provided an optimum learning environment then the learning becomes joyful and long-lasting.

Characteristics of activity-oriented approach:

The key feature of the AOA method is that it uses child-friendly educational aids to foster self-learning and allows a child to study according to his/her aptitude and skill. Under the system, the curriculum is divided into small units, each a group of Self Learning Materials (SLM) comprising attractively designed study cards for English, Tamil, Maths, Science and Social Science. When a child finishes a group of cards, he completes one "milestone". Activities in each milestone include games, rhymes, drawing, and songs to teach a letter or a word, form a sentence, do Maths and Science, or understand a concept. The child takes up an Exam Card only after completing all the milestones in a subject. If a child is absent one day, he/she continues from where he/she left unlike in the old system where the children had to learn on their own what they missed out on.

This kind of approach seeks to promote learning by providing students with experiences that allow them to discover and experiment with science. Through discovery and inquiry, teachers involve students in creating and expanding their knowledge and understanding about the content area being studied.

Though activity-oriented teaching has been accepted as a paradigm for science education and is also reflected in some measure in the textbooks developed at the national and state levels, it has hardly been translated to actual classroom practice. Activities still tend to be regarded as a way to verify the ideas / principles given in the text, rather than as a means for open-ended investigations. There is a general feeling that activity based teaching is expensive, takes more time that could be otherwise 'fruitfully' used for 'text based' teaching, and does not prepare the child for examinations and competitive tests.

The concern about expenditure involved in activities/experiments cannot be dismissed. Most schools cannot afford well-equipped science laboratories. However, it is certainly possible to design low cost activities and experiments using easily available materials. Thus cost should not be allowed to become an excuse for neglecting the very base of learning science. The concern regarding examinations can be addressed by reforms in the examination system that ensure due weightage to activities and experiments. Overall, we need to develop textbook approaches, teaching styles and assessment procedures to ensure that meaningful learning does follow from activities.

Many students with disabilities benefit from learning science through an activities-oriented approach that reduces the reliance on textbooks, lectures, knowledge of vocabulary, and pencil-and-paper tests. This kind of approach seeks to promote learning by providing students with experiences that allow them to discover and experiment with science. Through discovery and inquiry, teachers involve students in creating and expanding their knowledge and understanding about the content area being studied.

A Structured Learning Cycle:

When employing an activities-oriented approach, teachers offer students a variety of active educational experiences structured according to a learning cycle. This cycle consists of an instructional sequence that includes engagement, exploration, development, and extension. The learning cycle begins with the engagement phase, whereby teachers use real-life activities, problems, and questions to motivate students to learn about the topic and to assess their prior knowledge. Students explore the content and phenomena by manipulating materials and start to address the presented questions. For example, as part of a unit on simple machines, teachers can ask students to identify simple machines that they use and have students take apart broken household appliances. During the exploration phase, students formulate new ideas and questions to be developed in the subsequent phases. For example, teachers can have students explore how the household appliances work, identify their components, and formulate hypotheses about how to fix them. In the development phase, students add to their understanding by gathering more information and making conclusions about the concepts, phenomena, and questions previously generated. For example, students can use the Internet to learn more about the appliances and to draw conclusions about how they work. In the final stage, extension, students extend their learning by applying it to new and different situations as well as to their own experiences. For example, students can hypothesize about how other machines and household appliances that they use work. Educators help students move through the learning cycle by asking them to think about questions, helping them find solutions, providing additional activities that further students' learning, and aiding them in summarizing and evaluating their learning.

An integral part of an activities-oriented approach is providing hands-on, multisensory experiences and materials. Hands-on learning gives students concrete experiences that establish a foundation for learning more abstract concepts. These kinds of activities also help students actively explore and discover content, and they lessen the language and literacy demands that may interfere with learning for students who have learning difficulties and/or are second-language learners. For example, students can learn about electricity by building electric circuits or about earth science by creating models out of papier-mache.

Special Concerns:

Because students with physical, sensory, and fine-motor disabilities may experience some difficulties using manipulative and scientific materials and equipment, educators may need to offer adapted equipment. Students with visual disabilities, for example, may need Braille-marked and talking materials and equipment such as a Braille labeler, ruler, and meter stick; talking thermometer and balance; enlarged three-dimensional models; and large-screen video and micro projectors to enhance visual images.

In an activities-based science instruction approach, students often work in labs solving problems and conducting experiments. Educators can maximize this type of learning experience by showcasing and demonstrating essential aspects of problems and experiments, letting students with disabilities team up with nondisabled peers, disseminating a checklist of steps students can consider when working on a task, checking their progress, and asking them to maintain lab journals.

Teachers also can ensure that all students are able to work safely and successfully in laboratories and with materials. For example, teachers can begin each experiment by posting, discussing, and reviewing the rules, safety factors, and evacuation procedures and assessing students' knowledge of them. They can use print and tactile substances to label important areas, materials, and substances; have all students wear safety equipment (e.g., splash-proof goggles, rubber aprons, and gloves); and assign lab partners.

Teachers must know whether some students need adapted workstations and specialized equipment. Students with physical disabilities may need a workstation with a work surface 30 inches from the floor, accessible equipment controls, and appropriate clearance and leg space, as well as good aisle widths. These students also may benefit from adjustable-height storage units; pull-out or drop-leaf shelves and countertops; single-action lever controls and blade-type handles; flexible connections to water, electrical, and gas lines; and lightweight fire extinguishers. Similarly, the performance and safety of students with sensory disabilities may be enhanced through the use of adaptive equipment such as electric machines and alarm systems that have visual and auditory cues to indicate their on/off status, spoons with sliding covers, and glassware with raised letters and numbers.

Relate Science to Students' Lives:

Relating science instruction to students' personal experiences and to general societal problems is an essential component of an activities-oriented approach. Relating science to practical, civic, professional, recreational, and cultural events that are familiar and relevant to students' backgrounds and experiences can promote science literacy, motivate students, and help them learn to value science. To aid students in seeing the relevance of science to their lives, teachers can present them with information, issues, and problems that relate to real-life situations and discuss with them the relevance of these problems to their lives and the situations in which this content can be applied. For example, students can investigate socially significant problems such as water supply, weather, pollution, nutrition, and solar energy.

Teachers can make connections between science and students' cultural backgrounds by using learning activities and instructional materials that

- explore the different cultural origins of science,
- discuss scientific solutions and practices developed and used in all parts of the world,
- highlight the achievements of culturally and linguistically diverse scientists, and
- present a range of culturally diverse practical applications.

Connections to students' lives and cultures also can be established by having students

- conduct problem-solving activities that address community-based problems,

• use artifacts, buildings, geographical sites, museums, and other resources in their community, and
• interview community members.

These experiences will help illustrate and reinforce concepts, issues, phenomena, and events.

Organize Instruction Around "Big Ideas" and Interdisciplinary Themes:

In activities-oriented approaches, teachers focus on breadth of understanding rather than a broad coverage of science. Carnine (1995) proposed that educators structure instruction in science according to "big ideas," which he defined as important concepts or principles that help students organize, connect, and apply material so that they see a meaningful relationship between the material to be learned and their own lives. Carnine also suggested that teachers sequence instruction by employing big ideas to help students develop a mechanism for learning "smaller ideas" such as facts that relate to the broader concepts and big ideas being presented.

The science performance of students with disabilities will be enhanced when teachers organize instruction around broad-based, common, and interdisciplinary theme concepts. Interdisciplinary themes can link the various science disciplines (e.g., biology, chemistry, earth science, and physics) as well as relate science themes to other subject areas (e.g., English, mathematics, social studies, foreign languages, art, music). For example, for an interdisciplinary thematic unit on weather, students would study the scientific principles undergirding various weather patterns as part of science class and the history of weather and its effects on lifestyles and cultural traditions in social studies class. As part of their mathematics classes, students would be asked to solve various mathematical problems related to weather and, for language arts classes, to read literature and poetry related to weather. In art class, students would see how weather changes the appearance of various landscapes and then produce art forms to reflect these landscapes.

When selecting common and interdisciplinary themes around which to organize instruction, teachers should consider several factors, including whether the themes,

(a) Are feasible for students and teachers in terms of motivation, relevance to the curriculum and students' lives, length of time, availability of materials and resources;

(b) Provide sufficient opportunities to teach basic- and higher-level content, information, and skills; and

(c) Relate to meaningful and worthwhile contextualized content.

Once themes are selected, teachers formulate objectives and develop, select, and organize the content and instructional resources; implement with students a diverse set of theme-connected direct and hands-on learning activities that integrate science, social studies, language arts, music, art, and other content areas; and devise appropriate assessment procedures to be employed throughout the instructional unit. Interdisciplinary thematic units usually conclude with students completing a culminating activity that allows them to summarize and present what they have learned.

Have Students Work in Cooperative Learning Groups:

In an activities-based approach, teachers often structure learning so that students work in cooperative learning groups. The use of such groups can encourage the establishment of scientific classroom communities where students work in groups to communicate about and experiment with solutions to scientific problems. Cooperatively structured learning lets students formulate and pose questions, share ideas, clarify thoughts, experiment, brainstorm, and present solutions with their classmates. Students can see multiple perspectives and solutions to scientific problems. For example, in a unit about flowers, students can be assigned to work in cooperative groups to design a flower garden for their school. The group can plan their garden by posing questions (What flowers grow best in the available soil and lighting conditions? What flowers and colors go together? What materials will be needed to maintain the garden?) and gathering data to address these questions. The group also can share a drawing of their proposed garden and the reasons that guided their design with the whole class.

Use Instructional Technology and Multimedia:

Instructional technology and interactive multimedia provide students with access to learning environments that link text, sound, animation, video, and graphics to present content in a nonlinear and instantaneous fashion that can foster critical thinking skills and social interactions (The Cognition and Technology Group at Vanderbilt Learning Technology Center, 1993). These technologies also can be incorporated throughout the curriculum to adapt instruction to students' learning styles and provide them with experiences that allow them to control their learning.

Instructional technology and interactive multimedia such as computer software, hypertext/hypermedia, computer simulations, videocassettes, videodiscs, captioned television, liquid crystal display (LCD) computer projection panels, CD-ROM, virtual reality, and the Internet can be used to introduce, review, and apply science concepts and have students experience events, places, and phenomena. For example, through virtual reality systems, students can experience Newton's law of gravity firsthand or through multimedia applications, they can perform complicated scientific experiments such as studying chemical reactions. In addition to providing students with an opportunity to obtain information about and interact with unique aspects of science, these instructional delivery systems can motivate them and stimulate their curiosity.

The Internet holds great promise as an instructional tool because it provides educators and students with access to the information superhighway and a variety of exploratory- and discovery-based learning and communication experiences. The Internet also can offer students greater control over the curriculum because it provides them with many choices related to what and how they learn. Specifically, students can learn science by having access to information, educational resources, pictorials, databases, problem-solving experiences, and communications with other students and professionals from throughout the world. For example, the National Geographic Society and the Technical Education Research Center sponsor the Kids Network, an international telecommunications-based curriculum to teach science and geography to elementary and middle school students. Students work in small groups to pose questions concerning socially significant problems, conduct experiments, and collect and analyze data related to their questions. Through the network, students exchange information and share their findings with peers worldwide. Listings and descriptions of computer networking resources for educators and students are available and can be obtained by contacting professional organizations, state education departments, and computer-based companies.

Support Instruction through Specially Designed Programs and Curricula:

Specially designed science programs and curricula can be incorporated into an activities-based instructional program. An example would be the Full Option Science System (FOSS; Encyclopedia Britannica Co., 1992), which offers teachers a hands-on, laboratory-based K-6 curriculum, structured around four themes: scientific reasoning, physical science, earth science, and life science. FOSS also uses discovery learning, cooperative learning groups, interdisciplinary activities, and other types of activities to teach science language and the use of scientific equipment. It also includes Science Activities for the Visually Impaired (SAVI) and Science Enrichment Learning for Learners with Physical Handicaps (SELPH), activities-based science programs for students with disabilities.

Two hands-on laboratory-based curriculum models are

- Science for All Children, which addresses four interrelated themes and thinking processes: systems, change, structure, and relationship, has been designed as a multiple-option curriculum for elementary-level students and allows teachers to adapt the activities to the cognitive, cultural, language, and social-personal needs of their students.
- Applications in Biology/Chemistry, which seeks to promote the science literacy skills of secondary students in the middle 50% range by linking science concepts to personal and societal contexts and the world of work. Through the use of real-world activities, job profiles, cooperative learning, learning-style adaptations, laboratory exercises, and hands-on activities, the ABC curriculum provides teachers with a framework for teaching science in context.

Science curricula and programs designed to address the needs of students from culturally and linguistically diverse backgrounds also are available:

• Finding Out/Descubrimiento is a collaborative learning, hands-on, problem-solving math and science program for second-language learners that includes materials in English and Spanish and pictorial directions.

• Beginning Science Equitably is an early childhood science program designed to provide teachers with developmentally appropriate lessons that help students, regardless of gender, race, disability, or socio economic status, to develop the visual-spatial, problem-solving, and decision-making skills that promote positive attitudes toward and future success in science. The program also includes a hands-on curriculum that introduces a variety of science concepts using the scientific method and a series of science activities that families can do to help their children learn about science.

Evaluate Student Performance:

Rather than using paper-and-pencil tests to assess student performance, educators using an activities-oriented approach often employ authentic performance and student-centered assessments. Performance and student-centered assessments seek to connect assessment and instruction and involve students in examining the process and products of learning. In performance assessment, students reveal their skills, problem-solving abilities, and knowledge and understanding of science by creating and making things, developing projects, solving problems, producing written products, responding to simulations, giving presentations, conducting investigations, and designing and performing experiments. For example, as part of a unit on water pollution, students can perform a variety of activities and experiments using local water samples. These activities can then be assessed by having students present their findings to a local community group and/or by creating a Web page summarizing their results.

Students can be involved in the assessment process through use of such student-centered assessment strategies as portfolios, journals and learning logs, think-aloud, and self-evaluation questionnaires and interviews. These assessment strategies provide students with opportunities to monitor their progress, evaluate their understanding, and gain insights into the ways they approach and think about science. Portfolios are archival in nature and consist of student products selected by both students and teachers over a period of time. Portfolios are continuously examined by students, educators, and families to reflect upon and document the students' growth, effort, attitudes, and the processes they use to learn science.

Journals and learning logs offer students opportunities to react to and reflect upon their learning and to develop their skill at communicating scientifically. During or after a learning activity, students write entries in their journals/logs that address

1. What they learned,
2. How they learned it,
3. What they do not understand,
4. Why they do not understand it, and
5. What assistance they would like to receive.

Think-aloud techniques involve teachers prompting students to verbalize the processes they are using and their thoughts while working on a science activity by asking students to respond to a variety of questions (e.g., As you work on that activity, what are you thinking about? How did you arrive at that solution?). Similarly, self-evaluation interviews and questionnaires are designed so that students respond to a variety of questions that reveal their approach to various learning activities, their perceptions of their educational needs, and their progress in understanding science. Information collected from these student-centered assessment strategies can be used to devise instructional strategies that help students become better learners.

IV. RESOURCES FOR TEACHING SCIENCE

INSTRUCTIONAL MEDIA:

The term “instructional media”, refers to devices and materials employed in teaching and learning. It includes hardware like blackboards, radio, television, tape recorders, video tapes and recorders and projectors; and, software like transparencies, films, slides, teacher-made diagrams, real objects, cartoons, models, maps and photographs.

Instructional media encompasses all the materials and physical means an instructor might use to implement instruction and facilitate students' achievement of instructional objectives. This may include traditional materials such as chalkboards, handouts, charts, slides, overheads, real objects, and videotape or film, as well newer materials and methods such as computers, DVDs, CD-ROMs, the Internet, and interactive video conferencing.

Instructional media are generally designed to provide realistic images and substitute experience to reach curriculum experiences. The media are considered the most efficient facilitators in the education set up. They are not substitutes for the teacher. Their use however, calls for an imaginative approach by the teacher who needs to constantly be on the alert for new ideas and techniques to make the lessons presented with different instructional media achieve effective outcomes.

Some devices are designed to present information of a kind that would not be available in an ordinary school experience. Examples include, films, television, sound recordings. Other types of instructional media have the function to help the pupil grasp the underlying structure of a phenomenon. Visual media are primarily for seeing, audio devices for hearing, and multi-sensory materials for use via two or more senses.

CHARTS:

A chart can present any information other than geographical in an easy to understand way.

These are probably much more available and used and could be easily made by teachers. Things to consider in using charts include-

a) The chart should be simple, accurate and attractive.

b) Consider whether chart is needed and would do better than other resources.

c) The type of data and the number of learners to benefit from the charts should be considered.

Charts also play a significant role in making the ideas clear and comprehensive. It should be the result of active participation of both the teacher and the pupils.

The various charts include bar charts, organizational charts, pie charts, directional charts, pictorial charts, and flip charts. An appropriate chart should have features such as being simple to see, read and understand. It should not include too much text and should contain relevant materials appropriate for the lass. When the charts are available, the teacher can proceed to plan the over-all arrangements. Charts and diagrams are used to graphically represent complex ideas among others. They can be designed to clothe abstraction with greater meaning.

Charts present factual comparative information in the form of pie-chart graphs to focus attention on the features of an object. Charts clamped or fixed together at the top and fixed to a chalkboard can be used in a flip sequence to illustrate the structure of a topic. Different colour contrasts should be considered when arranging and using charts. Wall charts are large pictures with a lot of items used for question-and-answer work, and which are used for discussing the relations of objectives and people.

A chart may be diagrammatic or graphic; it may also be a combination of these. For example, a chart may, through a series of diagram, show the various parts of a flower or different types of leaves. The diagrams in a chart usually exhibit the contents in outlines with minimum pictorial representation. It may be used of conveying an idea or concept of a scientific principle, to compare and contrast the properties of an object or a thing, to represent a comparative data or to explain the working of the different parts of an object such as a complex machine. All charts are generally give short explanatory notes about the drawings. Often a single chart can be used to represent more than one idea. Colours may be used but precaution should be taken so that the chart does not become a confused colour display.

A chart is a flat surface upon which diagrams are drawn with names of the parts or short notes about them. The best example of a chart is the "Geological Time-Chart" which shows the development of animal life through the geological eras. The main purpose of a chart is to make the idea which it represents simple, clear and easily comprehensible. A chart may be used for initiating a discussion or for reviewing. It can also be used for testing the pupils.

The teacher should encourage the pupils to make charts, diagram, poster under his guidance. These should relate to the topic or topics discussed in the class. Charts may be drawn on subjects from any branch of science. It is, however, not feasible for the teachers and the pupils to make all the charts. Important and essential charts must be procured from scientific or commercial firms.

Definition:

It is defined as visual symbol summarizing or comparing or performing other helpful services in explaining subject matter.

Values:

1. It helps in elucidating an argument or statement and in clearing up difficulties of comprehension. For example, the process involved in the manufacture of sugar can be very easily and effectively illustrated with the help of charts and diagrams.
2. It stimulates interest and excites curiosity in things which could otherwise be dull and dry. For example, the electronic structure of atom.
3. It helps to secure better attention and process 'fixing power'. As a result of this, the acts learnt are retained for a much longer time.
4. It cultivates the power of observation and judgment. The preparation of a chart requires critical observation of the actual object and correct judgment for the accurate and truthful representation of the facts.
5. It gives vividness and simplifies the explanation and narration, which could otherwise be too complex and dull for the students to understand.

Using the Charts:

While using charts, the teacher should keep in view the following few points:

1. It should be interesting i.e., it should be according to the interests of the students. Bright colour, simple design and possibility or suggestion of action appeal to children. But care should be taken that the exactness and accuracy of the represented thing is not sacrificed in bringing brightness and simplicity in the chart.
2. It should be simple and comprehensible. The students should understand the purpose of the aid without any explanation or comment. The teacher should guard against crowding of observations. It is no use grouping all the facts in a simple chart. There should be proper spacing and the diagrams drawn should be quite big which can be seen from a distance.
3. It should be subordinate to the point illustrated. The diagram or picture used for elucidating certain points should not become a problem itself for the students.
4. The picture or the diagram should be relevant, accurate, exact and realistic. There should be no exaggeration of the facts.
5. It should be properly exhibited. The place where it is displayed should be well-illuminated and visible to all the students in the class. Sufficient time be given for display.

Important point in making charts:

Like posters, little skill is necessary to make charts. In making charts, the following points, however, should be remembered:

i. Charts like any other pictorial material should be sufficiently large to be seen easily. The producer of charts should be clear about the conditions under which they will be seen. What is the maximum distance from which the charts will be looked at? It is to be studied by all the children of the class, all looking at it or to be seen by a small group.

ii. Charts can tell a story in some detail but should not contain too many words.

iii. They should be strong in some enough to stand rough use.
iv. They should be attractive to look at.
v. As the main point about a chart is that it should be clearly understood by all those who are intended to study it, it should not contain any picture, which is not related at all to their experience.

It is advantageous to use charts because they are easy to use. But they have limitations too. A bad chart can confuse the very idea it represents. Moreover, all ideas cannot be represented on charts. But, even so, the school should provide the pupils with materials necessary for making charts and diagrams within the range of their ability and under the guidance of the science teacher.

MODELS:

Models are additional instructional media and copies of real objects. A model can be an enlargement, a reduction, or the size as the original. It represents a replica of the original, while simplified models do not represent reality in all details.

Some models are solid and show only the outline of the object they portray, while others can be manipulated or operated. Still others, called cut-away, are built in sections and can be taken apart to reveal the internal structure. Whenever possible, the various parts should be labeled or coloured to clarify relationships.

Although a model may not be a realistic copy of an actual piece of equipment, it can be used effectively in explaining operating principles of various types of equipment. They are especially adaptable to small group discussions in which learners can ask questions, is more effective if it works like the original and can be taken apart and reassembled.

Models, though not as effective as objects or specimens, are very useful in teaching certain concepts and principles of science. In fact, models are intended to simplify, thereby making it easier to understand the form and function of the object or thing about which it is difficult to gain direct experience. They are, however, not real things; neither are they true in size or colour. Models are simply replica of a thing or object. They may be larger or smaller than the real thing; may represent the whole or a part of it. Or they may or may not represent the whole or a part of it. Or they may or may not represent the working condition. But, even so, with the use of models, many ideas can be made comprehensible to the pupils, which is not possible with flat pictures.

Many models can be prepared in the school and others procured. Science teachers should use models when it is impossible to obtain the object or a specimen of the thing about which he is giving lessons. Enlarged models of the eye, ear, teeth, animal skeletons, sections of plants and its cells, human skeleton, atoms and molecules, etc., or working models of a steam engine should invariably be used while teaching about them.

Models are substitutes for real things. A model is a three-dimensional representation of a real thing. Models are concrete objects to explain clearly the structure or functions of real things. A model is a replica of the original. Models enable students to have a correct concept of the object. Models are objects that duplicate as accurately as possible the real objects. Sometimes they are smaller versions of the real objects. Some models can be commercially bought for teaching purposes and some can teacher-made. Of all the audiovisual materials, models are nearest to living experiences. Models are replicas of the original thing. They are contrived experiences where reality is altered or simplified for teaching purposes. Working scale models of the original are used where the specific action of the original is duplicated and could be explained easily.

Being three dimensional, models evoke great interest and simplify matters. Models enable us to reduce or enlarge objects to an observable size. It may not be possible or even practicable to make students see the whole of a large industrial unit or even a large machine unit, but a model will give the correct perspective. Preparation of models could form a topic for project work. It is essential to create interest in creative activity in students.

Models are working as well as static. A working model will secure immediate attention and serve as motivation to learn. Model can be prepared with several kinds of materials like cardboard, plastic, plaster of paris, wood, clay, and thermocole etc. Models are the replicas or copies of the real objects. Models are concrete objects, some considerably larger than the real object. Sectional models explain clearly the structure or functions of the original. In some cases working models of the original are used where the specific function of the original is duplicated and could be explained easily.

Following are the important functions of Models:

1. Models simplify reality.
2. Models concretise abstract concepts.
3. Models enable us to reduce or enlarge objects to an observable size.
4. A model provides the correct concept of an industrial unit or a bridge or a dam like, the Bhakra Dam etc.
5. A working model explains the various processes of objects and machines.
6. Preparation of models explains the various processes of objects and machines.

Cardboard, plastic, plastic of paris, wood thermocole and metal, etc., can be used in the preparation of a model.

Three Dimensional Aids:

Three dimensional aids serve as good substitutes for the real objects. There is no doubt that an encounter with real objects serves as an unmatchable source of learning. But on account of several as an unmatchable source of learning. But on account of several reasons it may not be possible to bring the real objects in the classroom. The real objects may be too large to move or store in the classroom. It may be too small to be seen for a group of students. It can be too complicated in real form to be understood. It may be too rapidy for its operations to be understood. Its movements may be too slow to be studied completely. It can be too expensive to be purchased by an educational institution. Being handicapped in such situations a teacher has to search for some good substitute for the real objects.

Kinds of models:

Models are of several different types.

Scale model:

The scale model, for items such as cars etc. is used to show the exterior form and shape of the original.

Working models:

Working models stress on operational part of the actual object show how these essential parts operate. For instance, the working model of a hydraulic brake of an automobile would probably show only the essential moving parts and not all the details of the original.

Sectional type model:

The sectional type model is constructed in such a manner that it can be dismantled to show inner construction or detail. The sectional model is sometimes called the dissectible model since it can be taken apart.

Mock-ups:

A mock-up refers to a specialized model or working replica of the object being depicted. In a mock-up, a certain element of the original reality is emphasized or highlighted to make it more meaningful for the purpose of instruction. While a model is a recognizable imitation of an object (through larger or smaller than the original one), a mock-up may or may not be similar in appearance. Mock-ups of aeroplanes, auto-mobile engines, bridges, ships and tunnels, etc., may be demonstrated for explaining their structure and actual working. Mock-ups are often used in technical institutions for training purposes.

Dioramas:

A diorama is a three dimensional scene in depth incorporating a group of modeled objects and figures in a natural setting. The diorama scene is set up on a small stage with a group of modeled objects kept on the foreground which is blended into a painted realistic background. Dioramas are very effective in the teaching of biological and social sciences.

Source of Three Dimensional Objects:

1. They objects may be borrowed from audio-visual aid centres, libraries and museums etc.
2. They may be purchased from concerned commercial establishments.
3. They may be prepared by the teachers and the students.

Selection and Use of Three Dimensional Objects:

1. Dimensional aids may be selected, keeping in view of the instructional needs and requirements.
2. As far as possible, they should be a true representative of the actual objects.
3. The complexity of the aids should match the level of maturity of the students.
4. The aids should make an appeal to as many of the five senses as possible.
5. As for a possible, aids should be prepared by the students under the proper supervision of teachers.
6. Every possible effort should be prepared by the students under the proper supervision of teacher.
7. Aids should be inexpensive.
8. Aids should be prepared with locally available material as for as possible.
9. Necessary instructions should be given to students to handle aids with care.
10. Necessary clarification may be given by the teacher at the presentation of these objects in the class.
11. Necessary demonstration in the use of these aids should be given to students.
12. Students' comprehension should be properly tested at the end of the use of aids.
13. Adequate storage arrangement should be made for their safe custody.

Advantages:

- ✓ The possibility of having enlarged or reduced scale models helps close examination.
- ✓ Models give a notion of reality.
- ✓ Models can show structural as well as functional aspects of an object as it is in reality, e.g. anatomical details of human model structure of an eye or working of a engine can be well demonstrated by a model.

Disadvantages:

- ✓ Many models are often fragile.

- ✓ They may at times give a wrong conception of size if poorly made.
- ✓ They have a limited audience as it entails close observations.

SPECIMENS/OBJECTS:

Collections such as specimens and objects are very effective teaching aids. Moreover, children have natural love for collecting such materials. These being three dimensional articles, experience of the learners becomes more vivid. Out of these two, objects rank first as these are real.

Specimens:

Specimens rank next to objects. When the teacher talks about flowers in general and represents all flowers by a typical flower, (say, a China-rose) then it is a specimen. But if he teaches about the characteristics of the China-rose itself then it is an object. Similarly, if the teacher is describing rocks and represents all rocks by a piece of quartz or marble then these are specimens. But if he teaches about the properties of quartz or marble itself, then these are objects. A specimen is a sample of a particular type of object or a part of the object.

A science teacher how can you collect specimens:

-asking children to bring samples of interesting things they find locally.

-collecting samples from places visited on holidays or journeys

-exchanging specimens with schools elsewhere.

-watching for manufacturers advertisements which offer free samples.

Objects:

Objects are real things. For example, a flower, a bird or an insect, a toad or a fish, a telescope or a microscope. The pupils should always be encouraged to collect such objects while teaching about them. Objects put the pupils in direct contact with real things. Museum and zoo are important sources where the pupils can come across real things which the school cannot provide.

Hence, a thing may be an object or a specimen depending upon how it is used. The teacher should, in co-operation with his pupils, collect all important specimens, especially the local ones, about which he is to teach in the class and preserve in the science room. This is not a difficult job; the pupils can easily collect local biological specimens. The school should procedure other specimens which the pupils cannot collect. The science teacher should make a list of all the essential specimens, including the rare specimens, which the school should possess. These specimens should be placed in the science room in such a way that the pupils can have a look at them any time they please. If there is no school museum, provision should be made for proper display of all types of objects, specimens and models in the science room. It is essential that the science teacher knows how to prepare various types of preserving solutions.

FILM STRIPS:

According to goods dictionary, "Film Strip" is short length of film containing a number of positives, each different but usually having some continuity, intended to be projected as a series of still pictures by means of film strip project."

A film strip, therefore, is a coherent sequence of still pictures and titles on a strip of 35 mm. film. It generally has 20 to 30 frames of pictures, drawings, or illustrations, and in size, it can be single or double frame.

A film strip is a series of related still photographs on a single role of processed film. Taken together the separate pictures present some process of learning in a step by step fashion. The average number or a film strip is 35, although the number can vary from 10 to 100.

A good film strip ought to stir up discussion, suggest new ideas and create interest in further of the topic. It should serve a precisely defined educational purpose and the teacher should ensure that it will have real value to the class.

A filmstrip is a length of 35mm film containing a series of still pictures intended for projection in sequence on at a time. Just like slides, filmstrips can be prepared for pictures, diagrams, graph, etc But unlike slides, there is sequential movement of filmstrips on a screen.

Filmstrips are projected with the help of a filmstrip projector. Filmstrips can be hooked to tape-recorder to provide the commentary.

The teacher can teach a lesson very effectively by way of stopping and moving different frames in a filmstrip. The teacher can prepare filmstrips by shooting appropriate frames in the film of a camera, and then sequencing them according to the lesson or theme he wants to deal with.

SLIDES / TRANSPARENCIES:

A slide is a film transparency contained in a frame or mount. When pictures, diagrams, specimens, etc. are to be shown to students, they can be mounted on slides and projected on screen by the use of slide projectors or viewer slides are a versatile medium.

They are easy to arrange and rearrange to meet a variety of instructional needs. There are several ways of preparing slides. Diagrams, pictures, graphs, and illustrations can be drawn on a glass slide using ink or by enclosing them between two glass slides (of 120mm) and binding them together.

A micro-specimen can be projected by mounting it on a slide (e.g. blood). These are usually projected, using an epidiascope. An epidiascope is also used to project opaque objects like a page book or a small three-dimensional specimen.

Slides of 35mm can be prepared by photographing objects, pictures, events, landscape, etc., and by getting a dia-positive mode. Another way of improving it is to project photographic negatives, which is much cheaper in comparison to a dia-positive.

Now-a-days, it is possible to use a computer to design and produce photographic slides.

The slides have to be projected in a dark room. Since it is a visual medium, back-ground commentary on the content of slides may be necessary. The teacher can make the commentary while showing the slides or it can be pre-recorded and played on the tape recorder along with the projection. But this has to be synchronized, i.e. visual and comment must match.

INSTRUCTION CARDS:

In some schools, card system is practiced for giving guidance to pupils. A card of about 6″ × 4″ is usually used and is placed besides each experiment. The card should give detailed and adequate information. The main purpose of the experiment should be made clear and definite. But too much information will be harmful for it will cause laziness in the students and habit of depending upon others. On the other hand too little of information will discourage the students. So the teacher should take in view while preparing instructions that they are neither inadequate not superfluous. The card should contain information regarding the following points:

i. The number of experiment
ii. The purpose of experiment
iii. The method to be adopted
iv. Precautions to be observed
v. Method of tabulating the results
vi. Any question that may help in reaching the desired conclusion
vii. Conclusion

Giving Instructions-we can support students' information processing by supplementing auditory information with visual clues. When we can provide students with multi-sensory experiences observing and communicating, it helps all students, especially emerging readers and English language learners. Instructions should be given using a variety of visual or aural support materials:

- drawings, diagrams, and pictures to support the spoken word
- written instructions on word cards or Smart Board along with verbal instructions
- set-up examples to supplement written lab instructions
- audiotaped instructions alongside written directions
- pictures with words in stages of lab procedures that students can sequence

Reading Science Text Card:

Text cards help students interact with words and their meanings. Teachers can create science text cards by writing statements about science concepts on index cards. Working individually or in small groups, students discuss the statements before sorting. A number of different formats can be used:

True/false cards:

These cards include statements drawn from the text. Students sort the cards into true and false piles. For example, when teaching a unit on plants, use statements such as: "Plants use light from the sun in the process of photosynthesis" (true), and "Plants must depend on animals for food" (false).

Agree/disagree cards:

This format works well for more value-laden or controversial topics. One statement (including appropriate vocabulary) is written on each card. Students sort the cards into three categories: "agree," "disagree," or "not sure."

Matching pairs:

Students are given a stack of cards and asked to match a term with its associated function, symbol, scientific name, etc. For example, a stack might include cards with the names of body parts and other cards that name the body parts' functions. Students match each part to its appropriate function. Other topics for matching pairs could include:

- parts of a device and its function (e.g. simple machines)
- types of teeth and their functions for classification of animals
- common name and scientific name
- material and its common use
- technical term, meaning, image
- chemical name and symbol

Sequencing:

For cyclical concepts like the water cycle or the seasons, create one card for each stage in the cycle. Have students arrange the cards in a circular formation to represent the stages of the cycle. Examples include:

- egg, larva, pupa, adult
- spring, summer, fall, winter
- evaporation, condensation, precipitation, accumulation

Classification:

Make a set of index cards naming vertebrates, for example, and another set with characteristics of each group — one characteristic per card:

Vertebrate	Characteristics
Birds	feathers, beaks, lay eggs
Reptiles	scales, cold-blooded, leathery eggs
Amphibians	cold-blooded, life cycles on water/land
Mammals	fur, warm-blooded, mothers provide milk for offspring
Fish	gills, cold-blooded

These cards can be used in two different ways: 1) Pass out one card to each student, and have them find the other students who belong in their group. 2) Mix up the cards and have students work in small groups to sort the characteristics into the appropriate groups. Additional examples for this strategy include:

- simple machines and examples of each
- insect orders and characteristics of each
- ecosystems with plants and animals that live in each

Instructions to pupils:

Before entering the laboratory, it is very important that the objectives of the experiment along with the procedure be clear to the student. Special instructions regarding particular experiment and the precautions to be taken should be given to the students before the class.

Give explicit oral instructions:

Oral instructions targeting the experimental details and theoretical background on all experiments in the cycle should be given. Wherever necessary blackboard may be used.

Refer the laboratory manual:

Every theory textbook has a manual accompanying it. The school library could have several copies to facilitate students referring when necessary, e.g. the NCERT has brought out a textbook in Physics-Standard XII together with an excellent laboratory manual. This ensures that the theory and practical's go hand-in-hand leading to better correlation.

Prepare instruction cards:

The teacher can make postcard size instruction cards on all experiments in the cycle. The card is placed near the relevant experiment. Each card should give details on aim, apparatus, procedure, tabular columns, any required diagrams, and special precautions to be taken. (Table)

Instruction Card-Chemistry:

Acidic Properties of Ammonia Exp. No. 1

Aim: To verify the acidic properties of ammonia

Apparatus: Test tubes, red and blue litmus paper, dilute HCl, ammonia gas etc.

Procedure: Prepare ammonia gas and store it in a gas jar. Use if for the following:

Experiment

Observation

1. *Test the action of ammonia on turmeric paper*
   (Turmeric paper is an absorbing paper which
   Has been soaked in an extract of turmeric)
2. *Test of red litmus paper*
   Pass the ammonia gas over the red litmus paper.
3. *Test of hydrochloric acid*
   Test the gas with a drop of HCl held on a glass rod.
4. *Test of Nessler's reagent*
   Test the gas with a drop of Nessler's reagent held on glass rod.

Conclusion:

***Result*:**

Instruction Card-Physics:

Focal Length of a Convex Lens

Aim: To find the focal length of a convex lens.

Apparatus: Convex lens, light source, screen and metre scale.

Procedure: 1. Keep the lens on the lens stand.

2. Focus it so that you get a clear image of the distant object on the screen. Measure the distance between the screen and the lens. This gives the value of the approximate focal length.

3. Place the source of light, lens and screen on a straight line.
4. Adjust the position of the lens and screen to get a clear image of the wire gauge.
5. Measure the distance (*u*) between the source and the lens.
6. Measure the distance (*v*) between the lens and screen.
7. Repeat the experiment for different values of *u* and *v* and tabulate the readings.
8. Calculate the value of *f*.

***Formula*:** $1/f = 1/u + 1/v$

Result: The focal length of the given convex lens is……cm.

Instruction Card-Biology:

Experiment: To show that carbon dioxide is produced during respiration.

Material Required:

Germinating seeds of pea, gram or bean, conical flask, cork with one hole stand with clamp, delivery tube, lime water, test tube, KOH solution etc.

Theory:

Respiration is the process in which organic food material (glucose) of the cell breaks down into simple substances to liberates energy and carbon dioxide. There are two types of respiration such as.

1. Aerobic respiration:

Oxygen is necessary for the oxidation of food, such as

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy.

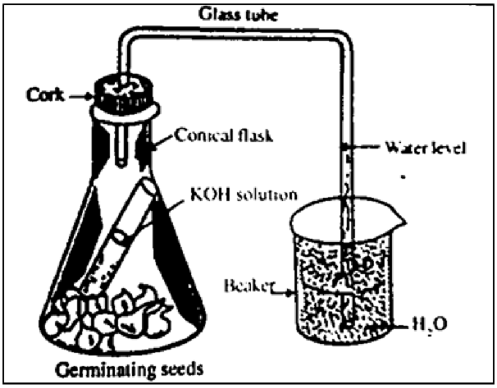
2. Anaerobic respiration:

Respiration takes place in the absence of molecular oxygen. In this respiration the food is incompletely oxidized and much less amount of energy is release and Ethyl alcohol, carbon dioxide are produced, such as

$C_6H_{12}O_6 + 6O_2 \xrightarrow[Zymase]{Yeast} 6CO_2 + 2C_2H_5OH$ + Energy.

Procedure:

Germinate seeds of pea, gram or bean by placing them in moist cotton or blotting paper for 3-4 days put in conical flask and put some KOH solution in a small test tube with the help of a string suspend through the hole of the cork pass a glass tube bent twice at right angles in such a way, that one end of the tube is in the beaker, and the other end in conical flask. Filled with lime water, make the apparatus airtight with wax and keep the apparatus undisturbed for 4-5 hours.



Experiment to show that carbon dioxide is produced during respiration.

Observation:

The lime water in the test tube turns milky.

Inference:

The turning of lime water milky indicate, that the gas produced during respiration is carbon dioxide (CO_2).

Precautions:

1. Apparatus should be airtight.
2. The end of the delivery tube in the flask should not touch the germinating seeds.
3. Other end of delivery tube should completely dip in lime water.
4. The germinating seeds should be kept moist and should not be let dry.
5. Only germinating seeds should be used.

SCIENCE LABORATORY:

Laboratory is a room where a group of students carry out practical work. It is very much essential for the effective teaching of science. It provides an atmosphere of science. Students get an opportunity for self-learning in their room. They are able to conduct experiments which is difficult to undertake in general classrooms.

The most effective way inquiry skills can be learned is through firsthand experiences in a laboratory or field setting. These experiences have been shown to effectively improve long-term comprehension and application of knowledge. Direct laboratory experiences also foster scientific habits of mind and promote the excitement and enjoyment of learning.

Science is a practical subject, teaching of which cannot be done properly only in theory form. For proper education of science, it is necessary to conduct various kinds of experimental works, which are practical in nature.

"These practical functions cannot be carrying out in absence of scientific apparatus and equipment. The place where various kinds of scientific apparatus and equipment are arranged in systematic manner is called science laboratory".

Science laboratory is central to scientific instructions and it forms essential component of science education. It is in this place that various kinds of practical works are carry out by the students. Without proper and well- equipped science laboratory, it is not possible to carry out the science teaching process effectively in any school or educational institution.

Students learn to handle various apparatus and to think independently in the laboratory, because of which it is considered to be one of an important place. When students carry out various kinds of experiments, then they draw conclusions from their studies, which raise their level of self-confidence and develop scientific attitude among them.

These are considered to be main objectives of science teaching, for which it is considered by experts that without a well-equipped and organised scientific laboratory, there cannot be any proper teaching of science. Students should be encouraged by the science teacher to make active parts in various experimental processes, as most of the achievements of modern science are due to the application of experimental methods.

Types of Science Laboratory:

Science Laboratory may be three types,

a) All-science room or general science room,
b) Semi-specialized science room for teaching different areas such as physical science, biological sciences, etc. and
c) Special science rooms for teaching subjects such as physics, chemistry, botany, zoology, etc.,

Organization of Science Laboratory:

Before constructing the laboratory, the following factors should be taken into consideration at the planning stage:

a) The number of pupils working at a time.
b) The minimum space necessary for each pupil for comfortable working.
c) Limitation of number of science teachers in secondary schools.
d) Need for ancillary accommodation for storage.
e) Designing the science classroom and laboratory in such a way that it could be used for science teaching for middle as well as for higher classes.
f) Imperative need for economy.

The following are some of the important points to be remembered for the proper organization of a science laboratory.

Preparation Room:

It is necessary for the assembly of apparatus to be used in a laboratory lecture room. In the preparation room tools, glass tubes and glass rods, are in current use. Nail and screw stripples to terminal, wire solding etc., may be kept which every science teacher can strive to collect.

Storage Room:

Here permanently under lock and key, are kept the materials which are distributed to the rooms as they are required. There is a need for a store outside the main building in which dangerous chemicals, concentrated acids etc., can be kept. A small separate store for chemicals only ensures that the general store is free from fumes, thus reducing the rate of corrosion of materials stored in it.

Lecture Room:

It is usually arranged with a demonstration bench in front of a large black-board. The pupils sit in seats arranged in tiers so that all may look down upon teacher's demonstration bench on which the experiments are performed. Projection apparatus, with a permanent or readily available, screen is normally used by it.

Dark Room:

A "dark room" permanently darkened, but adequately ventilated provided with themselves, a dark room light an electric supply socket is useful for distracting plants. For using special physical instruments, such as spectrometer, for carrying out simple experiments on photometry and for doing any photography which a science club may organise.

Science Room, Arrangement and Fittings:

The size of a laboratory is adequate into the floor area occupied by benches, tables, cup-boards and shelves is added 25 to 30 sq. ft. for each pupil in the class. If the provision of preparation room is inadequate, the size of a laboratory should be proportionately increased.

A preparation room should cover about 200 square ft. store room should be not less than 190 sq. ft., 12 ft. to allow easy access to shelves and rocks. A separate outside store may be smaller. A lecture room is usually not less than 400 sq. ft. in area and may with advantage be more.

A dark room should be not less than 8 feet wide, so that two person can work comfortably side by side at the sink.

Arrangement:

When two laboratories are available for teaching physics, chemistry and biology, it is better to use for physics and biology, preserving the other for chemistry only. The chemistry laboratory should be placed on the side of the school away form the prevailing wind. When the laboratory has to be accompanied with two storey block, the chemistry laboratory usually on the upper floor, but problems of water and gas supply, drainage etc., are greatly simplified when it can be situated on the ground floor only. Preparation room can readily be shared by two laboratories if it is placed between them and each has direct access to it. Doors should be arranged to permit entrance to a preparation room without passage through a laboratory where a class may be at work. The apparatus needed in a lecture room must be brought to it from elsewhere, and the room should therefore be centrally placed with respect to the laboratories and preparation rooms, if it is to be used often enough to justify it's existence.

Windows:

There should be provided along to opposite sides of a laboratory. One set of windows should face the prevailing wind in order to give plenty of ventilation. A laboratory needs shelves, cupboards long bench, a long black-board and wall place for the display of pictures, charts and other diagrams. If the wall space of which there is never too much, as unduly cut up by windows, the arrangement of these fitting becomes one of the increasing difficulty. This is an arrangement which yields light.

Artificial Lighting:

It is more economical and efficient to light a room, for example, by eight hundred watt electronic bulbs rather than four lamps of two hundred watt. For the sake of economy not more than two lights should be controlled by each switch, so that only lights actually necessary are used. On a dull day in the part of the room is adequately light. A separate independent light should be fixed so that the black-boards are illuminated well. Lights should not be hung from flexible wires, but should be fixed in button and holders fastened to wall or ceilings.

Acoustics:

Open windows always provide a partial wire for wire pure acoustics and in hot countries will usually be needed for satisfactory ventilation.

Laboratory Table:

There shall be laboratory table to conduct experiments. The top of this table should one made of teak, shesham or any other hard wood. This table should not have any drawer or cup-board.

Exists:

Each room except the dark room should have two doors. Preferably one at either side and opening outwards so that in case of fires or other emergency those in the room may leave it without danger or confusion. Grave emergencies may never arise but they should be guarded against.

Bulletin Boards:

Most of the material for exhibition on those boards will be fastened temporarily by drawing pins or thumb tacks. The board should therefore, be made of planks of local soft wood, made proofs against anttermites and woodworm by being treated with some repellent and framed in a narrow hard wood surround.

Clock:

If the school can provide a clock for the laboratory it should be one with second hands. There are numerous experiments in which this will prove useful. Without loss of wall space is attained their sills about 5 ft. 6 inches above the floor. All the wall space under such window is clear. There should be no windows within several but of the black-board walls.

Ventilation:

Heat is required in carrying out many experiments. If the rooms are not adequately ventilated by a through drought, the conditions in the topics in a hot day are almost intolerable. Fume chamber and dark room may be ventilated by exhaust fans which draw out the stale and discharge it outside.

Ideally rooms in the tropics should be surrounded by a verandah on all sides but in any case a roof overhanging at not less than 4 ft. as desirable to keep the sun at it's hottest from striking floors and vertical walls. A verandah is also a protection against heavy storms and driving rain.

Water:

Each area has it's own problem regarding the provision of water. Methods that have been found suitable for large houses and boarding establishments can be used for providing water for laboratories and preparation rooms. Whether the source of supply is rain water, well water or a supply maintained by local authority on a storage tank of not less than 100 gallons should be provided.

Space heating:

Their position in a laboratory is of secondary importance in the hot countries.

Heat supplies:

Heating by gas is to be preferred on the grounds of both convenience and economy. Where a local supply of gas is not obtainable, a special petrol gas installation is needed.

Gas Supply:

The following three types of gas-supply arrangement should be made in the laboratory.

i. Coal gas plant.
ii. Petrol-air gas plant.
iii. Kerosine oil gas plant.

Equipment's:

A science laboratory without the required equipment's, is no laboratory. An ideal science laboratory should have the following equipment's as recommended by the all India Seminar.

i. Gallaries Seats.
ii. A demonstration table about 8′ × 4′ with cup-boards gas and water fittings.
iii. A wall-back board.
iv. A white screen for projection.
v. Black curtains for doors and windows and ventilators.
vi. Almirahs.
vii. A wooden box with sand at bottom for waste materials.
viii. Special acid proof drainage system.
ix. Wall shelves for chemicals.
x. A froggery where necessary.

Wild Drainage:

Except for the first down drop from a sink, drains should not be provided with a trap but should need directly into open duets, which in turn empty into open drains, of half round section just below floor level.

The drain should not be covered with wooden boards, flush with floor and early removable for inspection. The ducts leading from skin waste pipe to the drains nearby of local damp resisting wood, fixed with lead, directly into a drain, so much the better.

The drains may be made of glazed earthenware, of half round section or of cement. A fall of not less that 1 in 15 is desirable. Waste water from the science rooms should not run into a static tank, it is not disposed of into it's own stack away pit, fi should run only into a waste system carrying plenty of water, so that it is well cleaned.

Floors:

From the point of view of conform, a coustics and possibilities of breaking glassware, a wooden floor is preferable. Its disadvantages however make it, usually:

a) It is expensive

b) Unless thoroughly it is liable to be attacked by termites books, etc.,

c) On the upper floor, it must be completely waste proved. A current floor must therefore be recommendables for the tropics as it is free from these objections and is more easily swept, washed down and kept in good conditions (wooden blocks proof against damp and termites and laid on a cement base probably make the best floor, but this idea is unattainable in most schools).

Water Taps:

Each sink on the students' branches should be provided with a water tap. The first-aid box should be well furnished with all necessary things like-bandage, cotton wool, forceps, scissors, iodine etc.,

A few words may be said about the supplementary rooms in science, a provision for which affects science teaching.

1) A dark-room in the science room can be used for doing experiments on light. Experiments or demonstrations on diffraction, vacuum tubes or with spectrometer are impossible without a dark-room. Many pupils may be interested in learning photography also. Only a dark-room can help in this case.

2) Some gifted pupils may like to perform experiments in science which are beyond the abilities of the average pupils. They should be helped and encouraged to pursue such individual projects. To help them, the provision for single (small) room is imperative. Such rooms should be well-equipped with provisions to enable them to perform their experiments.
3) In pursuing some biological problems, it often becomes inconvenient to continue in the general science room. For example, growing various types of plants or rearing animals cannot be conveniently done in the science room. In fact, this is impossible in many cases. Special rooms such as a green-house, a school zoo, if provided for this purpose, help better learning in these fields.

Science room for special subjects:

Schools teaching elective subjects in addition to general science have to have separate laboratories for each special subject. In such cases provision should be made for the special needs of that particular subject such as apparatus and arrangements, techniques and procedures peculiar to that field of study. How-ever in spite of its special nature, there should be facilities for demonstrations and experiments of general nature. This arrangement can be appreciated if we remember is unavoidable when the science room is used for teaching two or more fields in combination such as 'general science and biology' or 'physics and chemistry'.

For our Higher Secondary Schools teaching elective science in addition to the compulsory general science, we should have one general science laboratory and one laboratory for each special subject. But in general, the Higher Secondary Schools do not possess general science laboratory and one laboratory for each special subject. But in general, the Higher Secondary Schools do not possess general science laboratories. A detailed discussion on planning and arrangement of special science laboratories in India is available in the report of the Committee on Plan Projects, Government of India (Report on Science Laboratories and Equipment in High Higher Secondary Schools committee on plan projects-1962). For determining the total area of the laboratories, the Committee considered the following factors:

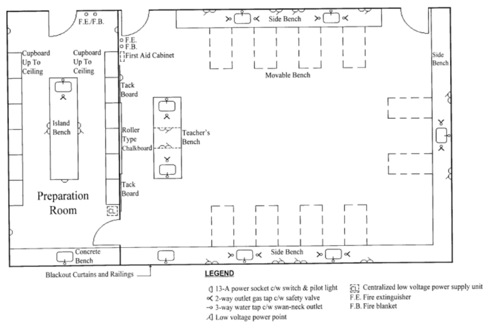
1. The number of pupils working at a time.
2. The minimum space necessary for each pupil for comfortable work, taking into account the subject of study and the prescribed syllabus.
3. The necessity for providing some flexibility in the accommodation to give an opportunity to the teachers to re-group the classes so that demonstration experiments could be carried out conveniently with the participation of the pupils.
4. a. Rooms for storage.
   b. Dark-room for certain experiments.
   c. Balance-room of chemistry laboratory.
   d. Room for gas-plant.
5. Special provision necessary for certain laboratories such as fume cupboards for chemistry, museums for biology, kitchen and wash rooms for home science.
6. The committee suggested the following specifications for different special laboratories:

Physics laboratory:

a. Power point-(220 v. 10 amps) on the side walls, one in the dark-room, one in the demonstration table and one for charging batteries.
b. Plug points-(220 v, 5 amps) two points distributed in the laboratory and four points in the dark-room.
c. Gas supply-one gas-tap on the demonstration table, three two-way gas-taps on the three tables on each side (underneath the tables).
d. Water supply-one tap with a sink on the demonstration table, two taps with sinks for general use (one in the laboratory and one in the store-cum-preparation room).
e. Work-tables-length 6 feet, breadth 3 ½ feet and height 3 feet (for four to work at a time). Physics work-tables need not have drawers or closed cupboards but may have intermediate shelves two feet wide and about one foot above the floor. The work-tables should have plain tops.

There should be stools of two sizes and almirahs or cupboards as necessary.

General Layout Plan of Physics Laboratory



Chemistry laboratory:

a. Power points-(220 v, 10 amps) two for exhaust fans, four points evenly distributed in the laboratory, one point on the demonstration table and one point in the preparation room.

b. Gas supply-two two-way gas-taps for each work table, one two-way tap on the demonstration table, one tap in the preparation room.

c. Water supply-two taps to each work table with a common sink, one tap for demonstration table with sink, one tap for preparation room with sink.

d. Work tables-(for a group of four pupils). Size 6 feet × 3 ½ feet and 2 feet 9 inches high with acid resistant top, with one sink in the middle having two taps and two reagent bottle racks on either side of the sink. The size of the rack should be 2 feet, 8 inches and 1 foot 6 inches high with intermediate tiers.

   There should be a fume-cupboard and a wooden box for waste materials.

Biology Laboratory:

a. Power point (220 v, 5 amps)-one point on the demonstration table.

b. Plug point from light circuit (220 v, 5 amp)-one on demonstration table. Light points-one to each table for microscopic work.

c. Water supply-two taps with sinks at work tables, one tap on the demonstration table with sink, one tap in the preparation room with a sink.

d. Work tables-general work tables of size 6 feet × 3 ½ feet and 2 feet 9 inches high with sinks one at each and (for dissection). Side tables of size 6 ½ ft. × 1 ft. 8 inches and 2 ft. 9 inches high to be placed against the walls and near the windows for microscopic work; and having drawers and small cupboards underneath. There should be sufficient space between cupboards.

There should be small table rack and wall-shelves for keeping chemicals.

The total laboratory space requirement suggested by the Committee for twenty-four pupils is (same for each laboratory, i.e., Physics, Chemistry and Biology) 640 sq. ft. (32′ × 20′) out of which 240 sq. ft. (12′ × 20′) may be used for the purpose of storage, dark room, etc. This is the minimum space that could be suggested for twenty-four pupils working at a time.

The science teacher should maintain the following records:

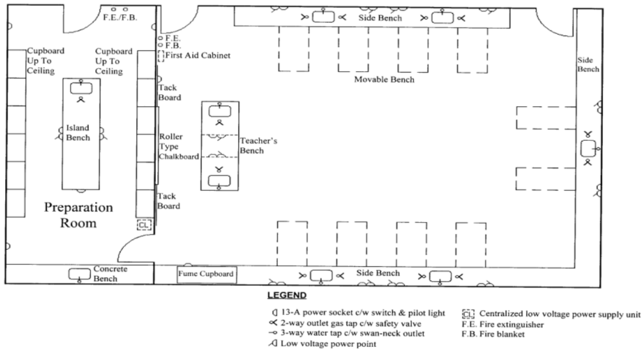
1. Stock register of chemicals:

This register should contain the names of the chemicals and their description. The record should be made in alphabetic order. There should be monthly and, if necessary, weekly checking of the stock register. This will also serve as stock register for consumable articles.

2. Permanent stock register:

This register should list all articles, apparatus, equipment, models and specimens (with description) which are non-breakable or non-consumable and thus permanent in nature. These are usually made of metal or wood or unbreakable hardware. These may also be listed alphabetically with other details such as date of purchase, number of quantity, name of the manufacturer, etc. Any article or equipment out of order should be noted as such in the remarks column.

General Layout Plan of Integrated Science Laboratory



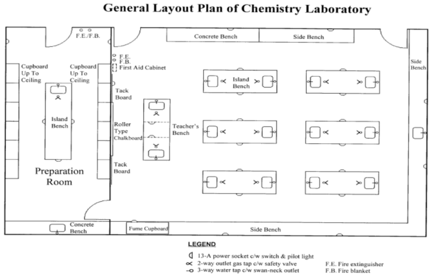
3. Stock register for breakable articles:

This lists all articles made of glass and China-ware such as beakers, troughs, thermometers, and models of other breakable materials.

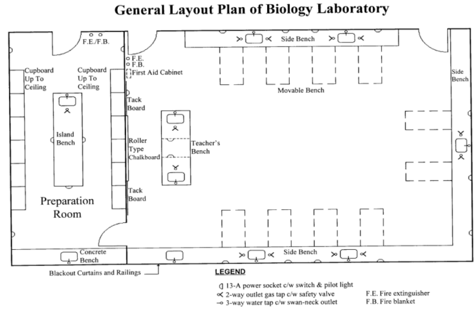
4. Order register:

This register should contain names of all articles, apparatus, equipment, chemicals, specimens, and models which are procured and received for use in the laboratory. The different columns in this register should indicate the date of order, order details, name of the firm, price, number of quantity purchased, date of delivery or receipt, date of payment, voucher details and also remarks about the quality of the materials. It would be useful to have a copy of the voucher attached in this register at its appropriate place. This register may have a section specially reserved for recording articles received gratis or as donation.

General Layout Plan of Chemistry Laboratory



General Layout Plan of Biology Laboratory



The science wing may also maintain a 'Requirement Register' to note down any new item that might be required for doing practical work in science. This register will come handy when time comes to place orders for purchase of equipment for the laboratory.

Importance of Laboratory in Science Education:

- Engage students in open-ended investigative processes, using scientific problem solving
- Provide application of information students have heard and seen in lecture, thereby reinforcing and clarifying scientific principles and concepts
- Involve multiple senses in three-dimensional rather than two-dimensional learning experiences important for greater retention of concepts and for accommodation of different learning styles
- Stimulate students to understand the nature of science including its unpredictability and complexity
- Provide opportunities to engage in collaborative work and to model scientific attitudes and behavior
- Develop mastery of techniques and skills needed for potential science, engineering, and technology majors
- Ensure science course transferability to four-year schools as well as to graduate and professional schools within the outside of Virginia

Student Safety Rules in Science Classroom:

Introduce safe practices and help your students understand why and how these practices are used. You may either set the rules or have students help you develop science safety rules. Either way, make sure students understand these rules and why they are necessary. You may choose to have students create posters for display in the room throughout the year to emphasize safety and remind students of the specific safety rules. Review the following safety rules with your students before beginning an activity.

• Always get your teacher's approval before conducting a science activity and be sure to have your teacher supervise whenever you conduct a science activity. Never experiment on your own.
• Always wear safety goggles when your teacher tells you to do so. Do not remove your goggles until your teacher says that it is OK.
• If instructed to do so, wear an apron or smock to protect your clothing.
• Read and follow all warning labels on substances being used.
• Be sure your teacher is aware of any allergies you may have.
• Carefully follow all instructions when conducting a science activity. Be sure to use substances exactly as described in the activity.
• Keep all materials used in the science activity away from your mouth, nose, and eyes. Do not place your hands on your face when conducting or cleaning after an activity.
• Never taste anything during a science activity. If an investigation involves tasting, it will be done in the cafeteria.
• Tie back long hair, and secure loose clothing and dangling jewelry.
• Know the location of all safety equipment, such as the goggle cabinet, fire blanket, first-aid kit, and so forth, in or near your classroom.
• Safety equipment must remain in good working condition. Do not play with it.
• Tell your teacher immediately if an injury, spill, or other accident occurs.
• Clean up your work area after conducting a science activity.
• Wash your hands with soap and water after completing a science activity.

Even very young students must follow safety rules and have a sense of whether or not a behavior will be safe. Make it clear that students who do not follow these rules will lose the privilege of taking part in fun, hands-on activities. For the safety of all, misbehaving students must be removed from the area where hands-on activities are being conducted.

As students continue to learn about the importance of science safety throughout their elementary school years, they will transfer these skills beyond the science classroom to other classes, to the science lab in middle and high school, and to life in general.

IMPROVISATION IN TEACHING:

Improvisation is the ability to take existing pieces and put them together in a new combination for a purpose. The pieces could be bits of information about a problem or they could be parts of a melody. Teachers or students apply tools or methods to these pieces in a very flexible manner.

Necessity is the mother of invention; new emerging needs of science teaching, therefore, call for improvisation.

- Unesco Source Book of Science Teaching

Meaning of Improvisation:

Improvisation means the act of creating something or using something in the absence of the ideal tools. According to Webster's dictionary (2004) improvisation is to provide, select or make substitute for something not available to use as the basis of free invention. Various authors have defined the concept 'improvisation' in different ways. Ogunbiyi, Okebukola and Fafunwa (1990) defines it as the act of substituting for the real thing that is not available. Bajah (1991) takes it to be the use of substitute equipment where the real one is not available. Kamoru and Umeano (2006) further define it as the act of using materials obtainable from the local environment or designed by the teacher or with the help of local personnel to enhance instruction. According to Ihiegbulem (2007), it is the act of substituting for the standard equipment or instructional materials not available, with locally made equipment or instructional materials from readily available natural resources. National Teacher Institute in Omachi (2000) defines improvisation as the act of using alternative materials and resources due to lack or insufficient hand teaching ads to facilitate instruction from these opinions, improvisation entails the production of equipment using available local and cheaper resources and the use of such equipment for effective teaching.

Importance of Improvisation:

Improvisation serves the following purposes in the education system:

• Reduces the money spent on the purchase of equipment in educational institutions;

• Ensures the realization of lesson objectives;

• Helps in solving the problem of lack of equipment in educational institutions;

• Gives room for a teacher to demonstrate his creative skills;

• Gives room for the use of cheap local materials as alternatives to the expensive foreign ones;

• Encourages students towards the development of creative abilities;

• Strengthen enquiry, discovery and investigative method in sciences

• It provides a frame of reference on which students can key their attention during Classroom activities.

• Enables teacher to think of cheaper, better and faster methods of making teaching learning process easier for students;

• Affords students the opportunity of becoming familiar with resources in their environment.

Without a gainsaying, experimental work in sciences always create a lasting picture in the memory of students, and discourage memorization of laws and theories. Concrete experiments help students see how the scientific concepts work in reality, particularly the kinesthetic learners will benefit from performing the experiment themselves Owolabi (2003) suggested that students should be given opportunity to discover and invent things; hence the teachers should allow the students to acquire skills that will make them learn on their own.. It must be noted that learners achieved more when they are allowed to manipulate apparatus rather than mere listen or observe teachers' idea.

If improvisation is important in teaching and learning, what are the conditions that can be set up to promote this in lectures. How can we use improvisation in our own teaching and how can we get students to improvise in order to solve problems and answer novel questions?

Science courses I usually use some variation on the following class schedule;

1. Presentation of new concepts and associations to previous concepts, sets the context
2. An assignment that has the students find examples of those concepts in use from the media or literature

3. Lecture period with examples, problem solving and discussion
4. application assignment where students use the concepts and approaches to address a novel question

In step 3, I use new examples that come from other sources than their textbook or work with examples that were provided from step 2 in the media assignment to demonstrate how to use the material we have learned to solve problems. Step 3 is the key step in these lectures, it is where students move from just memorizing the facts and example problems to being able to solve broader problems. This step requires me to improvise, take a given set of rules and apply them to given problems. I think this step works better when I have a good idea of the structure of the information that I want the students to construct and also an idea of the different structures that the students might be harboring.

Step 3, the examples and discussion, can be viewed as a conversation with the students. This can take the form of a teacher initiated question, student response and the evaluation (IRE). Classroom discourse can be described as building from these simple elements and having an overall set of concepts that are being addressed. In the analysis of classroom discourse there were some cases that couldn't be categorized and broke all the rules, from this come to the "recognition of improvisation as a necessary part of teaching competence."

Student improvisation:

The other side of the story is the importance of understanding how student improvise. Perkins defines understanding as a very active concept where students have to act on their new knowledge in a flexible way. This requires putting new components together in novel ways, improvising for solutions. The value of understanding the structure of the information in this case is that the teacher should make sure that the students have all of the individual skills and competencies and then provide situations for the students to practice and perform their abilities to solve problems. Solving problems requires the students to improvise. Viewing the students' task as improvisation povides the insight that faculty should construct the problems as themes that are ammenable, even inviting, to improvisize on. Just as in music, certain melodies are good substrates for improvisation, the structure of the problems posed to students might need to be constructed to contain elements. In jazz, one of the structures that provides this is that the melody contains notes that are in a chord progression.

The Improvisation is designed for students to:

• build trust,

• foster teamwork and better brainstorming,

• improve communication and presentation skills,

• promote creative problem solving,

• respond quickly and decisively to unanticipated challenges,

• think on their feet and recognize opportunities as they arise,

• increase their comfort level with change and willingness to take risks, and

• manage change and promote a supportive, improvisational corporate culture.

Why Use Improvisation in the Classroom?

Improvisational performance is typically viewed as an alternative to scripted theatre, but over time it has also taken on a variety of creative genres, including storytelling, pantomime, music, poetry, and comedy.

There are four major instructional reasons for using improvisation in the classroom:

(1) It is consistent with the characteristics of the current generation of students, also known as the Net Generation, which has grown up with the technology—especially their desire to learn by inductive discovery, experientially, their need for social interaction and collaboration, their emotional openness, and their limited attention span.

(2) It taps into students' multiple and emotional intelligences, particularly verbal/linguistic, visual/spatial, bodily/kinesthetic, interpersonal, and intrapersonal.

(3) It fosters collaborative learning by helping to build trust, respect, and team spirit as well as listening, verbal and nonverbal communication, ad-libbing, role-playing, risk-taking, and storytelling skills; and

(4) It promotes deep learning through the active engagement with new ideas, concepts, or problems; linking the activities or tasks to prior learning; applying the content to real-life applications; and evaluating the logic and evidence presented.

Applications of Improvisation:

Improvisation involves students creating a physical reality through individual action and emotion while, at the same time, developing a shared vision with the other students. Spolin (1999) stated that the goal of improvisation is to "solve a problem." The power of improvisation lies in being in the moment at all times. A major concept is that the point of concentration requires close attention to the problem rather than to the individuals who are addressing the problem. For example, in a volleyball game, all players concentrate on the ball; each individual player, as a member of the team, must focus on the ball and act in collaboration with their teammates.

There are more than 200 improvisational games or activities described in the theatre literature. Some are more appropriate than others as instructional strategies in the college classroom. This section provides a sample of four generic improvisation activities that are easily adaptable to most subject matter content: "One Word at a Time/One Sentence at a Time," "Speech Tag," "Freeze Tag," and "Gibberish Expert Interview." These activities are based on classical improvisational exercises.

The purposes of the four activities are described first. Then each activity is demonstrated as it was applied to different content topics taught in an advanced undergraduate course, "Mental Health and Stress Management".

Purposes of Improvisational Activities:

Any one of the activities may be used as a warm-up or energy builder. More important, however, as a teaching tool, the activities can be used to review, apply, synthesize, or evaluate any content to facilitate learning. They are particularly effective with problem-based material, as in problem-based learning (PBL). Students experience team identity by creating a unique story and/or unique answers, as each successive student volunteer contributes without hesitation. Students learn to listen to one another at all times and let go of the need to figure out the ending or direct the outcome. Each exercise can serve as a warm-up for students so they may to begin to trust one another and practice the acceptance of unexpected ideas and information without objection, ridicule, and intimidation. It can also increase listening awareness as well as enhance creative and critical thinking through the debriefing Q&A at the end. The examples that follow indicate the types of questions that can be used to tap deep learning of the content.

These four improvisation activities involve total engagement, visual-spatial skills, physical interaction, verbal exchange, and buckets of fun. They draw especially on the students' verbal/linguistic, visual/spatial, bodily/ kinesthetic, and interpersonal intelligences.

Improvisation Activities: Four Examples:

What follows are actual examples of what students said and did when these four exercises were used in the course "Mental Health and Stress Management" at Towson University. Depending on the subject taught, the students, and other variables, results will vary. The first two activities, "One Word at a Time/One Sentence at a Time" and "Speech Tag," seem the least risky to students on first exposure, and the last two, "Freeze Tag" and "Gibberish Expert Interview," require slightly more risk.

Problems of Improvisation:

Improvisation help in forcing students to think critically about the scientific concepts, yet there are many obstacles associated with the use of improvised materials. Balogun (1982) explained the two militating factors of improvisation as technical and human factors.Low degree of accuracy and precision affects some improvised materials are termed as "technical factor". While the human factors problems are attributed to skillfulness, creativity and competence Accuracy and precision play a prominent role in science experiment, otherwise much error recorded during practical work will render the findings impotent, useless and unacceptable .Owolabi (1999) identified some common errors that can affect the accuracy in science practical results as, Environmental, Instrumental, Personal and Experimental errors. Technical factors are problems associated with instrumental errors which result from inevitable errors during the manufacturing process. The problem of inconsistency in measurement will resulted to low level of reliability of the instrument .Iwuzor (2000) posited that the problem is more crucial at the secondary school levels and tertiary institutions where more sensitive experiments and observations are carried out. Personal errors can also lead to low degree of accuracy. Scientists referred to this as human factor. These are problems associated with teachers' professional competency, creative ability and commitment. Once the teachers begin to understand the principle behind improvisation, they can begin to improvise their own tools, though a lot of teachers lack confidence in their ability to design their own experiments.

Improvisational techniques have been in the business and management training domain. Despite the documented effectiveness of the techniques in this domain, their potential for application to virtually all other disciplines has not been realized. The next step is to conduct research on those activities in all fields to justify the contributions improvisation can make to learner-centered teaching. A scale to evaluate the effectiveness of various improvisational exercises to facilitate data-gathering in any classroom application is provided in Appendix A. We strongly encourage faculty not only to test out these activities with their students, but also to collect evidence of their instructional efficacy.

We hope that improvisation will gain popularity as a form of collaborative learning among those faculty already employing cooperative-learning exercises as well as newcomers to these activities who want to break out of their teaching mold. Improvisation is another versatile tool to put in our teaching tool belts that the Net Geners will love and Tim "The Toolman" Taylor will applaud.

SCIENCE KITS:

"*A portable box containing a number of useful scientific tools and equipment's to enable the teacher to teach effectively is called a Science Kit****"***

Science kits could also mean organization, planning and selection of the materials and equipment's' into different sections. In a small box along with stencils. In the science kit, cut stencils are placed in a manner to hold and arrange different apparatus according to the requirement of the experiments. The central science workshop of the NCERT has produced low-cost science kits for the schools. These kits can be used as mini laboratories. A teacher can take the science kit from one classroom to another students can repeat the experiments at home.

In addition to science kits the Department of Science Education has also produced the following of teacher training films:

Science is Doing
Science Side
Primary Science Kit
Teaching Elementary Physics
Physics Kit I, II and III
Know Your Biology Kit
Tools and Techniques of Biological Cell Study
Chemistry Kit

Characteristics of a Good science kit:

- ✓ It does away with the need of a large laboratory.
- ✓ It contains full sets of materials required for different experiments.
- ✓ Its contents are arranged systematically.

Contents of science kits:

- ✓ The science kit may be a small box made up of wood, iron or aluminium.
- ✓ Gas jars could be replaced by small test tubes.
- ✓ Wide-mouthed bottles can be used in place of woulfe bottles.
- ✓ Wires in the science kits are multi-purpose as they could be used to build funnels, test tubes etc.
- ✓ Small bottles (injection bottles) would hold different chemical.
- ✓ Apparatus are placed in such a fashion that they would not collide with each other while being carried.
- ✓ Chemicals are also placed similarly so that they do not spill over.

Types of science kits employed at different levels:

Science kits are broadly classified into two types:

i. Demonstration kit.

ii. Student's kit.

NCERT has developed different kits to be used at different levels of school, mentioned below,

Primary school science kits:

- ✓ These kits provide basic facilities regarding experimentation and are mainly used for demonstrations.
- ✓ They contain general items, consumables, chemicals, charts and tables.
- ✓ They are meant for class III, IV and V.

Middle school science kits:

There are a total of six school science kits meant for class VI, VII and VIII as follows:

i. Three demonstration kits: They are more advanced than primary level kits and are different according to the branches of science as physics, chemistry and biology.

ii. Three students' kits: They are meant for experiments to be carried out by pupils.

High school science kits:

These are meant for IX and X.

i. Demonstration kit: It is the most advanced type of kit meant for demonstrating important experiments covered within the curriculum.

ii. Pupil's working kits: Students can take these kits home and do their experiments with the help of apparatus and materials provided in these kits.

Importance of Science kits:

Portable and cheap:

Science kits, due to their small size, can be carried away easily and occupy less space. These are useful for both demonstrations as well as experimentation home-made apparatus and materials could also be used in these kits.

Help in understanding the concepts of science in a lucid manner:

Science kits provide good knowledge to the students as they do their experiments practically on their own. During a demonstration, the teacher draws diagrams regarding the experiments with the help of stencils provided in the kit. This helps the students to understand the concept clearly. There is also lesser chance of breakage of materials so the student can handle these apparatus with ease.

Serve as improvised mini mobile laboratory:

For schools which canner affords to maintain of separate big laboratories, such science kits could serve as mini laboratories. Students can fold the apparatus and use them for experimentation. Working table are not required as the kit box itself could work as tables. Apparatus and materials contained in the tool box substitute for the real apparatus and materials of a well established laboratory. Different subject kits could be prepared with the help of the teacher and brought to the classrooms for demonstrations and experimentations.

Provide opportunity for doing practical work:

Practical sessions invoke the interest of the students in the subject.

Help to develop scientific thinking among the students:

When pupils work with their science kits, they get the opportunity to think, reason out, observe and conclude the experiments on their own. Such an opportunity helps them to develop an understanding of different methods to study science such as observation, problem-solving, experimentation and investigation. Thus, science kits help in understanding the process of science.

Help in stimulating the inherent scientific interest:

The kits help in relating the theory learnt in the classrooms with the practical. It help familiarize with the basic understanding the process of science, concepts and methods of science.

Help in consuming less energy, time and resources:

As the kits are small, the apparatus and instruments are arranged systematically and can be brought to the classroom more easily. There is no likelihood of breakage and the experiments require less time and resources.

Requirement of science kits:

- ✓ According to the recommendations of the Kothari commission (1964 - 66) and other committees, the disciplinary approach is now adopted at the middle stage in place of general science and with the introduction of improved curriculum and advancement in science and technology, apparatus, which is more effective than complicated technical devices has now been developed. They have in effect replaced the conventional laboratories.

- ✓ The introduction of science as a compulsory subject in primary schools posed a serious challenge for teaching science and to face this challenge science kits came into picture.
- ✓ The interest of poorly motivated student may be kindled when he is given the opportunity to work with a science kit that meets his needs and abilities.
- ✓ The science kit box contains all the things, required by a science teacher for general experiments, like scissors, strings, pins, bands, pencils, candles, blades, balloons, thread, measuring tape, matches, cello tape, nails, etc.

V. PLANNING FOR INSTRUCTION:

In the words of Nathan S. Washton, "The artistry of teaching is dependent on how skillfully the teacher blends several of the methods into a unified teaching lesson. The nature of the lesson, the personality and goals of the teacher, the climate of the class, and the interest and needs of the students will determine the ultimate selection and utilization of appropriate teaching methods in science."

This clearly indicate that good teaching includes the proper selection of content, formulation of objectives, organizing learning activities, based on careful planning. The last factor namely, careful planning is very important for the new entrant in the profession of teaching, which will build confidence in him.

Intelligent and wise planning of every lesson in advance and visualizing the entire teaching-learning situation in the classroom are the keys to success. A good lawyer spends several hours in preparing his case before he enters the court-room. A good surgeon checks all relevant data before performing an operation. Likewise, a good teacher should plan carefully class-room activities in order that she can reach her educational goals directly and efficiently.

A plan is a blue print which helps in the efficient, economical and smooth conduct of any activity. To plan is to act with a purpose. The major concern of the teacher in imparting a lesson is disseminating knowledge with a view to help pupils comprehend and discover knowledge and develop insight and skills. Good teaching results when overall planning is prefaced with powerful motivational factors, flexible approach for improvisation and inspiration and efficient execution of the plan.

There are major phases in planning lessons. They are:

i. Plan for the whole course for the year or semester. This determines the general objectives, specific objectives and the courses to be taught.

ii. Plan each major block or unit leading to the organization of the selected courses into meaningful segments of activity and experience; and

iii. Plan for the daily lessons.

Planning lessons is a continuous process. It begins with the goals to be achieved, with consideration for the time block allowed. It moves through as a creatively conceived means of achieving the goals, and ends with valid plans for evaluating the efforts of both the teacher and the pupils. Each teacher establishes her own objectives with due consideration for the goals which are generally recognized as is significant.

UNIT PLAN:

What is a Unit?

A unit was considered to be a block of subject-matter but the present concept of a unit includes the procedure of presentation of the subject-matter also. i.e., it is both a block of content as well as method.

Definition of Unit:

"A unit is as large a block of related subject-matter as can be over-viewed by the learner." – Preston.

A unit plan is developed by the teacher and serves as a long-range plan. It contains multiple lessons that are related. Unit plans are utilized to break the annual plan down into manageable units, based upon the needs, interests and ability of the students. Unit goals clearly state a tentative timeline for achieving those goals. Evaluation procedures are established as a part of the unit plan so that both student and teacher will be fully informed about the expectations for the class.

Characteristics of a Good Unit:

The aim should be clear and well defined.

It should cater to the needs, capabilities and interests of the students.

A good unit should provide suitable activities for students.

A good unit should be flexible enough to provide for individual differences.

A unit should have meaningful segments of well organized subject matter.

It should provide for project work, excursions, film viewing and the like.

A unit should not be too lengthy or too short.

The length of the unit should be such as to retain the interest of the students.

A good unit should be such as to retain the interest of the students till the end.

It should be part of a sequence that permits growth from year to year.

Steps Involved in Developing a Teaching Unit:

A teaching unit is developed in almost the same way as by the Herbartian steps. It consists of:

i. Preparation or motivation:

The pupils establish the purpose and are motivated to achieve it. The motivation should not be forced from outside by the teacher but should be natural and self-directed. They should also overview the unit and find out the scope of the material. Motivation is not only required in the beginning but throughout the lesson.

ii. Knowing the previous experiences:

"Start with the pupils where they are" is the modern slogan in education. It is essential to know about the background of the students so that neither there is duplication of what they already have nor any danger of having anything in the unit which is above the comprehension of the students. The background can be found out by questioning or by preparing an inventory.

iii. Presentation:

In this step some new experiences are given to the students. These experiences may be direct or vicarious though efforts should be made to provide opportunities for direct experiences. Care should be taken that only that much amount of new experience is given to the students as they easily digest and assimilate.

iv. Organisation of learning:

The students should get opportunities to bring their learning together so that they may establish relationships between the new experiences and assimilate them. This organisation may be written or verbal.

v. Summarization:

This is usually required at the close of the teaching unit to bring together all the learning. This may also be done at intervals during the progress of the unit. Organisation and summarization go together.

vi. Review and drill:

During the progress of the teaching unit there is every likelihood that some part of it is forgotten and some has not been completely comprehended. For this review or reteaching or just revision of the new experience taught during presentation is required. Some learning experiences require repetition or repeated review which is called "drill". Review and drill may also be required at a number or places during the lesson.

vii. Evaluaiton:

This is required to know what the students have achieved and what they have failed to achieve. Evaluation should be mainly self evaluation. This may be in the form of oral or written tests after short intervals say after a week or fortnight or may be in the form of performance tests, interviews, self-check test, puzzles, etc. The final test at the unit is given to give grades to the pupils and also to evaluate the effectiveness of teaching.

The following performa can be used for developing Teaching Unit.

Performa for Teaching Unit "A"

Subject ....

Class.........................

Name of the Unit..................

Major Objectives of the Unit

S.No	Concepts (Topics)	Number of Lesson required	Time required (periods)	Scope of Subject Content	Procedure to be adopted (indicate the method of teaching)	Teaching Aids
1. 2. 3. 4.						

Content Analysis or Determination of Teaching Points

The points which are to be emphasized from the curriculum are known as 'teaching point' or 'testing points'. In order to fix these teaching points the teacher carefully analyses the contents and curriculum. The main facts and thought regarding the topic should be very precise.

The selection of the teaching points should be done very carefully. After going through the curriculum the total number of the teaching points can be known. With the help of these teaching points the teacher can achieve the fixed objectives for his students. Based on the number of the teaching points and the objectives, the time to be devoted for each teaching point is determined. On the basis of these teaching points the science teacher makes his teaching more competent and thus learning becomes efficient.

The determination of teaching points is necessary for the following reasons:

1. For selecting important points of curriculum and education process.
2. For obtaining objectives of teaching easily.
3. For providing weightage and distribution of marks in examination.
4. For providing definite and clear shape to the process of education.
5. For maintaining curricular or content validity of examination.
6. For giving importance to planning of teaching.

Method of determining teaching points:

After dividing the course curriculum into major concepts or topics according to Performa 'A' each concept is further divided into sub concepts or teaching points according to Performa 'B'.

The teaching points should be determined by first deciding on the objectives to be achieved. These objectives should be defined in terms of behavioral outcomes under different domains.

Stating objectives in behaviour terms:

For stating objectives in 'Behavioural terms' some keywords are used. Cognitive domain consists and evaluation. Behavioural terms for each category are listed below:

(i). Knowledge:

Define, describe, identify, list, match, name, outline, reproduce, select, state, etc.

(ii). Comprehension (Understanding):

Explain, convert, extend, generalize, give example, infer, paraphrase, predict, rewrite, summarise etc.

(iii). Application:

Compute, change, demonstrate, discover, manipulate, modify, operate, predict, prepare, relate, show, solve, use etc.

(iv). Analysis:

Differentiate, discriminate, distinguish, identify, illustrate, infer, point out, outline, relate select, subdivide, separate etc.

(v). Synthesis:

Compose, categorize, combine, compile, compose, create, devise, design, explain, generate, modify, plan, rearrange, organize, revise, rewrite, write, tell summarise etc.

(vi). Evaluation:

Compare, appraise, conclude, contrast, describe, discriminate, explain, justify, interpret, relate, summarise, suppose etc.

Performa for Developing Teaching Points 'B'

Concepts: (Forma proforma 'A')……………………

Lesson No.:……………………………………………

S.No	*Sub-concepts or Teaching Points*	*Behavioural Objectives*	*Procedure (Teaching-pupil activity)*	*Pupils' Assignment*	*Evaluation*
1. 2. 3. 4.					

Subject: BIOLOGY

Class: X

Name of the Unit: Reproduction in Plants

Major objectives of the unit:

(i) The pupils understand and appreciate the sexual and the vegetative modes of reproduction in plants.

(ii) Develop the skills of observation, experimentation (artificial ways of vegetative propagation – cutting, layering and grafting) and model-making.

(iii) Develop interest in nature.

(iv) Develop investigatory approach of doing things.

Concepts	No. of Lessons	Time Required	Scope of Content	Teaching Aids
1	2	3	4	5
1. Pollination is the first step in sexual reproduction	One	40-45 minutes (one period)	Unisexual and bi-sexual flowers; different seasonal flowering plants; pollination, its process; types and factors responsible.	Fresh or preserved specimens of unisexual and bi-sexual flower; chart showing different seasonal plants; chart showing self and cross-pollination.
2. Pollination takes place through a number of ways.	One	Two periods	Agencies of pollination wind and insects; characteristics of flowers pollinated by	Chart or film (if available) showing pollination by wind and insects; specimens of

			wind and insects. Mechanics of insect pollination in Salvia; artificial pollination.	Salvia flower; mounted needles; forceps; brushes; watch-glasses; cellophane bags.
3. Fertilization is caused by the fusion of male nucleus with the egg cell.	One	One period	Structure of pollen grain and its germination on the stigma; structure of ovule; process of fertilization; double fertilization; after effects of fertilization.	Pollen grains, sugar solution; chart showing the structure of ovule and path of pollen tube inside the style; fruits of orange, mango, wheat, rice etc.
4. Besides reproducing sexually plants reproduce vegetatively also.	One	One period	Concept of vegetative reproduction; vegetative reproduction in stems and leaves; advantages of vegetative reproduction; over sexual reproduction; vegetative	Different underground stems-Asparagus, Dalhia, Bryophyllum leaves etc.; slides and charts of different modes of reproduction in lower plants such as

			and asexual reproduction in lower plants-fission, budding, fragmentation and spore formation.	budding in yeast, multicellular fragmentation in Riccia, Spirogyra; spore formation in Mucor, Puccinia, etc.
5. Vegetative reproduction in plants.	One	Three periods	Artificial ways and vegetative propagation-cutting, layering and grafting; their demonstration and practice by the pupils.	Various specimens and implements to demonstrate cutting, layering and grafting; chart showing these ways of propagation.

[According to Proforms 'B']

Unit: Reproduction in Plants

Class X

Lesson No.1

Concept: Pollination is the first step in sexual reproduction.

Sub-concepts Teaching points	Objectives	Procedure (Teacher-pupil Activity)	Pupil's Assignments	Evaluation
1	2	3	4	5
1. Flowers are staminate, pistillate and bi-sexual.	The pupils: - develop skills of collecting and preserving plants. - develop observational skills. – can differentiate unisexual and bisexual flowers.	Clarify the concepts of staminate, pistillate and bi-sexual flowers by inductive approach and with the help of charts. (Distribute the uni-sexual and bi-sexual flowers to the students, ask them to observe and differentiate the different flowers.	Collect flowers from locality, classify them into staminate, pistilate and bi-sexual flowers. Preserve them in your album.	1. What do you understand by i. Staminate flower ii. Pistillate flower iii. Bi-sexual flower.

		From this develop the concept of staminate, pistillate and bi-sexual flower.)		
2. Plants flower at different seasons.	-Investigate the flowering season of different plants in the locality. -Can list the plant in their order of flowering season.	With the help of questioning and discussion, clarify the concept that some plants like Chinarose flower throughout the year whereas some flower during summer, winter, spring. Show actual specimens and charts of different seasonal flowering	Prepare herbarium of different flowers and arrange them in order of their flowering seasons.	2. What are the conditions essential for i. Self-Pollination. ii. Cross-pollination

		plants.		
3. Pollination is essential for sexual reproduction.	-Explain the process of pollination. -Differentiate between cross and self-pollination. -Identify the conditions essential for self and cross pollination. -Understand the importance of pollination for sexual reproduction	Recapitulate the parts of flower and emphasise the functions fo stamens and carpel. Explain the concept of pollination and derive the definition from the students. Explain self and cross-pollination and the factors essential for self and cross-pollination.	Prepare a list of flowers which are self and cross pollinated.	

Lesson No. 2

Concept: Pollination takes place through a number of ways.

Sub-concepts	Behavioural Objectives	Procedure (Teacher-pupil Activity)	Pupil's Assignments	Evaluation
1	2	3	4	5
1. Pollination takes place through natural agencies like insects, air and water.	The pupils -Develop the ability to find out characters in differentiating flowers. -Establish relationship between the characteristics of flowers and the ways of agencies of pollination.	Discuss the possible ways of pollination. Distribute the flowers of rose, jasmine, etc. and ask the student to observe the special distinguishing characteristics of each. Now distribute inflorescence of wheat, maize or grass. Ask the students to find the distinguishing character in the flowers of rose and	Prepare list of flowers which are pollinated by wind and insects and compare their characters. Prepare a model showing pollination in Salvia.	1. What are the characteristics of flowers which are pollinated by (i) Wind (ii) Insects (iii) Water

		wheat. Derive from the pupils the characters essential for wind pollination and insect pollination. Insect pollinated flowers; sweet smell, attractive appearance, nectar etc. Wind pollinated flower: abundant pollens, long feathery stigma, light or winged pollens, flowers small, gathered in clusters and inflorescence stands high above the leaves. Explain how the insects		

		carry pollens from the flower to another. Also draw the attention of the pupils towards the fact that flowers which open at night have white flowers and sweet smell and which open at day time have bright colours. Why?		
2. There is special mechanism for pollination in certain flowers such as Salvia.	-Explain the mechanism of pollination in plants like Salvia. -Develop skill of devising simple models.	Demonstrate the special mechanism for insect pollination in Salvia with the help of model and chart.		2. What are the special features of pollination in Salvia.
3. Pollination can be	-Develop the skill of artificial	Demonstration of artificial	Do artificial pollination	3. Evaluate the model prepared by

done artificially.	pollination. - Understand the importance of artificial pollination.	pollination. Select the flowers having ripe pollen grains and collect the pollens in a patridish with the help of a brush. Select a flower but whose pollen grains are not ripe and remove its stamens with the forceps. Touch the stigma of this flower with the brush containing pollen grains of the first flower. Cover it with a Cellophane bag so that the pollens of other flowers do not fall on it.	in the school garden or at home and record your observation.	the students. 4. Observe and evaluate the students while doing artificial pollination. Do artificial pollination in the school garden or at home and record your observations. 5. What is the importance of artificial pollination?

		Attach a paperflag with details written on it. Ask the students to observe the changes regularly and record them on their notebooks. Explain that many new varieties of plants are evolved in this way.		

Lesson No. 3

Concepts: Fertilization is caused by the fusion of male nucleus with the egg-cell.

Sub-concepts	Behavioural Objectives	Procedure (Teacher-pupil Activity)	Pupil's Assignments	Evaluation
1	2	3	4	5
1. Pollen grains give rise to pollen tubes.	The pupils -Explain the different parts of pollen grain. -Explain the origin and structure of pollen tube.	**Demonstration:** Grow some pollen grains in 3% sugar solution and show the pollen tubes under the microscope. Explain that pollen tube carries two male nuclei inside it.	Prepare a model of the process of fertilization.	1. What happens to the pollen grain after it has fallen on the stigma?
2. Egg-cell is contained in the ovule.	-Explain the structure of ovule.	**Demonstration:** Show the slide of the structure of ovule and explain with the help of chart. Point out the importance of egg-cell and secondary	Grow pollen grain in different concentrations of sugar solution and find out the effect on the rate of growth of the pollen	2. What happens to the egg-cell and secondary nuclei after fertilization?

		nuclei.	tubes.	
3. One male nucleus fuses with the egg-cell and causes fertilization.	- Understand the importance of egg-cell and secondary nuclei in the process of fertilization.	Discuss the path of pollen-tube inside the style and the fusion of male nucleus with egg-cell with the help of chart. Explain the fusion of second male nucleus with secondary nuclei and the formation of endosperm. Clarify why it is called double fertilization?		3. What do you understand by double fertilization? 4. Evaluate the model/chart prepared by the students.
4. In angiosperms double fertilization is the rule.	-Explain the term double fertilization.			
5. Fertilization results in formation	- Understand the importance of	Explain that after fertilization ovary develops into		

of seeds and fruits.	fertilization. -Differentiate between seeds and fruit. -Explain phenomenon of parthenocarpy.	fruits and ovule into seeds. Discuss other changes also which occur after fertilization, ovary may swell or shrink. Show fruit of orange, mango, wheat, rice etc. Seeds when sown grow into a full plant. Also give reference to parthenocarpy.		

Lesson No. 4

Concept: Besides reproducing sexually plants reproduce vegetatively also.

Sub-concepts	Behavioural Objectives	Procedure (Teacher-pupil Activity)	Pupil's Assignments	Evaluation
1	2	3	4	5
		Derive the concept of vegetative reproduction from the pupils viz. when plants give rise to another plants from any part of the plant. Recall ginger, potato, onion, sugarcane, etc. and how they are produced. Take the students to field and show how potato, sugarcane, etc. are	Prepare a list of plants which propagate vegetatively.	1. What are the characteristics of plants which reproduce vegetatively?

		sown. Explain that suckers, stolons and runners also reproduce vegetatively. Show the leaves of Broyophyllum with leaf buds.		
2. Plants which grow vegetatively have advantages over plants which reproduce sexually.	-Can list plants which reproduce vegetatively. -Understand the importance of vegetative reproduction.	Discuss the advantages of vegetative reproduction over sexual reproduction viz. getting desired plants of the same kind in less time.	Prepare a list of plants which propagate vegetatively.	2. What are the advantages of vegetative reproduction?
3. Lower plants also reproduce vegetatively and sexually.	-Explain the process of reproduction in lower plants.	Explain with the help of slides and charts the different modes of reproduction in lower plants viz.,	Prepare a list of plants which propagate vegetatively.	3. What do you understand by the following modes of reproduction? (i) Budding

		binary and multiple fusion, budding, fragmentation and spore formation.		(ii) Binary and multiple fission (iii) Fragmentation (iv) Spore formation.

Lesson No.5

Concept: Vegetative reproduction in plants.

Sub-concepts	Behavioural Objectives	Procedure (Teacher-pupil Activity)	Pupil's Assignments	Evaluation
1	2	3	4	5
1. There are artificial ways of vegetative reproduction.	**The pupils:** -Develop the skill in the different ways of artificial propagation. - Understand the importance of vegetative reproduction.	**Demonstration:** *Cutting:* Show how to prepare cutting of rose, croton, sugarcane etc. and how to sow them. *Layering:* Certain plants propagate when a part of the stem is kept below the soil for some time. Show how it is done in the	Practice cutting, layering and grafting.	1. What is the difference between: (i) Cutting (ii) Layering 2. What are the advantages of artificial reproduction in plants? 3. Observe and evaluate the students

		case of lemon, jasmine, etc. *Grafting:* Take the students in the nearby horticulture station to show grafting. Demonstrate how it is done. Introduce terms like scion and stock. Explain the importance of grafting. i.e., we get improved variety in shorter period as in Citrus, Mango, Guava etc.		while doing practical in the field.

LESSON PLAN

Good lesson planning is the key to successful teaching. Lesson planning in advance has a futuristic implication which permits a teacher to anticipate pupils' reactions, and by using these reactions to prepare adequately in order to avoid foreseeable difficulties. It helps a teacher mange her time effectively.

Definitions:

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

Good defines a lesson plan as an "outline of the important points of a lesson arranged in the order in which they are to be presented to students by the teacher".

"It is the ability of a teacher to behave in specified way within a social situation in order to produce empirically demonstrated effects approved by those in the environment in which he functions."

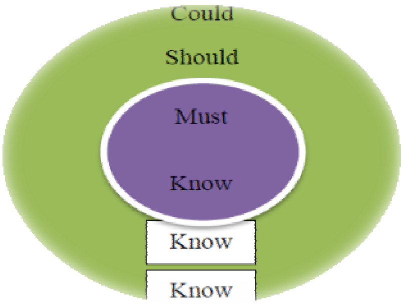
In the broadest sense teaching effectiveness can be defined as "the ability of a teacher to produce agreed upon results".

Though there is controversy on what effective teaching means yet there are some aspects which are generally agreed upon by the educationists and are helpful in better learning on the part of the pupils. These aspects must be kept in view while planning for effective teaching. Some of these aspects aspects are discussed here.

1. Motivation:

'You can take the horse to water but cannot make him drink ', is a good old saying. The same is applicable in teaching. The students must be in a receptive frame of mind and must have the desire to learn. The most important factor which determines effective teaching and better learning is that how much interest has been created and maintained in the students for learning. Interest is essential for attention and attention is essential for learning. Motivation energises action and also gives direction to action. The teacher should always try to make use of the different motivation techniques to make his teaching interesting and effective. It is, however, not within the

scope of this book to digress upon the different motivational techniques. Devices like praise blame, knowledge of progress, group approval, teacher approval, knowledge of goal, competition, surprise, variety, physical conditions, etc., should be used.



The teacher must decide what students must learn, should learn and could learn

2. Organization:

(i) Decide how much you want to teach:

The whole teaching process should be organized according to the previous knowledge of the students and the amount of knowledge that they can easily digest. It is better to teach less which the students can understand than a lot they cannot understand. We should always remember that the more we teach, the less the students learn. The teacher must decide the priorities of the knowledge or skills that he wants to develop. There is some knowledge which is core and which the students must learn. There is some knowledge which the students should learn. And there is some which the students could know but is not so important.

(ii). Sequence the material to be taught:

After deciding the amount of knowledge to be given to the students, the material should be arranged in logical as well as psychological manner. The different principles of learning and maxims of teaching should be used in sequencing the material. Some of the maxims of teaching are listed here:

Proceed from:

a. Known to unknown
b. Simple to complex
c. Concrete to abstract
d. Particular to general
e. Abstract to reasoning
f. Whole to parts and back to whole (inductive-deductive approach).

(iii). Decide the pace of your lesson:

The teacher should decide the speed with which he can teach keeping in mind the psychological principles of learning. There are usually three categories of students-intelligent, average and below average. The speed of your teaching should suit every category of students. In general it is better to go the pace of the bottom 20% rather than the top 20%. The disadvantage of going slowly for the top students can be removed by giving them more and challenging work from time to time. It is better to teach a little well than to teach a lot badly. The process of teaching should neither be too swift nor too slow. The speed should be decided according to the intake capacity of the students. This may be clear from the following analogy:

If we take a jar with a narrow mouth (comparable to the student with low intelligence) and attempt to pour a quantity of water into it violently, instead of allowing it to trickle in drop by drop, greater part of the liquid will flow over the sides and ultimately the jar will contain less than if the operation had taken place gradually.

(iv) Decide the pauses and introduce variety:

The teaching should not be non-stop. The students lose all interest if the teaching is without adequate pauses. Fatigue and boredom set in if one type of teaching activity continues for a long time. A class is fully with you for about 10-15 minutes, after that attention is liable to wander unless some variety is introduced by way of students' activity, demonstration, question-answer discussion etc. *One cannot eat non-stop for an hour, but you may manage satisfactorily a banquet of 5-6 courses with the usual intervals between the courses. You must allow time for the class to digest mentally what* *they have taken and put the 'Courses' on in the psychological order much the same way as a chef plans a menu.*

3. Make use of Senses:

Senses are the gate ways of knowledge. The success in teaching lies in the maximum use of the different sense. Out of the five senses- sight, hearing, feeling or touch, smell and taste, the first three are most important in learning. The senses of smell and touch are also used in learning many things but are comparatively less used in learning science and technical subjects. How much do we learn through the different senses is clear from the following chart:

Senses / Objectives	Vision	Hearing	Touch	Smell and Taste
Knowledge	75%	25%	-	Used only in some subjects such as identification of chemicals, sanitation, cookery etc.
Skills	25%	10%	65%	

It is clear from the above chart that in teaching science effectively the sense of hearing (lecture, discussions, question-answer etc.) has comparatively little place.

Advantage of Planning a Lesson:

1. It keeps the teachers to be systematic and orderly in the treatment of the subject-matter. He proceeds on well-thought-of and definite lines and does not follow haphazard and thoughtless teaching.
2. The teacher sets forth with some definite aims in view and is conscious of the interest, attitudes, etc. that he is to develop in the students through certain activities or some other means.
3. Planning a lesson gives confidence and self-reliance to the teacher which is of great value for successful teaching.
4. It saves time in the sense that the students get a better understanding of the subject and form some desirable

attitudes and habits which would otherwise have been impossible in the same period. It encourages the continuity in the teaching process and the needless repetition is avoided.

5. Because the lesson is correlated with the social and physical environments of the students their interest is maintained throughout the lesson.
6. The micro-lesson are helpful in developing specific teaching skills.
7. The effectiveness of a teacher depends on a good lesson plan. It develops the reasoning decision making ability and imagination to pupil teachers.
8. Lesson Planning encourages a proper consideration of the learning process and definite choice of appropriate learning procedures.
9. Lesson planning provides for an adequate checking of the outcomes of instruction.
10. Lesson planning ensures a proper connection of the new lesson with the previous lesson.

Steps Involved in Lesson Planning – Herbartian Steps:

Herbart, J. F. (1776-1841) suggested six formal steps for the development of a lesson plan. They are:

1. Preparation or Introduction
2. Presentation
3. Comparison or Association
4. Generalisation
5. Application
6. Recapitulation.

1. Preparation:

The teacher must prepare the students to receive new knowledge. This knowledge is to be linked with previous knowledge of the students. Preparation, in fact, means the exploration of the pupils knowledge, which leads to the aim of the lesson.

Teaching's skill lies in leading the pupils to see that their knowledge is incomplete and that new field to conquer lies before them. This can be done:

i. By testing of the previous knowledge of pupils, and introducing the lesson with an explanation.

ii. By asking questions that may reveal their ignorance, arouse interest and curiosity to learn the new matter.

iii. Through the use of charts, maps or pictures.

iv. Through skillful conversation.

It should, however, be noted that this step should be brief and to the point and should not in any case take more than five minutes.

2. Presentation:

Before the presentation of the subject-matter, the aim of the lesson should be clearly stated. By this, teacher as well as the students are engaged upon a common pursuit.

In the presentation step, the pupils must get some new ideas and knowledge. Both the teacher and pupils should be the active participants in the teaching-learning process. The teacher should try to introduce everything from the students. A sort of heuristic attitude should prevail the whole teaching. Questioning should form an important device of this step. Other aids should also be used to make the lesson more interesting and comprehensive. Blackboard summary should be developed along with.

3. Comparison or Association:

Some examples are given to the students and they are asked to observe carefully and compare them with other set of the examples and facts. This step is importance where some definition or some generalization is to be induced from the students.

4. Generalisation:

With this step, the aim of the lesson is achieved. This step involves reflective thinking because the whole knowledge learnt in presentation is to be systematized which leads to generalization, formulate, rules, etc. through comparison or association. This step completes the enquiry by providing the answer to the problems with which it began. Thus, the students get a new knowledge which is ready for use.

5. Application:

At this stage, the students make use of the acquired knowledge in familiar and unfamiliar situations. At the same time, it tests the validity of the generalization arrived at by the pupils. In this way, the new knowledge gained by the pupils will become permanent in the minds of the students and will not fade from consciousness soon.

6. Recapitulation:

This is the last step. The understanding and comprehension of the subject-matter taught by the teacher can be tested by putting some suitable questions on the topic to the students. This will also help the teacher to find out whether his method of teaching is effective and successful or not.

Sample Proforma for Lesson Plans

Class:……………… Subject:………………

Concept/Topic:…… Date:…………………

Objectives

i) General

ii) Specific

Instructional Materials:

Previous Knowledge (Assumed)

Introduction or Preparation:

Presentation:

Teaching points (content)	Behavioural Objectives	Learning Experiences (Teacher-pupil Activities)	Evaluation	Black Board Summary

Generalization (if any):
Application:
Recapitulation:
Home Assignment:
Signature of the Guide teacher Signature of the student teacher

Specimen Lesson Plans
Biology

Subject: **Botany**
Topic : **Transpiration**
Class : **IX**

Objectives:

The pupils:

i. Draw conclusions from their observation.
ii. Explain the mechanism of transpiration.
iii. Explain the method for finding out the rate of transpiration.
iv. Devise experiments.
v. Understand the significance of transpiration.

Instructional material:

Potted plant, conical flask, photometer (Ganong's), fresh twig of Tecoma, chart showing the passage of water from the roots to the stem, chart showing the structure of leaf especially stomata.

Previous Knowledge (Assumed):

The students have studied the structure and function of leaf and water path from the roots to the stem and the leaves.

Introduction:

Pointing towards the chart of path of water from root to stem the following questions will be asked:

i. How is water conducted from the roots to the stem and leaves?
ii. How does water rise in the plants having 100 ft height?

iii. What happens to water when it reaches the leaves?
iv. Is the whole water which reaches the leaves from the roots consumed by the plants?
v. How does water evaporate from the leaves?

Explanation by the teacher:

Though water is very essential for the plant yet a major part of it is lost through evaporation from the aerial parts of the plant especially leaves. We shall see how it occurs.

Presentation:

1. Teaching Points Procedure (Teacher-Pupil Activity)

1. What is transpiration? (Definition)	**Experiments:** Put a leaf or two in the flask, close its mouth with cotton wool. Keep the apparatus in warm lighted place. Showing this experiment put the following questions: i. What do you observe in the experiment? ii. From where has this water come? (from plant as a result of evaporate-ion). iii. What is the technical name given to this process? (Telling by the teacher in no response?) iv. How can you define transpiration?
2. Kind of transpiration	Explanation by the teacher with the help i. Stomatal. of chart showing the structure of leaf and ii. Cuticular, deriving the two kinds of transpirations from the students by putting some questions.
3. Mechanism of transpiration	Showing the chart of the T.S of leaf, put the following questions: i. Which part of the leaf gets water from the root? (Xylem) ii. Under what conditions can water pass from xylem to the outer mesophyll cells? (recapitulate the concept of Osmosis). iii. What will happen to the cells (pointing

	to the spongy parenchyma) when water is lost through the stomata? (Concentration of the cell-sap will rise). iv. What is the function of the stomata during transpiration? (Control gates for transpiration). Explanation by the teacher of the whole mechanism of transpiration.
4. Measurement of transpiration	**Experiment:** Fit up the Ganong's Potometer with the help of students. Technique of introducing the air bubble should be shown to students. Put the following questions: i. What do you observe in the experiment? ii. How can you find out the rate of transpiration with the help Ganong's photometer?

Explanation:

The rate of transpiration is different in different plants and under different conditions. A grown-up plant of Maize evaporates 200 to 800 litres of water in 24 hours.

Blackboard work:

1. **What is transpiration?** Diagram of the first experiment showing water vapours inside the flask.
   Definition: The evaporation of water from the surface of the aerial parts of the plant is called transpiration.
2. **Kinds of transpiration**
   i. Stomatal: Diffusion of water from the intercellular spaces of the leaf into the outer air through stomata.
   ii. Cuticular: Direct evaporation from the outer walls of the epidermal cells through the cuticle.
3. **Mechanism of transpiration:**
   Water lost through the stomata causes rise in the concentration of cell-sap in the adjoin mesophyll cells which draw water from the inside cells. These cells in turn draw

water from the xylem of the leaf. The whole process is carried through osmosis (To be explained with the help of chart).

4. **Measurement of transpiration:**

   Diagram of Ganong's photometer. Calculation of the rate of transpiration:

   Rate of transpiration = Distance travelled by the bubble in c.c. divided by Time taken.

Application:

What is the use of transpiration to the plant? (helps in absorption of water by the roots from the soil, in the conduction of salts from soil to other parts of the plant, in keeping the temperature of plant low).

Recapitulation:

i. How can you define transpiration?
ii. What is osmosis?
iii. How can we measure the rate of transpiration?

Home Assignments:

Devise and experiment to establish relationship between the number of leaves and the rate of transpiration.

(**Hint:** Take three or four test-tubes and mark the level of water in them. Put a twig in each with different number of leaves. Keep them for 24 hours. Note the level of water in all the tubes).

Importance of Planning a Lesson:

- ✓ Lesson planning makes the regular, well-organised and systematic.
- ✓ It enhances the self-confidence and self-reliance of the teacher.
- ✓ If facilitates appropriate use of aids at appropriate places.
- ✓ It is economical in terms of time, as every step has been planned with forethought. Repetition is hence avoided.
- ✓ Lesson planning establishes proper connection between different lessons of study, thus ensuring continuity in the teaching-learning process.

- ✓ The student's interest can be retained by planning suitable activities and assignments, according to the mental level of the students.

Merits of Herbartian Lesson Planning:

- ✓ It ensures that the lesson has been prepared well.
- ✓ The planning is based keeping in view the logical and psychological aspects associated and hence incorporates basic principles of learning.
- ✓ It is an easy and simple approach.
- ✓ Content matter is given utmost importance.
- ✓ The objectives / purpose / aim of lesson is made clear.
- ✓ It employs deductive thinking for learning.
- ✓ It links previous knowledge of students to impart present / new knowledge.
- ✓ This approach can be used for any class size or organization.
- ✓ It helps in applying knowledge to new / unfamiliar situations.
- ✓ It helps in achieving cognitive objectives of teaching.

Limitations of Herbartian Lesson Planning:

Although Herbartian lesson plan is the most widely used approach in lesson planning it has some limitations. They are:

- ✓ It exphasises mainly on the content aspects.
- ✓ It confines teaching only to memory level.
- ✓ It does not cater to the abilities and interests of students.
- ✓ It helps in achieving cognitive objectives only and does not bother about affective and psychomotor domains.
- ✓ The approach has teacher as the pivot and he dominates the teaching – learning process.
- ✓ Emphasis is on presentation / teaching rather than on learning.

Comparison of Lesson Plan and Unit Plan:

S. No	Lesson Plan	Unit Plan
1.	A daily action plan	Extends over more than 8 or 10 periods, depending on the subject matter, the objectives to be achieved and the learning activities.
2.	Content presented in the form of teaching points, in logical and psychological order.	Content is grouped in terms of facts, principles, generalizations etc.
3.	Learning activities in detail.	Learning activities just mentioned.
4.	Actual test items given.	Evaluation tools and techniques just mentioned.
5.	Part of the whole.	Made up of several lesson plans.

SCIENCE TEXT BOOK:

The text book is one of the important aids in the teaching learning process and has occupied a pivotal role in educating the school children. The teacher should never read the text book in the classroom in science teaching. The contents of a text book should be read only when the material is considered to be very important and difficult for the children to comprehend.

- ✓ The text book is meant for supplementing the teacher's work and can never suppliant the teacher.
- ✓ It helps in home study after demonstration lesson in the class.
- ✓ It helps in doing home work and the preparatory part of assignments.

- ✓ It helps in systematic and speedy revision after the course has been finished.
- ✓ It helps the pupils to form correct understanding of basic concepts and principles of science.

Qualities of a Good Science Text-book:

- ✓ A good text-book should inculcate scientific attitude in the pupils and develop an understanding about the scientific method. It should develop open-mindedness.
- ✓ It should provide for the development of certain skills. This can be achieved if the teacher provides for pupils to handle the instruments in the laboratory.
- ✓ It should help the pupils for systematic and speedy revision of the lesson they have finished.
- ✓ The quality of paper, binding, printing and type of letters used should be fine and appealing.
- ✓ There must be proper selection and organization of the subject matter. Psychological approach should be adopted in developing the topics.
- ✓ The subject matter should be written in very simple, clear and lucid language.
- ✓ Each chapter should begin with a brief introduction and end with summary.
- ✓ At the end of each chapter there should be assignments.
- ✓ Headings and sub-headings should be in bold type.
- ✓ Detailed table of contents, index and glossary of scientific terms with their English equivalents. Must be available in the text book.
- ✓ Provision should be made to correlate science with other school subjects and life situations. Suggestions for improvising science apparatus and experiments may also be given.
- ✓ To facilitate learning, some memory aids should be given. Wherever possible the text book should be accompanied by a laboratory manual and a teacher's guide book.

Criteria of a Good Text Book:

Author – his qualification and experience:

The person who writes a book should have some year of experience in that field. He must be conversant with latest methods of teaching and techniques. He must have the minimum academic qualification.

Mechanical features / aspects:

The paper should be of good quality. The printing and binding should be good. The size of the letter should take into account the level of the students. It should be handy in size. The cover design should be attractive. The cost of the book should be at moderate level.

Content:

It should be appropriate to the age level of students, consistent with pupils need and interest and should stand for objectives of teaching science. The statement of the fact and principle should be very accurate because this is the only source for pupils to gain knowledge.

Organization:

Care must be taken of the mental growth and interests of the pupils. Subject matter should be developed in a psychological sequence. Each lesson should start with brief introduction and end with good summary. There should be an assignment or activity at the end of a topic. There should be an assignment or activity at the end of a topic. There should be heading and sub heading to identify the content.

Illustration:

It should be clear and colourful if possible. It should find its proper place in the book and well labeled. Diagrams and illustrations are the amplifiers of the text. Hence the text book should contain lot of cross-cut diagrams of complicated apparatus.

Literary style and other aspects:

The sentences used should be as simple as possible. The vocabulary used should be suitable to the level of age group. Reference book should be listed for further information. Table of content at the beginning and index at the end should find a place.

Uses of text book for the student:

Revision: Students can revise the learnt material independently at their own time.

Complete the assignment: It helps the student to complete the assignment.

Prepare for Examinations: It helps the students to prepare for examination.

Direction to experiment: It gives instruction and directions to students to perform experiment in the laboratory.

Self education: It helps the students for self study.

In distance education / open education:

In distance learning mode and open learning system, the learning materials are the only primary source for getting education.

Evaluation of a science text book:

The science teacher has to recommend suitable text books to the students. He has to give his recommendation on the basis of objective analysis of the available books, keeping in view the qualities of a good text book.

Hunter's score card:

Under this score card, 1000 marks or points are marked as under.

		Marks (1000)
i.	Educational Rank of the author	50
ii.	Mechanical makeup and cost	100
iii.	Psychological soundness	300
iv.	Subject matter	250
v.	Literary style	110
vi.	Learning exercises	140
vii.	Teachers help	50
	Total	**1000**

SELECTION OF METHOD AND INSTRUCTIONAL MEDIA FOR INSTRUCTION:

The different instructional media exist to meet the different capabilities of learners. Whether for the purposes of seeing or hearing and others for seeing and hearing at the same time, instructional media are intended to bring about meaningful understanding and hence learning. There are certain advantages and disadvantages that have to be considered to ensure their proper selection and use.

Selection and Use:

Models for media selection range from simple procedure or algorithms to complex theoretical schemes. Some are based on the communication 'channel' being used (audio, video, etc.) or the characteristics of the media itself. Other emphasize the learning outcomes being addressed, while still other focus on learner attributes or educational theory or the teaching-learning process.

Regarding media richness and instructional appropriateness, the following table specifies the various characteristics of common media that should be considered in the selection process.

Learning will be enhanced if media:	Real Objects	Text (handouts, books etc)	Easel, chalk or whiteboard	Overheads of computer presentations	35mm Slides	Video (tape, discs, TV)	Graphics (photos, diagrams)	Audio (tape, CD)	Computer software
Shows motion						■			■
Reproduces sounds								■	■
Shows realistic images					■	■	■		■
Is portable		■			■				
Can be used as an aid or reference after the lesson		■							
Allows drawing writing or highlighting during lesson		■	■	■					
Allows students to interact			■						
Can be used independently		■			■	■		■	■
Allows user to review or control pace				■	■	■	■	■	■
Allows students to touch or see objects	■								
Allows observation of dangerous processes or distant locations						■			■
Can be easily modified		■	■	■					
Can be easily reordered		■		■	■		■		
Allows participants to respond simultaneously		■	■						
Shapes attitudes						■			
Presents problems solving situations						■			■

Instructors apply the following exclusion and inclusion criteria in selecting media for the various common learning outcomes.

Criteria for selecting media:

Learning Outcome	Exclusions	Selections
Intellectual Skills	Exclude media having no interactive feature	Select media providing feedback to learner responses
Cognitive Strategies	Exclude media having not interactive feature	Select media providing feedback to learner responses
Verbal Information	Exclude only real equipment or simulator with no verbal accompaniments.	Select media able to present verbal messages and elaboration.
Attitudes	Exclude only real equipment or simulator with no verbal accompaniments.	Select media able to present realistic picture of human model and the model's message
Motor Skills	Exclude media having no provision for learner response and feedback	Select media making possible direct practice of skill, with informative feedback

Nine key factors that should influence media selection as institutional resource constraints, course content appropriateness, learner characteristics, professor attitudes and skill levels, course learning objectives, the learning relationships, learning location, time (synchronous versus asynchronous), and media richness level.

These nine factors down to three major criteria for selecting instructional media: practicality, student appropriateness, and instructional appropriateness. These are explained as follows:

Practicality: Is the intended media practical, in that the media is available, cost efficient, time efficient, and understood by the instructor?

Student Appropriateness: Is the intended media appropriate for the developmental and experiential levels of the students?

Instructional Appropriateness: Is the intended media appropriate for the planned instructional strategy? Will the media allow for the presentation of the proposed lesson in an efficient and effective manner? Will the media facilitate the students' acquisition of the specific learning objectives?

Three major constraints that operate on media selection, each of which may impede the selection process. These constraints include the following:

(Un) availability of Materials: Using existing instructional materials can facilitate the creation of instructional units; however, if no appropriate materials exist, then the instructor must create the materials. This usually leads to a production constraint.

Production Constraints: Creating quality instructional media can be a costly, in both time and money, enterprise. A central question to answer is what level of media quality is acceptable, that is, both time and cost efficient as well as instructionally effective.

Instructor Facilitation: Most forms of instructional media involve teacher modeling, demonstration, implementation, or more broadly, facilitation. The amount or difficulty of this process of media facilitation may inhibit a teacher's ability to effectively utilize the particular media.

Types of Instructional Media:

- ✓ Real objects and models
- ✓ Printed text (books, handouts, worksheets)
- ✓ Printed visuals (pictures, photos, drawings, charts, graphs)
- ✓ Display boards (chalk, bulletin, multipurpose)
- ✓ Interactive whiteboards

- ✓ Models
- ✓ Overhead transparencies
- ✓ Slides and filmstrips
- ✓ Audio (tape, disc, voice)
- ✓ Video and film (tape, disc)
- ✓ Tape Recorder
- ✓ Radio
- ✓ Opaque Projector or Epidiascope
- ✓ Television (live)
- ✓ Computer software
- ✓ Internet
- ✓ e-learning
- ✓ The World Wide Web
- ✓ The Websites

Media Options with Defining Comments

Media	Defining Comments
Real equipment	Actual equipment used on the job. Examples are computers, machinery, laboratory chemicals, and tools.
Simulator	Equipment that incorporates the operating characteristics of real equipment or systems, including the "feel." An example is the flight simulator.
Training device	Reproduces the essential performance of real equipment but not its appearance or operating characteristics, e.g. a maintenance trainer for electronic equipment.
Computer	Displays text and graphics on screen. It may use animation and sound. Students may interact using a keyboard, mouse or touch screen.
Interactive multimedia	Computer-based text: sound, data, graphics, still pictures, and motion video. They provide random (quick) access to any segment.
Virtual reality	An application of interactive video disc that places the learner in a simulated situation

	that feels real, even though the learner is actually interacting with a computer screen. Examples are virtual libraries and laboratories.
Radio or TV broadcast	One-way communication of sound or motion picture with sound from a central station.
Motion picture (Film or video)	Visual display with motion and sound capabilities. It may not be interactive but excellent for instruction. Examples are films and videos.
Programmed text	Printed frames of text presented in small steps. It requires frequent responding and provides feedback.
Slide tape or filmstrip	Visual display of still pictures, text, and graphics. Sound capability is not interactive.
Audio poster or chart whiteboard, chalkboard flipchart	Static print media that may include pictures and colour.
Overhead transparencies and slides	Static projected media for text and graphics.

Why Use Media in Instruction?

As a rule, educational experiences that involve the learner physically and that give concrete examples are retained longer than abstract experiences such as listening to a lecture. Instructional media help add elements of reality – for instance, including pictures or highly involved computer simulations in a lecture.

Media can be used to support one or more of the following instructional activities:

Gain attention:

A picture on the screen, a question on the board, or music playing as students enter the room all serve to get the student's attention.

Recall prerequisites:

Use media to help students recall what they learned in the last class, so that new material can be attached to and built upon it.

Present objectives to the learners:

Hand out or project the day's learning objectives.

Present new content:

Not only can media help make new content more memorable, media can also help deliver new content (a text, movie, or video).

Support learning through examples and visual elaboration:

One of the biggest advantages of media is to bring the world into the classroom when it is not possible to take the student into the world.

Elicit student response:

Present information to students and pose questions to them, getting them involved in answering the questions.

Provide feedback:

Media can be used to provide feedback relating to a test or class exercise.

Enhance retention and transfer:

Pictures enhance retention. Instructional media help students visualize a lesson and transfer abstract concepts into concrete, easier to remember objects.

Assess performance:

Media is an excellent way to pose assessment questions for the class to answer, or students can submit mediated presentations as classroom projects.

Guidelines for a Variety of Instructional Media:

- ✓ Visual aids should augment the presentation; they are not meant to be the entire presentation.
- ✓ It is important to be able to teach without them. Instructional aids may arrive late, or not arrive at all. Also, something may go wrong or break down. Even careful planning cannot cover every possibility.

- ✓ It is imperative that all instructional media are previewed before they are used in class or online. This will familiarize you with content and structure, as well as ensuring that no unfortunate (and sometimes embarrassing) mix-ups have occurred.
- ✓ Visuals are best kept simple, with minimal wording. They should always be readable from a distance (when reproducing from texts and enlarging graphics). You can practice using the visual aids in the actual classroom before the lecture begins.
- ✓ The audience's line of vision should not be obstructed.
- ✓ Visual materials should be displayed only when the instructor is ready to use them, and they should be kept visible until the students have finished taking notes. You should remove the materials when you are ready to talk about something else, signaling that it is time for discussion or noting a subject change.
- ✓ Effective instructors talk to the students, not the visual aids.

Advantages of using instructional media:

a) There is standardized information delivery. Each student sees and learns the same message, hence forming the basis for further study, practice and appreciation.

b) Attention is ensured through the use of instructional media. Members are therefore kept informed. The clarity and coherence of a message, the attractiveness of changing images, the use of certain special effects, as well as the impact of ideas that can create or cause effect, cause an audience to laugh or be thoughtful, contributing to the motivational and interest-calling aspects of media.

c) The quality of learning can be improved through careful integration of pictures and words. Media can communicate elements of knowledge in a well-organized, specific and clearly defined manner. Through much effort from students, learning can be expected to reach an acceptable competency level.

d) Learning can be enhanced since there is reduction of repeated information. This enables important aspects of lessons to be delved into.

e) Learning becomes interesting. Thus, alert instructors are continuously searching for refreshing ways of generating and expanding interest. This is because data presented represent situations, and pose questions in exciting ways.

f) They extend the scope of experience. For example, by using various media, concepts can be taught through real life demonstrations.

g) Instructional media help to supply a concrete basis for conceptual thinking whiles increasing learner's interest. This means that the media help to stimulate self-activity in learners, making learning more permanent.

h) Instructional media enhances retention and transfer of knowledge and support learning through examples and visual elaboration.

i) New content, experiences and expectations could also be presented through the use of instructional media, leading to efficient preservation of records and documents and experiencing materials that could have looked far-fetched.

j) Through the use of media such as LCD projectors, knowledge and information is able to reach a lot of people simultaneously.

k) Instructional media are capable of focusing attention on whom and what is important and interesting thereby raising aspirations and whetting the appetite of the learners. This is critical in promoting distance education across various disciplines and almost all forms of education and training, be it formal, informal or non-formal.

l) Instructional media also serve as the means of expressing the psychological dimension of life, since without using media it would be very difficult to find expression for certain states of matter.

Disadvantages of Media Use:

a) Bureaucracy and delay at the Ministry of Education in providing the needed financial and technical resources to provide media in educational institutions. This leads to lack of sufficient materials to use.

b) Not many teachers see the need for media use in the classroom.

c) Lack of adequate personnel to train teachers to use media in schools.

d) Lack of enough patronage from heads and supervisors of educational institutions for media usage.

e) The impression that new technology would replace teachers makes some teachers to see instructional media as threats.

f) Lack of flexible curricular to incorporate the appropriate teaching and learning materials.

g) Inadequate time and laziness on the part of teachers to use media.

Instructional media though have some weaknesses; the variable benefits the media provide should be overlooked.

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