Science Methodology

Selected Essays

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Science Method

Unit-1

STRUCTURE

1.0 Objectives:-

After reading this unit you will be able to

- Understand the meaning & importance of general science.
- Describe the place of science in school curriculum
- Explain the disciplinary approach of organization of science curriculum.
- Explain the integrated approach of organization of science curriculum.

1.1 Introduction:-

"Science does not simply sit down & pray for things to happen, but seeks to find out why things happen. It experiments and tries again and again and sometimes fails and sometimes succeeds & so bit by bit it adds to human knowledge. This modern world of ours is very different from ancient world or the middle ages. This great difference is largely due to Science."

\- Pandit Jawaharlal Nehru -

As very rightly quoted above our every day is different from the earlier days & this is largely due to the contribution of science in our life. We can't live happy life without Science. The science has become integral part of our life. Science has also influenced educational enterprise & hence it is also the integral part of our educational system. Learning of science has become unavoidable part of general education. In this chapter we shall discuss the meaning importance & place of science in school curriculum and general and specific instructional objectives we shall also learn about organization of science curriculum using disciplinary approach & integrated approach.

1.2 Meaning of General Science

The term science & general science are used synonymously.

Einstein defines science as “An attempt to make the chaotic diversity of our sense experience correspond to logically uniform systems of thought.”

According to the Columbia dictionary “Science is an accumulated & systematized learning, in general usage restricted to natural phenomenon.”

According to ‘Science Manpower Project’, “Science is a cumulative and endless series of empirical observation which result in the formation of concepts & theories, with both concepts & theories being subject of modification in the light of further empirical observation. Science is both a body of knowledge & the process of acquiring & refining knowledge.”

According to Griggs, “In the literal sense science means the pursuit of knowledge but it has a wider connotation for our purpose, and can be said to mean a knowledge of nature in the widest possible form.”

On the basis of these definitions of science we can say that

1. Science is a study of natural phenomenon.
2. It is organized & systematized learning.
3. It is a body of cumulative & ordered observations.
4. It is the knowledge based on observations, experiments.
5. Science is a process as well as the product.

1.3 Importance of General Science

The modern civilization is a scientific civilization. In this age the modern society is completely drawn into the scientific environment. Today science has become an integral part of our life & living. Now we cannot think of a world without science. The importance of general science in day to day life may be summarized as under.

1. Agricultural Advancement:-

The Science has revolutionized the agricultural field. The new scientific understanding of the nature of living creatures, both plants & animals, has led to a spectacular improvement in agricultural technology. Science has brought revolution in mechanism of agriculture to which Indian Farmers have readily accepted. The effective use of fertilizers, pesticides, modern methods of cultivation, improved verities of seeds etc. are few examples of importance of science in the agricultural sector. Science gives information about insert-control, cattle-diseased, use of manures & health measures help a farmer & his family.

2. Health:-

Science has helped all of us in improving our health. The old prejudice of vaccination has broken down with the result of that small pox has been practically wiped out. Science has proved

to be a savior to mankind where contagious diseases & epidemics have been prevented by scientific techniques. Due to contribution of science and average life of an individual is increased from 32 years in 1950 to over 55 years to day in India.

3. Trade & Industry:-

The ways & processes of trade & industry have been changed due to impact of science. Industries have become advanced due to advancement in sciences. For example industries such as textile, steel, electronic, drug, small scale etc have been advanced due to advancement in science.

In the words of Kothari Commission, "The Wealth & Prosperity of a nation depends on the effective utilization of its human & material resources through industrialization. The use of human material for industrialization demands its education in science & training in technical skills. Industry opens up possibilities of greater fulfillment for the individual."

4. Education:-

Facilities for study of engineering & medicine in different branches have been increased due to development of science. As a result various new branches in different disciplines have emerged. This provides more opportunities for jobs in the market.

5. Other beneficiary areas:- These include,

a. Transportation
b. Banking
c. Communication
d. Entertainment
e. Digitalization & Media

1.4 Place in School Curriculum

Science is an important subject in school curriculum because man's future depends to a large extent on scientific advances & development of productive activity. Hence there is a great need to teach science in school curriculum.

Kothari Commission strongly emphasized that, "We lay great emphasis on making science an important element in school curriculum. We, therefore, recommend that science and mathematics should be taught on compulsory basis to all pupils as a part of general education during first ten years of schooling. In addition there should be provision of special course in these subjects at the secondary stage, for students of more than average ability."

UNESCO's International Education Commission (1972) recommended that,

"Science & technology must become essential components in any educational enterprise; they must be incorporated into all educational activity intended for children, young people & adults."

Science has now become a compulsory subject in the school curriculum because of its multifarious value to the individual as well as the society.

1. Intellectual Value:-

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

2. Vocational Value:-

In present age all the vocation need the knowledge of science more ever there are large no of vocations for which study of science is compulsory requirement examples: Medicine, Engineering, Computers, Para medicines, agriculture etc. The study of science at a school level is the basis of many vocations & other productive activities in the latter life of students.

3. Aesthetic Value:-

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

4. Utilitarian Value:-

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

5. Cultural Value:-

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

6. Moral Value:-

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

7. Psychological Value:-

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

8. Adjustment Value:-

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

9. Leisure Time Value:-

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

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

1.5 General & Specific Instrumental Objectives

The subject taught in the schools have their own identity, importance & educational values. The educational value of a subject is established by goals / aims & objectives. Which are achieved by through the study of the subject. The aims or long term goals can be regarded as expression of strategy while objectives are specific, immediate and attainable goals, specific to one subject, precise & clearly defined, objectives are more directly concerned with what specifically is being attempted over a relatively short period.

An objective is a point or an end view of the possible achievement in terms of what a pupil is to be able to do when the whole educational system is directed towards educational aims.

The objectives are

a. General Objectives:-
b. Specific Instrumental Objectives:-

1.5 (a) General Objectives:-

The Directorate of Extension Programmes for Secondary Education, Government of India, in its brochure on 'Evaluation in General Science' sets some of the objectives of teaching general science in secondary schools as follows:

1. The pupils studying general science should acquire knowledge of the fundamentals of science useful to all in everyday life.
2. They should develop the ability to apply the knowledge in everyday life.
3. They should acquire experimental skills such as
   a. Handing apparatus & Instruments
   b. Arranging apparatus for an experiment.
   c. Preserving apparatus, chemicals, specimens, models etc.
4. They should acquire constructional skills such as
   a. Improving simple instruments & appliances; &
   b. Repairing certain instruments & appliances of everyday use.
5. They should develop drawing skills such as
   a. Drawing & sketching certain objects, instruments & arrangements &
   b. Photography in certain objects & specimens.
6. They should be able to locate reliable & recent information from appropriate sources.

7. They should be able to interpret scientific data given in various forms such as tabular, graphical, scientific etc.
8. They should develop the power of minute observation of their surroundings.
9. They should develop the power of oval expression in science to discuss, argue, describe & raise questions, using scientific terminology.
10. They should develop the scientific method in thinking & action.
11. They should adopt the scientific attitude in making statements, accepting information & forming beliefs.
12. They should develop interest in scientific reading & hobbies.
13. They should be able to appreciate the impact of science on life, both personal & social, the struggle through which science has advanced & the inspiring work of the scientists.

1.5 (b) Specific Instrumental Objectives

Specific objectives are related to a particular topic in a particular period of time. These objectives can be further divided into the following categories:-

1. Knowledge
2. Understanding
3. Application
4. Skills

1. Knowledge:-

The pupil acquires knowledge of terms, concepts, symbols, definitions, principles, processes & formula of science.

Specification:-

To demonstrate the achievement of above objectives, the pupil;

a. Recalls or reproduces
b. Recognizes

2. Understanding:-

The pupil develops understanding of terms, concepts, symbols, definitions, principles, process, formula, reactions, mechanisms etc.

Specification:-

To demonstrate the achievement of above objectives the pupil;

a. Give illustrations,
b. Compares,
c. Discriminates between closely related concepts,
d. Classifies
e. Identifies relationship
f. Estimate
g. Estimate the results
h. Interprets
i. Verifies

3. Application:-

The pupil applies his knowledge & understanding of science to unfamiliar situations (or new problem).

Specification:-

To demonstrate the achievement of above objectives the pupil,

a. Analyse a given problem
b. Construct hypothesis based on observations
c. Arrange experiments for verification of hypothesis
d. Develop relation between reason & effect
e. Be able to give logic in favour of events/happenings in science
f. Draw conclusions from facts acquired from observations.

4. **Skills:-**

The pupil acquire skill in experimentation, construction, observation, drawing & problem solving.

Specification:-

To demonstrate the achievement of above objectives the pupil,

a. Draw diagrams nearly, proportionately & methodically
b. Keep the apparatus / specimen systematically
c. Handle apparatus properly.
d. Improvise apparatus models & experiments
e. Locate errors & limitations in experimental set up & in procedures.
f. Solve numerical problems concerning physical sciences
g. Measure the objects & events in terms of physical quantities & units.

It is important to note that these objectives are determined before teaching starts. If these objectives are not clear for science teacher he/she may be deviated from their path. Teacher will not be sure what suppose to teach why it is to be taught. How it is to be taught? Hence it is very essential for a science teacher to predetermine the objectives of science.

1.6 Organization of Science Curriculum

The main purpose of every school is – "To make the child a complete and perfect man." This will help the child to be able to lead his life in a better way than he is today. Therefore schooling is an important human activity. In formal school education curriculum is the major means to impart knowledge and skills. Different scholars have defined it in different ways. According to Cunningham, "The curriculum is a tool in the hands of artist (teacher) to mould his material (pupils) according to his ideals (objectives) in his studio (school). According to P. Samuel, "The curriculum is the sum total of the experiences of the pupil that he receives through the manifold activities that go on in the school, in the classroom, in the laboratory, in the library, on the playground, in the workshops & seminars, & in the numerous informal contacts between teacher & pupils."

The major issue in the field of education today is organizing science curriculum in an effective manner.

Therefore are two major approaches regarding organization of science curriculum viz. Disciplinary Approach & Integrated Approach. These two approaches are explained below.

1.6 (a) Disciplinary Approach

This approach is also known as the subject approach or the traditional approach. as each subject is separately taught by the teacher in the area of the particular subject in question. For

example science was traditionally taught as a subject with different compartments such as physics, biology, and chemistry as separate components of the science subject.

Similarly language was taught as a separate subject from other subjects. English was taught as being different from Hindi, Oriya, History, Geography etc. Thus each subject has a well defined boundary from which there is no connection to the other.

Thus the approach in which every subject is taught as a separate discipline is called as disciplinary approach. This approach is based on the premise that, the subject is a store house of facts, methods, theories, concepts & generalizations. In disciplinary approach the focus is more on the subject & its content rather than the process. In India the disciplinary approach is very popular in the higher secondary level. It shall be the responsibility of teacher to show the connection between different disciplines (subjects).

Characteristics of disciplinary approach

a. In-depth Conceptual Knowledge
   Every subject has detailed and in-depth conceptual knowledge
b. Disciplinary based teaching
   Each subject is taught as a separate discipline.
c. Content based teaching
   The teaching of disciplinary based curriculum largely based on content.
d. Source of knowledge/information
   In disciplinary approach the teacher is the main source of knowledge / information.
e. Main purpose
   The main purpose of disciplinary approach is to prepare specialist, scientists etc.
f. Mastery of the subject
   The learner is expected to master the subject matter.
g. Chalk & talk based teaching
   This approach mostly leads to chalk & talk based teaching.
h. Text book is main authority
   This approach restrains student observations, values or conclusions different from the text book which is the main authority in disciplinary approach.

Importance /Merits of the disciplinary approach

a. Expert in the subject
   This approach develops expertise in particular subject
b. Subject Growth
   The disciplinary approach foster the growth of the subject.
c. Time Saving
   Disciplinary approach is very time saving in terms of course completion.
d. Detailed Conceptual Understanding
   The disciplinary approach of organizing science curriculum provides detailed conceptual understanding of the subject.
e. Theory building
   The disciplinary approach is very useful in building theory in particular subject/discipline.
f. Higher level thinking

As in disciplinary approach the subject is store house of theories, concepts, generalizations etc. This lead to higher level thinking.

Limitations

1. Less opportunity for creativity
   The disciplinary approach does not provide much opportunities for students creativity.
2. Dropout
   Disinterest in particular subject / discipline may lead to dropout.
3. Require expert teachers
   The disciplinary approach requires highly knowledgeable & expert teachers.
4. Less Scope of socialization & social skills
   Isolated teaching reduces the scope of socialization and social skills.

1.6 (b) Integrated Approach:-

"An integrated approach allows learners to explore, gather, process, refine and present information about the topics they want to investigate without the constraints imposed by traditional subject barriers. "(Pigdon & Woolley, 1992)

Integrated approach encourages student to see the interconnectedness and interrelationships between the different curriculum areas. Instead of focusing on learning in isolated curriculum areas, an integrated approach is based on skill development around a particular theme that is relevant to students of a particular class.

Example:-

1. The curriculum set up of science at primary level i.e. general science is an example of integrated approach.
   Following are the ways of integration
   a. Cross disciplinary approach:-
   This approach examine an issue typically relevant to one discipline through the lens of another discipline.
   b. Multi disciplinary approach:-
   This approach examines an issue from multiple perspectives, without making a concerted effort to systematically integrate various disciplines.
   Inter-disciplinary approach:-
   This approach examines an issue from multiple perspectives, leading to a systematic effort to integrate the alternative perspectives into a unified or coherent framework of analysis.
   The integrated curriculum approach is successful in making students more aware of content area connections, providing a learning environment supporting academic and social needs, dissolving the boundaries among the disciplines, and fostering stronger student/teacher relationships. Students participating in an integrated curriculum have demonstrated a more positive attitude about themselves & school. Similarly teachers are provided with a new opportunity to work together, increasing collegiality.

Characteristics of Integrated approach:-

1. Wide conceptual knowledge
   Integrated approach provides an opportunity for broader & wider conceptual knowledge.
2. Child-centered teaching

Integrated approach promotes child centered teaching

3. Integration of skills with contents
   Integrated approach of curriculum organization promote integration of skills with contents.
4. Teacher as a mediator
   The role of a teacher is mediator between knowledge and child.
5. Use of modern method
   The integrated approach requires use of modern methods of teaching such as inquiry based teaching.
6. Flexibility:-
   No rigid disciplines exist. Integrated approach is flexible.
7. Preparation of future citizens:-
   The main purpose of integrated approach is to prepare the future citizens of a society.
8. Openness:-
   The approach is open to new ideas and procedures.
9. Multi learning Environment:-
   The approach requires multi learning environment such as classroom, lab, outdoor, computer, internet etc.

Importance / Merits of integrated approach

1. Detailed conceptual understanding
   This approach help the learner to get detailed conceptual understanding of the content.
2. Choice based selection of discipline / subject
   Integrated approach help the students to select discipline / subject according to their own interest.
3. Creativity
   This approach foster creativity among learner.
4. Promotion of modern methods
   This approach promotes modern methods of teaching such as collaborative learning, cooperative learning etc.
5. Development of self concept & socialization
   Integrated approach helps in developing self concept & socialization
6. Realistic Application
   This approach has realistic applications.

Limitations of integrated approach

1. Time Consuming
   Integrated approach is time consuming as a single theme analysis is done with different discipline point of view.
2. Need of well equipped & expert teacher
   Integrated approach needs well equipped & expert teachers who are capable of using modern methods of teaching.
3. Create confusion
   If this approach is not handled carefully then child may get confuse in various disciplines.
4. Proper selection & organization of various disciplines
   Integrated approach needs expertise to select theme and organization of various disciplines.

1.7 Let us Sum Up

There is no definition of general science or science which is universally accepted. In general we can define science as an accumulated and systematized learning in general usage restricted to natural phenomenon. Science is the activity where truthfulness is obviously an essential condition for success. Its success is measured by its truthfulness. Today each and every occasion of life is influenced by science has become an integral part of our school education system.

Check your progress

1. Give any two definitions of general science.
2. Enumerate the areas influenced by science

   _____

   _____

   _____

   _____

3. State any five general objectives of teaching general science

   _____

   _____

   _____

   _____

   _____

   _____

4. Write specific instructional objectives for the topic “Chemical Change”

   _____

   _____

   _____

   _____

   _____

5. Write two approach of organizing science curriculum

   _____

   _____

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UNIT – II

METHOD OF TEACHING GENERAL SCIENCE

UNIT STRUCTURE

UNIT-II

METHODS OF TEACHING GENERAL SCIENCE

2.0 Objectives

After going through this unit, you will be able to:

- Develop an understanding of different methods of teaching science.
- Develop an understanding of lecture-cum-discussion method.
- Develop an understanding of laboratory method and its utilization in teaching of mathematics.
- Develop an understanding of importance of observation method in science teaching.
- Develop an understanding of project method.
- Develop an understanding of problem solving method.

2.1 INTRODUCTION:

I think teaching is an art and there are born teachers. But there are majority of teachers, who can improve upon by experience of practice and utilization of various methods of teaching science. The basic aim of teaching any subject is to bring about desired change in behavior. The change in behavior of child will be indicated through children's capacity to learn effectively. This is only possible by adopting various methods of teaching. The teacher cannot utilize any method to any type of students in any type of environment. He / She has to choose and adopt the right method of teaching keeping in mind the capability of the students and the curriculum. Thus, method in a way of presentation of the content in the classroom. But, it in however very important to keep in mind that a method is not an end in itself but is used to achieve the set aims of teaching. You should also keep in mind that, same method should not be used at all times but there should be flexibility in using it as for as situations circumstances, and condition in a particular case. You should use various methods depending upon demand of the situation. The method which in a particular class under a particular circumstance, may be a total failure for other teacher. However, some set criteria for selection of a method of teaching will be discussed further in the following paragraphs.

Principles for selecting methods:-

There are some guiding principles for determining teaching methods. They are as follows:-

1. Principle of sense of achievement through interest and purpose.
2. Principle of active cooperation.
3. Principle of capability of students of particular class.
4. Principle of realization of meaning of education i.e., “I bring up”, “I nourish”, “Drawing art”.
5. Psychological principle i.e., need, interest, of students.
6. Principle of individual difference i.e., different potentialities of students.

2.2 METHODS OF TEACHING GENERAL SCIENCE:-

All the methods of teaching science can be classified into two types:-

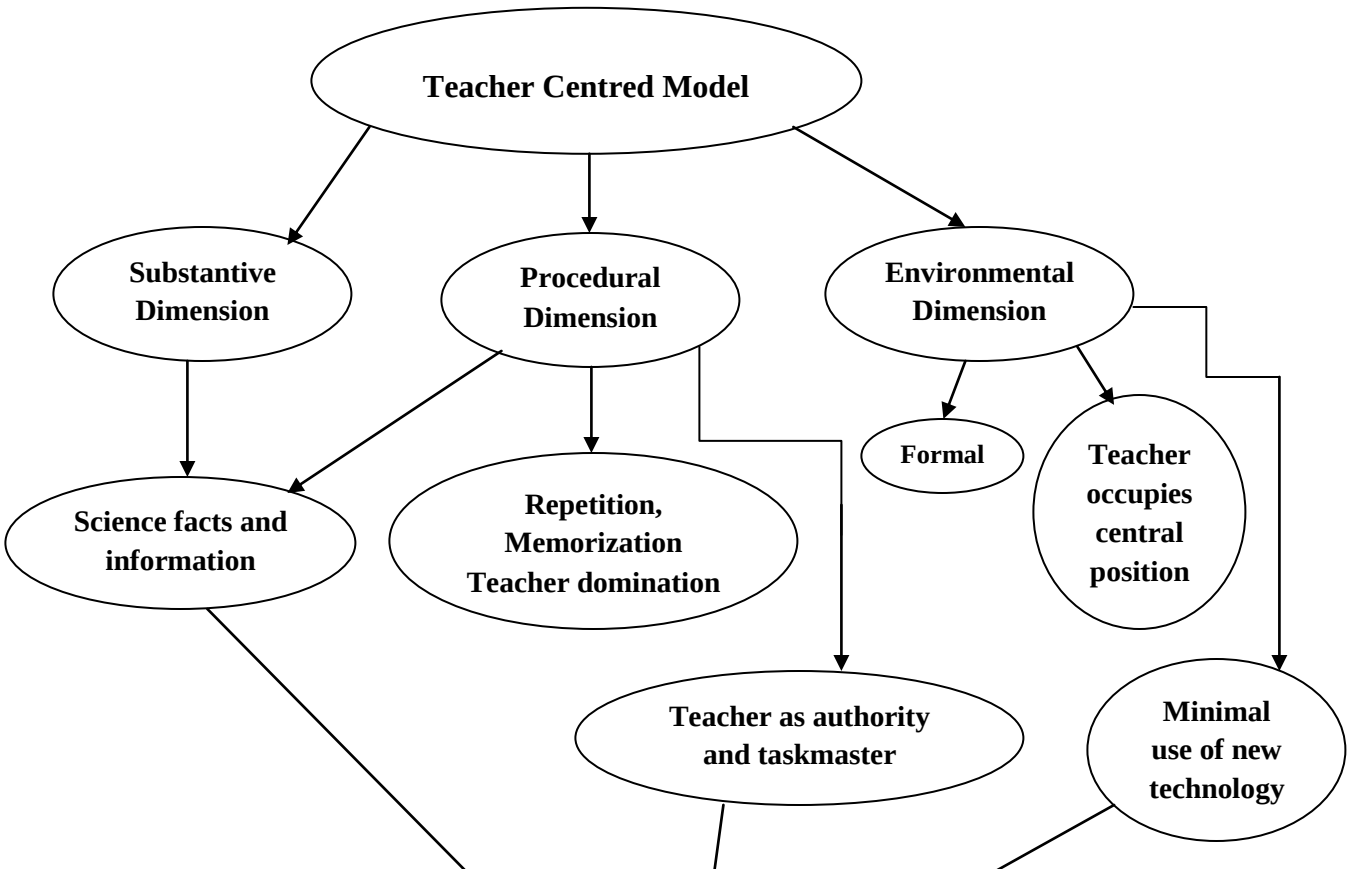
(i) Teacher-Centred and (ii) Pupil-Centred

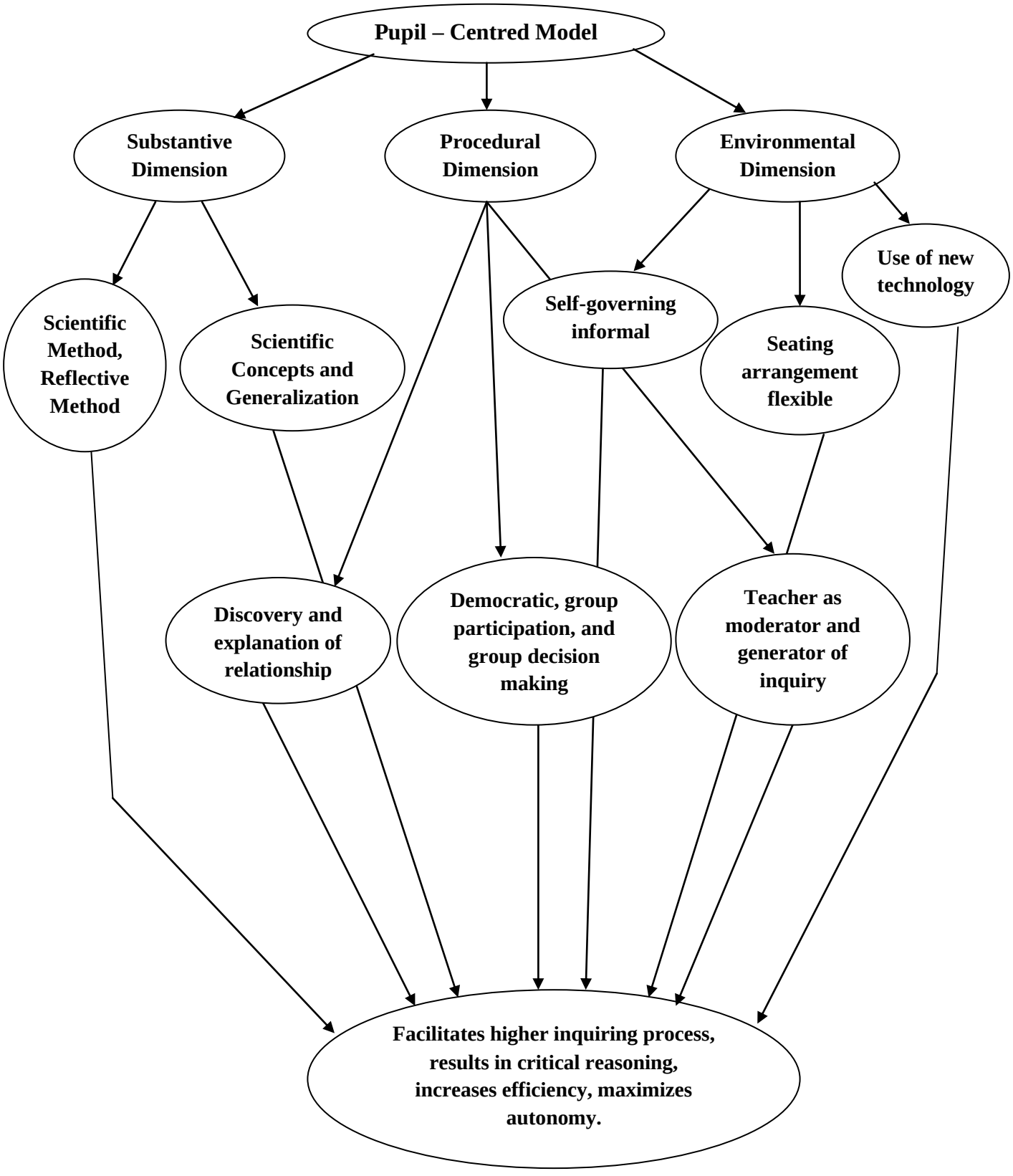
(i) Teacher-Centred Methods:-

This type of teaching methods focus on telling, memorizing, recalling informations. The students participation is very limited where in they only ask questions or answers questions. Most of the time the students are passive listeners and receive the knowledge. The teacher is centre of process that goes on in the classroom.

(ii) Pupil-Centred Methods:-

This process emphasizes on need, requirement, interest and capability of students. The students are active participants where in their skills and abilities are developed. The climate in the classroom is conducive where in flexibility in there. Teacher and students jointly explore the different aspects of problem. The role of the teacher in to create a problematic situation, have materials and resources available to the students, and help them identify issues, state hypotheses, clarify and test hypotheses and draw conclusions.




Pupil – Centred Model
Substantive Dimension
Procedural Dimension
Environmental Dimension
Scientific Method, Reflective Method
Scientific Concepts and Generalization
Self-governing informal
Seating arrangement flexible
Use of new technology
Discovery and explanation of relationship
Democratic, group participation, and group decision making
Teacher as moderator and generator of inquiry
Facilitates higher inquiring process, results in critical reasoning, increases efficiency, maximizes autonomy.

2.2.1 LECTURE-CUM-DISCUSSION METHOD:-

This method is a combination of lecture method and discussion method. This is very helpful in building an active verbal interaction between the teachers and students. The teacher delivers the lecture and provides some time (10 minutes) after the lecture for discussion among the students and teacher in the classroom. The student's views, comments experiences, problems, difficulties in understanding any point or portion of the lecture come to teacher's knowledge and teacher replies, and clarifies the doubts. It is an important strategy in stimulating the students interests and assess their understanding of the concept. It is a process in which interaction goes on in between teacher and students, where in question and answer are asked and given by both the teacher and students making the process interactive, and effective. The basic purpose of this method is to disseminate information and attain educational objectives by learning. The discussion in the class is intended to be a give and take between teacher and students. This method helps students to apply critical thinking power in various situations. Higher learning skills like analyzing, synthesizing, generalizing are given front seat.

PRINCIPLES OF LECTURE-CUM-DISCUSSION METHOD:-

The Principles are as follows:-

1. The teacher should be aware of needs of learners.
2. The teacher must arouse interest in the subject and sustain in the mind of students.
3. Teacher must use visual aids and use ICT.
4. The teacher must take enough time to build mental pictures, with new concepts, previous knowledge, moving from simple to difficult ideas, for better conceptual development.

ROLE OF TEACHER

The teacher has to perform following roles:-

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

MERIT OF LECTURE-CUM-DISCUSSION METHOD:-

1. It creates democratic environment in the class.
2. Develops and improves communication skills of students.

3. It brings about attitudinal change among students.
4. It helps in assessing the factual knowledge of the students.

LIMITATIONS OF LECTURE-CUM-DISCUSSION METHOD:-

1. It is helpful for mature students.
2. If it is not properly used, then the principle of “learning by participating” is not achieved.
3. If teacher does not handle students effectively then the students may be in disciplined rather than participation.
4. If not managed properly, it will not help all types of students in the class.
5. Teacher must control his emotions else this may result in wrong output.

SUGGESTION FOR IMPROVEMENT:-

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

2.2.2 LABORATORY METHOD:-

This method in commonly thought of as a hands on and minds on approach to teach science where in students have the opportunity to gain some experience with phenomena associated with their course of study. In this method either student participate alone or in small groups. They produce or manipulate various variables that are under exploration. The degree to which student has control over exploration can vary over a wide range. Here the students learn by actual doing rather than my observing the experiments. As young children do it by themselves, the experience is impressed more firmly in their minds. Thus this method in psychologically sound as it satisfies the natural urge for activity. This method broadens interest of the students. They learn many virtues through laboratory activity. The experience in a laboratory is very rich in personal satisfaction as they gain it firsthand. The sense of excitement and challenge help them to achieve some tangible him.

PRINCIPLES OF LABORATORY METHOD:-

1. It follows the principle of learning by doing.
2. It follows psychological principle, where students age, lord and interest is taken into consideration.
3. The work should be Pre-organized and Pre-selected.
4. Teacher must see that, students are allowed to work independently without much interference.
5. The teacher must ensure that apparatus and equipments should be checked pair hand.
6. Teacher must see that students are able to follow in struction and record their observation properly.

ROLE OF TEACHER:-

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

MERITS OF LABORATORY METHOD:-

The Merits are listed below:-

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

LIMITATIONS OF LABORATORY METHOD:-

The limitations of this method are as follows:-

1. It is expensive and uneconomical.
2. It is time consuming as it takes much time in some experiments to come to conclusion.
3. It expects a lot from students and teacher.
4. It does not guarantee that, students would be equally efficient in solving problems outside laboratory.
5. All students cannot be expected to be skilled workers.
6. Most of the students are either not ready or lack to ability to undertake original work.

SUGGESTIONS TO IMPROVE:-

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

2.2.3 OBSERVATION METHOD:-

In this method, the student observes and acquires knowledge. Through we cannot call this as a specific method of science teaching but as a matter of fact almost all science begins with observation the students observe nature, in groups, in lab at school at home or in gardens. The

result of this process information of a concept of nature which in permanent in mind. The training of pupils in observation is really strong his mind with suitable experiences all thoroughly classified and digested. Science provides remarkable. A raining in observation and reasoning. The learners reasons from the once established facts and form concepts about further observed phenomena .

PRINCIPLES OF OBSERVATION:-

It is based on following principles.

1. Principle of freedom.
2. Principle of experience.
3. Principle of play-way.
4. Principle of individual effort.
5. Principle of activity.
6. Principle of logical thinking.
7. Principle of purpose fullness.

ROLE OF TEACHER:-

A lot is expected / demanded of the teacher in this method:-

i) He must be man of knowledge and give adequate references for further observation.
ii) He should possess curiosity, scientific attitude, interest, sprit of investigation so as to inculcate such qualities among students who in term observe and discover many things.
iii) He must provide an atmosphere for freedom in the classroom in order to encourage students to make observations.
iv) He must be a guide, a working partner and friend of the students.
v) He should devise and plan different activities according to the age, ability and interests of the students.

MERIT OF OBSERVATION METHOD:-

1. The work of the teacher becomes interesting.
2. The students see think give logic and thoughtful answers.
3. The students learn the similarities and dissimilarities of objects clearly and easily.
4. The knowledge acquired in permanent.
5. Students develop interest in subject.
6. Students become self-dependent, self-reliant and self-confident.
7. The problem of home-work in solved.
8. The relation between teacher and taught becomes intimate and healthy.

LIMITATIONS OF OBSERVATION METHOD:-

1. It is too much to expect children observe and retain knowledge. The students are in nature sometimes and their knowledge and thinking power in limited.
2. It is not suitable for all the topic of science.
3. This method is information. The practical part of it remains underdeveloped.
4. It is not economical from time point of view.
5. This method is also not economical as it requires a lot of preparation and maintenance form school point of view. Where is students can observe many things.

SUGGESTION TO IMPROVE:-

1. The students must be given full freedom during observation.
2. Interest and curiosity must be developed in students prior to making observations.
3. The teacher must check and observe things beforehand.
4. The teacher must put questions and pinpoint students observation as and when required.
5. The school must have science corner where in students observation and activity goes on continuously.
6. A science bulletin board, A museum shelf, Aquaria and terraria must be there in school where in students develop a constant interest in the subject.
7. A weather station must be setup where in students observe the weather develop interest.

2.2.4 PROJECT METHOD

This method was propounded by W.H Kilpatrick. This method was perfected by J.A Sternson. The base of this method lies in the philosophy of pragmatism. This method emphasizes on building a comprehensive unit around an activity which may be carried out in school or outside. The essence of this method lies in the fact that a group of students do a purposeful task. This implies the students undertake the activity in a group or individually over a period of time. It may include a number of activities and the end product is in the form of written report or a display.

"A project is a whole-hearted purposeful activity proceeding in a social environment"- Dr. William Kilpatrick.

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

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

Thus, project is a purposeful activity and planned activity which is achieved in social, natural situations created in schools.

PRINCIPLES OF PROJECT METHOD:-

1. The Principle of freedom.
2. The Principle of purpose.
3. The Principle of activity.
4. The Principle of interest.
5. The Principle of utility.
6. The Principle of correlation.
7. The Principle of sociability.
8. The Principle of experience.
9. The Principle of reality.
10. The Principle of learning by doing.

TYPES OF PROJECT:-

All the project can be divided majorly into two types.

(i) Individual Project.
(ii) Group Project.

According to W.H. Kilpatrick projects are of four project.

i) Producer projects
ii) Consumer projects

iii) Problem projects
iv) Drill projects.

PRODUCER PROJECT: -

Here the emphasis is on actual construction of a material object or article.

CONSUMER PROJECT: -

Here the emphasis is gain on obtaining either direct or vicarious experience, such as reading and learning stories, listening to a musical delectation etc.

PROBLEM PROJECTS:-

The main purpose is to solve a problem using intellectual process, such as determining the density of a certain liquid.

DRILL PROJECTS: -

This type of project emphasizes on attaining a certain degree of skill in a reaction as learning a vocabulary.

Steps of Project Method:-

1. **PROVIDING A SITUATION: -**

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

2. **CHOOSING AND PURPOSING: -**

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

3. **PLANNING: -**

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

4. **EXECUTING: -**

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

5. EVALUATION: -

This is very important step as; the students review the project and find out mistakes if any. Self-Criticism is very important at this stage. The students discuss their work and rectify their mistakes and recollect useful knowledge. The teacher sees that the objectives of the project have been achieved.

6. RECORDING: -

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

EXAMPLES OF PROJECTS: -

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

ROLE OF TEACHER: -

1) Teacher must be a friend, guide and working partner.
2) Teacher must have through knowledge of individual student and allot work accordingly.
3) Provide democratic atmosphere.
4) He should learn with students and should not claim to know everything.
5) He must be inexperienced, initiative and process tact for creating positive ambience.

MERITS OF PROJECT METHOD: -

1) It promotes Co-operative activity.
2) It arouses and maintains interest of students.
3) It keeps the students on freedom of thought and action while doing the work.
4) It develops scientific attitude.
5) It widens the mental horizon of student.
6) It develops dignity of labour.
7) The students learn by self activity.
8) It supports all the laws of learning i.e., law of readiness, law of exercise, law of effect.
9) The correlation of subjects is best followed in this method. The subjects are not treated as water tight compartments.
10) This is a psychological method.

DEMERITS OF PROJECT METHOD: -

1. The knowledge is not acquired in a sequential manner.
2. There may be a chance of overlapping of subject matter.
3. If not planned and executed properly them, it may not be completed in time.

4. It is a time consuming process.
5. It may be a costly affair where in same items/things may not be available at times.
6. There may be overdevelopment of individualism and under development of co-operation and group responsibility.
7. If the topic in wrongly selected them the objective may not be achieved.
8. It gives to students a superficial knowledge of great many things. Therefore it is not suitable for all types of students.
9. This method is not suitable for a mature teacher.
10. The whole syllabus, for higher classes cannot be accomplished with this method.

SUGGESTIONS TO IMPROVE: -

1. The topic should have same educational value.
2. Project should be selected according to the student's interest.
3. Entire course should not be planned only using this method.
4. The objectives of the project must be clear and defined.
5. Students should be assigned various duties according to their capabilities.
6. The students should be given freedom to interact among themselves.

2.2.5 PROBLEM SOLVING METHOD: -

Science subject is one of the important subjects in school education. However, really the traditional teaching methods are challenged for their inability to foster critical thinking, holistic learning environment among children. The science subject must develop science process skills where children, observe, measure, classify, process information, interpret think on solving problems, analyze, synthesize, formulate conclusions, etc. but, it should be kept in mind that, creativity in an essential element of P.S.

In a problem solving method, children learn by working on problems. This enables the students to learn new knowledge by facing the problems to be solved. The students are expected to observe, understand, analyze, interpret find solutions, perform applications that lead to a holistic understanding of the concept. This method develops scientific process skills. This method helps in developing brainstorming approach to learning concepts.

The students thinking on problem and their understanding of the science behind it is based on common sense. It does not start from textual knowledge. Rather it proceeds from experiencing to gradually forming concepts through books at later stage. It is a process from practice to theory not vice versa. Knowledge here is not a goal but a natural out came of working on tasks. Students live in the real world and like to deal with concrete things where they can touch, feel manipulate things then the method is useful in igniting the process of science learning.

PRINCIPLES OF PROBLEM SOLVING METHOD: -

1. Principle of learning by doing.
2. Principle of purpose.
3. Principle of freedom of thought.
4. Principle of learning by experiencing.
5. Principle of utility.
6. Principle of scientific attitude.
7. Principle of interest.

8. Principle of reality.
9. Principle of concreteness.
10. Principle of objectivity.

STEPS IN PROBLEM SOLVING METHOD: -

1. Selection of problem.
2. Presentation of problem.
3. Collection of facts.
4. Drawing an outlines.
5. To reach a satisfactory conclusion.
6. Evaluation.
7. Writing report.

1) SELECTION OF THE PROBLEM: -

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

2) PRESENTATION OF PROBLEM: -

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

3) COLLECTION OF FACTS: -

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

4) DRAWING AN OUTLINE: -

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

5) TO REACH A SATISFACTORY CONCLUSION: -

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

6) EVALUATION: -

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

7) WRITING REPORT: -

A complete report must be written by students. This will include, how they planned, what discussions were held, how duties were assigned, how satisfactory conclusion was reached

etc. the writing of report will be maintained as a record which will be used in future course of time.

ROLE OF TEACHER: -

1. Teacher must work as a facilitator.
2. Teacher must keep in mind that if in a child-directed learning not teacher-directed.
3. Teacher must provide situation for all students to come formed and contribute towards the success of the activity.
4. He must be alert and active to arouse interest among students.
5. Teacher must provide democratic atmosphere.
6. He must be initialize, tactful and we experienced.

MERITS OF PROBLEM SOLVING METHODS: -

1. Students develop democratic feting.
2. This method follows the principle of learning by doing.
3. They learn to use old facts in new references.
4. They become capable to generalize.
5. Students learn to find solution to their problem.

DEMERITS OF PROBLEM SOLVING METHOD: -

1. It is not economical from time and money point of view.
2. There is always a doubt of drawing wrong conclusions.
3. There is short of talented teachers to practice this method.
4. This is not suitable for all level students.

SUGGESTIONS TO IMPROVE: -

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

2.3 LET US SUM UP: -

As we have seen all above methods have their pros and cons. But, effectiveness of teaching depends upon the method that teacher adopts. Group teaching does not happen over right. For effective teaching, knowledge of different methods of teaching science in essential. The teacher however must be free to choose any method that he thinks is suited to the students. For many decades now, which is not practiced i.e., creating excitement of science, use of new and innovative methods must be practiced now. Same are discussed here.

In lecture-cum-discussion method is best suited for all lords of students. The basic purpose of this method is to disseminate and encourage them to take part in the discussion.

However, teacher has to see that all students are given equal chance or else this will loose its charm.

In laboratory method, the student controls and observed the changes under investigation. Students learn by actual activity students learn many virtues through laboratory activity.

Observation method encourages students to develop a keen power of observation and acquire knowledge. This aims at training students mind to store suitable experiences for reasoning and establish facts observation of nature develops a sense of satisfaction and develops awareness towards protection of nature.

Project method has certain steps to be followed by students. This method in based on philosophy of pragmatism. The sense practicalism develops an attitude to undertake the activity and complete it scientifically.

Problem solving method develop skill of finding solutions to the problem on their own. The students thinking on problem and their understanding of the science behind anything helps them to solve problems of their life objectivity. Students live in the real world and like to deal with concrete things.

At the end, we can conclude that it is you teachers who have to keep in mind, which method is suitable to which type of students under what circumstance. Every method has its merits and demerits. The choosing of methods depends upon your intelligence, resource fullness.

UNIT AND EXERCISE: -

1. Discuss briefly the advantages and disadvantages of lecture-cum-discussion method.
2. Describe the laboratory method of teaching science keeping its merits and demerits in mind.
3. Identify a topic where in you can adept problem solving method.
4. “Observation develops optical reasoning and concentration power”. Explain?
5. Discuss the project method for teaching science. Illustrate it.
6. What are the merits and demerits of laboratory method of teaching science.

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TEACHING GENERAL SCIENCE

UNIT-III

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3.0 Objectives: -

In this unit, an overview of following points will be given to you. After reading this unit, you would be able to:

- Formulate instructional objectives of teaching science.
- Plan a teaching unit of science.
- Plan a lesson effectively according to different approaches.
- Know the process of developing improvised teaching aids in general science.

3.1 Introduction: -

If you are keen in making lesson plans which may help you in achieving your identified objectives, then they should be stated clearly. If objectives are not clearly defined, it is impossible to evaluate a student, a lesson, a unit, a course or a programme effectively. This leads to teaching disaster. Unless you have clear picture of instructional intention, you will be unable to select test items it the objectives are clearly defined, then students know which activities are relevant for success of the teaching learning process.

A meaningfully stated objective is that clearly communicate the readers the writer's intention- It states the behavioral outcome students after completing a chapter. The most important characteristics of useful objectives are that it identifies the kind of performance that will be accepted as evidence that the learner has achiever the objective.

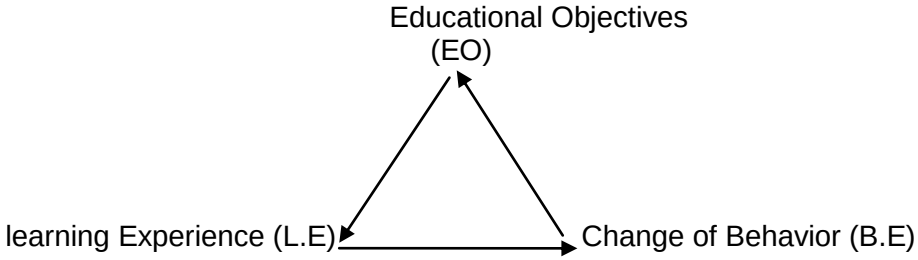
According to B.S. Bloom

"Educational objectives are not only the goals towards which curriculum is shaped and towards which instruction in guided, but they are also the goals that provide, the detailed specification for the construction and use of education techniques".

According to E.J. Frust,

"An educational objective may be defined as a desired change in behavior in a person that we are trying to bring about through education".

If we look back at the objectives of teaching science in early twentieth century, then we see major stress was on teaching of facts. As the time passed and various committee and commissions recommended changes according to need of changing time, still we see the stress was on acquisition of knowledge.



This show learning experiences are provided by teaching activities to achieve educational objectives and change of behavior is evaluated in terms of educational objectives.

Objectives are of two types: -

i) Educational Objectives.

ii) Teaching / Instructional Objectives.

Educational Objectives: -

These objectives are broad and related to educational system and school.

Teaching / Instructional Objectives: -

These objectives are narrow and specific and are concerned with classroom teaching. The educational objective stretches to a longer period of time say from primary level to university level, where as instructional objectives may be realized within the stipulated period of 40 minutes duration. For example – Educational objectives is “To develop the feeling of national integration”. This includes several teaching objectives like knowledge, understanding, application, interest, attitude of national integration.

3.2 Formulation of instructional objectives: -

Benjamin S. Bloom has divided the cognitive objectives into six categories. But, instructional objectives are related to classroom objectives we will see them one by one.

(A) Classroom Instructional Objectives: -

1. The pupil acquires knowledge of scientific facts, terms, concepts, principles, theories.

Specifications: -

i) The pupil recalls……
   a) The facts, terminology.
   b) The definition of various laws, principles.
   c) The names of different parts of flower, leaf, plants.
   d) The concept of classification of substances.
   e) The names of types of diseases.

ii) The pupil ‘lists all the elements on the periodic table.

iii) The pupil recognizes……
   a) Different apparatus used in various experiments.

2. The pupil develops an understanding of various scientific terms, facts, definitions, concepts, laws, theories, procedures, etc.

Specifications: -

i) The pupil sees a relationship between different facts, concepts i.e., mass and volume.
ii) The pupil cites examples of metals and metalloids.
iii) The pupil classifies plant kingdom and animal kingdom.
iv) The pupil selects appropriate for performing experiment.
v) The pupil compares the characteristic of metals, non-metals etc.
vi) The pupil defects errors in a given example.
vii) The pupil rectifies errors in a given statement, diagram, formula, example etc.
viii) The pupil verifies the answer by substituting the values in a given problem or equation.
ix) The pupil uses an appropriate method to solve a problem, to do titration.
x) Pupil cites illustrations of different types of chemical equations.

3. The pupil applies his knowledge and understanding in new and unfamiliar situation.

Specifications: -

i) The pupil analyses the given example into what in given and what to be found out.
ii) The pupil formulates hypothesis to organize the elements.
iii) The pupil collects relevant data related to a hypothesis.
iv) The pupil selects relevant data, i.e., facts and principles for a particular situation eg. Relationship among different group elements.
v) The pupil judges the adequacy of data or procedure or apparatus eg. to check laws of reflection, refraction, etc.
vi) The pupil suggests new illustrations for different types of llences, propagation of lights etc.
vii) The pupil predicts various applicability of laws.
viii) The pupil solves the problems on velocity, momentum, etc.
ix) The pupil interprets various graphs, charts etc.
x) The pupil translates statements into symbols.

4. The pupil develops the skills required for science learning.

Specifications: -

i) The pupil checks the feasibility on instruments before using them.
ii) The pupil rectifies the defects in the instruments e.g. the presence of air bubble in the burette during titration.
iii) The pupil sets up appropriate apparatus for perform different experiment.
iv) The pupil measures with reasonable accuracy the length of pendulum and period of oscillations.
v) The pupil reads the log table, mathematical symbol, different tables.
vi) The pupil records the observation accurately and neatly.
vii) The pupil makes accurate observations while reading graphs, tables etc.
viii) The pupil uses the relevant data to reach at a solution.
ix) The pupil draws conclusions.
x) The pupil summarizes observations after the experiment.

B) Personality Objectives

5. The pupil develops interest in science.

Specifications: -

i) The pupil reads, on his own, a number of books, magazines, newspapers related to scientific information.
ii) The pupil visits places of scientific importance and interest e.g. planetarium, laboratories, science centres etc.
iii) The pupil participates in activities like debates, projects, talks, elocution, in or out side school.
iv) The pupil collects, picture, specimens, data, of scientific importance from books, journals, gardens etc.
v) The pupil prepares models, charts, pictures etc.
vi) Contributes exhibits censuring scientific facts for display in or outside schools.
vii) The pupil writes articles, news items related to scientific concepts.
viii) The pupil prefers to attend to programme related to science on TV, Radio, etc.
ix) The pupil meets scientist astronauts etc.
x) The pupil helps in maintenance of a science laboratory, science club, museum, herbarium etc.

6. The pupil develops positive scientific attitude.

Specifications: -

i) The pupil respects research finding or new approaches contrary to existing theory.
ii) The pupil accepts those conclusion based on logical reasoning.
iii) The pupil expresses his ideas in a logical sequence.
iv) The pupil arrives at a judgment after weighing all possible evidence carefully.
v) The pupil considers new ideas, discoveries, inventions free from prejudice.
vi) The pupil reconsiders his own judgments and beliefs in the light of new knowledge and theories.
vii) The pupil cooperates with others in arranging scientific, models, charts, materials, etc in proper places.
viii) The pupil faces problems with full confidence.

7. The pupil appreciates the contribution of science in every walk of life and knowledge.

Specifications: -

i) The pupil expresses his appreciation of man's effort to conquer nature and natural forces.
ii) The pupil recognizes the contribution of scientists to the modern world.
iii) The pupil derives a sense of pleasure in understanding the achievement of science e.g. god particle, travel to space, satellites etc.

Check your progress: -

1. Define educational objectives.
2. What is instructional or classroom objective?

3.3 Unit Planning: -

"A unit is as large a block of related subject matter as can be over viewed b the learner".

➢ Preston

‘Outline of carefully selected subject matter which has been isolated because of its relationship to pupils.

- Sanford

“The unit is an organized body of information and experience designed to effect significant outcomes for the learner”.

- Wisely

Thus, a teaching unit keeps in view the needs, capabilities and interest of pupils. It provides organized body of information and experience. This aims at significant outcome from the learners.

Points to be kept in mind while planning for a unit: -

1. It must be related to social and physical environment of the pupils.
2. It must take into account the previous experiences of pupils.
3. It must provide now experiences to the pupils.
4. It must not be too lengthy, so that pupil’s interest is sustained.
5. It should be flexible so as to allow different types of students to explore their capacities.
6. It should be the result of cooperative planning of teacher and pupil as far as possible.

Steps of Developing a Teaching Unit

1. **Preparation or motivation: -**
   The pupils establish the purpose and one motivated to achieve it. The motivation must be self-directed. This is required throughout the lesson.
2. **Knowing the previous experience: -**
   It is always advisable to start with the pupils where they are this is helpful in knowing the background so that duplication or danger of non-understanding can be arrived. This can be done by questioning.
3. **Presentation: -**
   In this step new experiences are given to the students. These may be direct or vicarious care must be taken to present adequate amount of new experience that can be digested by pupils.
4. **Organization of learning: -**
   The student should get opportunity to bring their learning together so that they may establish relationship between the new experiences and assimilate them.
5. **Summarization: -**
   This is usually done at the end of the teaching unit to bring together all the learning. This may be done at internals during the progress of the unit organization and summarizations go together.
6. **Review and drill: -**
   During the progress of unit, there is a chance of forgetting some part of it and not comprehending same. This requires to review or drill the new content taught for better retention from time to time during the lesson.
7. **Evaluation: -**

Evaluation should be done to know the level of achievement of students. This can be done either by written from or oral form after short intervals. i.e., after a week or fortnight. This can also be done by interview self-check test, puzzles etc. The final test given grades to the pupils and tests effectiveness of teaching.

Proforma for Teaching Unit

Subject: - **Standard: -**

Name of the Unit: -
Major objectives of the Unit: -

Sl. No.	Topics	No. of lessons required	Time required (periods)	Scope of subject content	Procedure to be adopted (Method of teaching)	Teaching Aids
1						
2						
3						
4						

Specimen Unit Plans

Subject – Biology
Class –
Name of
the unit – Reproduction in Plants.

Major Objectives of the unit: -

i) Pupils develops understanding and appreciate the vegetative and the, sexual mode of reproduction in plants.
ii) Develop skills of observation, experimentation.
iii) Develop interest in nature.
iv) Develop investigatory method of doing things.

Concepts	No of lessons	Time required	Scope of content	Teaching Aids
1	2	3	4	5
1. Pollution is first step in sexual reproduction	One	One period	Unisexual and bisexual flowers, different seasonal flowing plants, pollination, process, types and factor's responsible.	Fresh or preserved specimen's of unisexual and bisexual flowers chart showing seasonal plants chart showing self and cross pollination.
2. Pollination takes place through a no. of way	One	Two period	Agencies of pollination, characteristics of flowers pollinated by mind and insects, artificial pollination, and germination on stigma.	Chart or film showing pollution by mind and insects, specimens of salvia flower, mounted needles, forceps, brushes, watch-glass etc.

3. Fertilization in caused due to fusion of male nucleus with egg cell.	One	One period	Structure of pollen grain and its germination on 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 vegitatively.	One	One period	Concept of vegetative reproduction, vegetative reproduction in steps and leaves, advantages of vegetative reproduction, over sexual reproduction vegetative & asexual reproduction budding.	Different underground stems. Asparagus, dahlia, Bryophyllum slides and charts of different modes of reproduction like, budding fragmentation spore format.
5. Vegetative propagation in plants	One	Three period	Artificial ways and vegetative propagation cutting, layering, and grafting, their demonstration and practice by students.	Various specimens and implement to demonstrate cutting, laying and grafting chart showing three way of propagation.

Check your progress: -

1. Prepare a unit plan on living things.

2. Prepare an unit plan on properties of gases.

3.4 Lesson Planning: -

Proper planning of the lessons in key to effective teaching. A daily lesson planning consists of teaching points, specification to be achieved, organization of an orderly sequence of learning activities, actual test items to which pupils are to be exposed Lesson Planning is essential because, effective learning takes place only if content in presented in an integrated and correlated manner G.H. Green says “The teacher who has planned his lesson wisely related” to his topic and to his classroom without any anxiety, ready to embark with confidence upon a job he understands and prepared to carry in to a workable conclusion. He has foreseen the difficulties that are likely to arise, and prepare himself to deal with them. He knows the aims that lesson is intended to fulfill, and he has marshaled his own resources for the purpose. And because he is free of anxiety he will be able to estimate the value of his work as lesson proceeds, equally aware of failure and success and prepared to learn from both.

A daily lesson plan is confined to only one period. The contention presented in the form of teaching points. The learning activities discussed in detail. The test items may be in the form of an essay or short answer or objective type questions.

Suggestions to improve lesson plan: -

1. It is important to highlight only the key concepts or relation and save most of the time for them.
2. It must be made in the context of overall unit plan and should be continuous from day to day.
3. To make the lesson plan fit a long-range schedule the teacher must give careful attention to important ideas of the textbook for a particular day.

Steps in lesson planning (Herbartion steps)

1. Introduction: - This stage prepares the students for new knowledge. This step is important but, must be brief. It must test previous knowledge of the child. Curiosity of pupils can be aroused by some experiment, chart, model, story, discussion etc.
2. Presentation: -
   The actual lesson begins at this stage. The teacher makes use of different teaching aids to make lesson effective. Teacher must involve students to make lesson interesting.
3. Association: -
   The new ideas must be associated with daily life situation by citing suitable examples and drawing comparison with related concepts. This step is important as principles are established.
4. Generalization: -
   An effort must be made so that, students draw the conclusion themselves. Teacher should guide the students only if their generalization in either incomplete or irrelevant.
5. Application: -
   The knowledge gained through the lesson must be applied to certain situations. This step is conformity with the general desire of the students to make use of generalization in order to see for themselves if the generalizations are valid in certain situations or not?
6. Recapitulation: -
   At this last stage, teacher tries to ascertain whether his students have understood and grasped the subject or not. This cheeks the effectiveness of the lesson.

   All these six steps are herbartion try gives for lesson planning. Teacher can guide lines and in many lessons it is not possible to follow all the methods

Advantages of lesson plan: -

1. It stimulates the teacher to ask questions.
2. It provides freedom in teaching.
3. In induces confidence among teachers.
4. Lesson planning make the work, regular, organized and systematic.
5. It saves a lot of time.

Sample proforma for lesson plans: -

1. For problem solving method: -

   Sub: - Topic: -
   Class: - Time: -
   Objectives: -
   Instructional material: -

- Creating a situation or posing problem:
- Defining and delimiting the problem:
- Collecting and interpreting data:
- Formulating hypothesis:
- Experimentation (Test of hypothesis) : -
- Drawing conclusion:
- Generalization and application:

2. **Laboratory Method: -**
   Sub: - Topic: -
   Class: - Time: -
   Objectives: -
   Material required: -
   Introduction: -
   Direction for the experiments: -
   Grouping students: -
   Demonstration (If required): -
   Guidance and supervision during laboratory work.

3. **Lecture cum Discussion method:-**
   Sub: - Topic: - Class:-
   Time: - Objective:-
   Pervious knowledge:-
   Introduction (motivation):-
   Assignments to each group for self-study
   Date and period for discussion:-
   Initiation of discussion by teacher
   Discussion by each group in turn:-
   Role of teacher:-
   Main learning points:-
   Evaluation:-
   Follow- up assignments:-

Check your progress:-

1) What are the advantages of preparing lesson plans?
2) What are the determinants of effective teaching? Explain.

3.5 Improvisation of teaching Aids in general science:-

"Necessity in the mother of invention, new emerging needs of science teaching, therefore, calls for improvisation."

-Unesco Source Book
for science Teaching

The important objectives of teaching science into arouse the students' attitude and interest towards science .It is possible only when students do something themselves use some improvised apparatus and make save improvements in them. It is obvious that, unless students perform practical activities, they will not understand the facts, laws and principle of science. Therefore students must prepare or improvise apparatus after studying theory properly according to their ability and interest these apparatus can be prepared out of ordinary, inexpensive items. Such apparatus which students prepare themselves with the help of teachers which are inexpensive and display same process of science are called as improvised apparatus.

Many great scientists like, Madam Curie, Dalton, Priestly, Edison, carried out their experiment successfully in the humblest conditions.

Characteristics of improvised apparatus:-

1) The material in simple, accurate and appropriate to the age tends of the users.
2) The process involved in the production of materials in simple and inexpensive.
3) The materials can be easily and effectively used by the teachers and pupils.
4) The raw materials are easily available in the local environments.
5) The materials don't involve specialization skills and can be made by pupils and teachers easily.
6) The production of materials is not time consuming.
7) The material is free from distractions conflicts or bias.

Need/Importance of improvised Apparatus:-

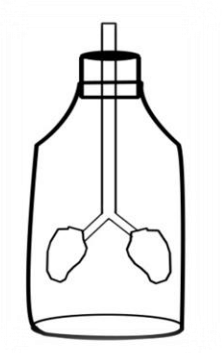
1. Economic Value-these items are prepared art of materials which are considered to be waste or low cost. Thus they have great economics value "Best art of waste"
2. Social value: - The construction of these materials follows the principle of learning by doing. The habit to work together without any disporting in formed and the child moulds himself according to the needs of society and moves towards the goal of socialism.
3. Recreational Value: - Students do the work on their own they keep themselves occupied and utilize their leisure time. Thus, it has got recreational value

4. Practical Value: - While constructing apparatus, they became; organized. They themselves discovered new apparatus, can produce according to the needs, repairs old apparatus can also take interest of doing more.
5. Educational and psychological value: - The improvised apparatus provide opportunities for the exercise and development of ingenuity and the resourcefulness. The pupil find new way of applying their knowledge. They learn to think critically and scientifically.

   Coordination of hands and heads develops as sense of confidence and constructive and creative instincts of pupils are satisfied. They energy of the child in channelized in a proper way.
6. Scientific Value: - The students develop interest in scientific activities and in turn they gain scientific knowledge.

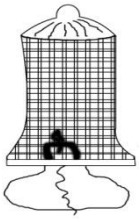
<u>Examples of Improvised Apparatus:-</u>

1. **Working model of lungs: -** Cut bottom of a large plastic B bottle. Fit a cork to the neck with "Y" tube in it. On both side of "Y" tube tie a rubber balloon or some small bladder. Tie a sheet of brown paper or rubber sheet the bottom of the bottle, with piece of string knotted through a hole and sealed with wax. Pulling this string lower the diaphragm and air enters the neck of "Y" tube and balloons dilate. Pressing the diaphragm upwards has the opposite effect.

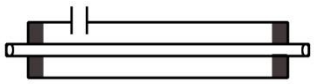


2. **Astronomical Telescope: -** Take two card board tubes are fitting each other. Fin two tenses of different focal lengths at the end of each tube. The lens of law focal length says 2cm & 3cm serves as the edge piece and of 15-30 cm as object lens.

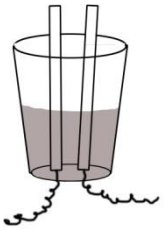
3. **Davy's safety lamp: -** Take an ordinary spirit lamp empty tin box/empty ink-pot and surrender the flame by wire gaze preferably of copper.



4. **Liebig's condenser: -** Take metallic pipe of required length and diameters make two holes on each end. One for inlet and other for armlet. Solder two small tubes are on each hole. Fix the cork at each end.



5. **Voltmeter: -** Take a plastic glass and make two holes at bottom. Insert two copper wires one in each hole. Fill the glass with acidulated water and invert two test tubes of water one on each wire. Connect wire to two terminals of batting; water will begin to decompose into oxygen and



hydrogen.

6. **Dropping Funnel: -** Take a glass or plastic funnel fit rubber tubing to the funnel. Attach glass tube to it. Attach pinchcock.

LIST OF ITEM THAT CAN BE IMPROVISED.

Physics: -

1. Thermos Flask
2. Thermo Couple
3. Telescope
4. Telegraph system
5. Spectroscope
6. Ripple tank
7. Periscope
8. Kaleidoscope
9. Hydrometer
10. Dip circle
11. Brain
12. Calorimeter
13. Telephone model
14. Steam engine
15. Pascal's law apparatus
16. Pinhole camera
17. Galvanoscope
18. Electric ball
19. Automatic signal
20. Aneroid barometer
21. Gold leaf electroscope
22. Strom finder
23. Air oven
24. Rain gauge
25. A simple refraction bottle

Chemistry: -

1. Fire extinguisher
2. Model of atoms
3. Sand baths
4. Test tube stands
5. Bunsen burner
6. Apparatus for preparing & collecting gas.
7. Wick holders

Biology: -

1. Osmometer
2. Photometer
3. Preparation of simple slides of plants and animals.
4. Models of plants, animals, etc.

Check your progress; -

1. Name save improvised apparatus.
2. Why improvised apparatus are encouraged for students?

3.6 Let us Sum Up: -

In this unit, we have discussed about formulation of instructional objectives, unit planning, lesson planning and improvisation of teaching aids in general science.

As we know the objectives of teaching science have been changing from time to time the rapid progress of science and technology has changed the objectives of teaching science in school. However major instructional objects remain more or less same. They import fundamental knowledge. Inculcate scientific attitude. Instructional objectives aims at imparting training in scientific method or reflective thinking.

The unit planning involves certain steps. As a unit in a block of related subject matter which are so organized to help divide the syllabus into small workable sections.

For an effective and efficient teaching, planning in essential. This helps teacher to gain confidence. The teaching becomes systematic and organized. The teacher proceeds in a wel chalked out guidelines.

Last but not the least this unit has improvisation of teaching aids in general science, which is the need of time. In the view of economic constraints the developing countries cannot provide all the necessary equipment and materials of science. Many countries are now emphasizing on development of low-cost science materials using locally available resources.

UNIT END EXERCISE

1. State the objectives of teaching science specify each objective in terms if classroom objectives.
2. What is the new of writing objectives in behavioral terms?
3. State the objectives of teaching science topics like volume, density, reflection of light and specify each objective in terms of at least three specifications.
4. What do you understand by unit planning? What steps should be followed in preparing a unit plan?
5. Prepare unit plans for nutrition in plants and animals.
6. What are the various steps of preparation in lesson planning?
7. Discuss different proforma for lesson planning.
8. Discuss the new and importance of improvised apparatus for teaching of science at high school level.
9. What are the characteristic of improvised apparatus? Explain four improvised science apparatus.

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1. Das, R.C. Science teaching in Schools, sterling publication PVT. Ltd. 1985.
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3. Sharma, R.C. Modern science teaching, Dhanpat Rai Publishing company (P) ltd, New Delhi, 2006.
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UNIT -4 EVALUATION IN GENERAL SCIENCE

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4.1.1Introduction:

Evaluation is a methodological area that is closely related to, but distinguishable from more traditional social research. Evaluation utilizes many of the same methodologies used in traditional social research, but because evaluation takes place within a political and organizational context, it requires group skills, management ability, political dexterity, sensitivity to multiple stakeholders and other skills that social research in general does not rely on as much. Here we introduce the idea of evaluation and some of the major terms and issues in the field.

4.1.1.a. Objectives/Learning Outcomes

- To explain types of formative and summative evaluation in science
- To classify different types of evaluation in science.
- To make effective use of objectives for achievement tests in science.
- To develop competency through effective use of achievement tests in science.

4.1.2 Definitions of Evaluation

Probably the most frequently given definition is:

Evaluation is the systematic assessment of the worth or merit of some object

This definition is hardly perfect. There are many types of evaluations that do not *necessarily* result in an assessment of worth or merit -- descriptive studies, implementation analyses, and formative evaluations, to name a few. Better perhaps is a definition that emphasizes the information-processing and feedback functions of evaluation. For instance, one might say:

Evaluation is the systematic acquisition and assessment of information to provide useful feedback about some object

Both definitions agree that evaluation is a *systematic* endeavor and both use the deliberately ambiguous term 'object' which could refer to a program, policy, technology, person, need, activity, and so on. The latter definition emphasizes *acquiring and assessing information* rather than *assessing worth or merit* because all evaluation work involves collecting and sifting through data, making judgments' about the validity of the information and of inferences we derive from it, whether or not an assessment of worth or merit results.

Check your progress

Read the following and answer the question:

Q1)What do you mean by Evaluation?

4.1.3 The Goals of Evaluation

The generic goal of most evaluations is to provide "useful feedback" to a variety of audiences including sponsors, donors, client-groups, administrators, staff, and other relevant constituencies. Most often, feedback is perceived as "useful" if it aids in decision-making. But the relationship between an evaluation and its impact is not a simple one -- studies that seem critical sometimes fail to influence short-term decisions, and studies that initially seem to have no influence can have a delayed impact when more congenial conditions arise. Despite this, there is broad consensus that the major goal of evaluation should be to influence decision-making or policy formulation through the provision of empirically-driven feedback.

4.1.4 Types of Evaluation

There are many different types of evaluations depending on the object being evaluated and the purpose of the evaluation. Perhaps the most important basic distinction in evaluation types is that between ***formative*** and ***summative*** evaluation. Formative evaluations strengthen or improve the object being evaluated -- they help form it by examining the delivery of the program or technology, the quality of its implementation, and the assessment of the organizational context, personnel, procedures, inputs, and so on. Summative evaluations, in contrast, examine the effects or outcomes of some object -- they summarize it by describing what happens subsequent to delivery of the program or technology; assessing whether the object can be said to have caused the outcome; determining the overall impact of the causal factor beyond only the immediate target outcomes; and, estimating the relative costs associated with the object.

4.1.4(a) FORMATIVE EVALUATION

Formative evaluation is primarily a building process which accumulates a series of components of new materials, skill, and problems into an ultimate meaningful whole

-Wally Guyot

Formative evaluation (sometimes referred to as internal) is a method of judging the worth of a program while the program activities are *forming* (in progress). This part of the evaluation focuses on the process. Thus, formative evaluations are basically done on the fly. They permit the designers, learners, and instructors to monitor how well the instructional goals and objectives are being met. Its main purpose is to catch deficiencies so that the proper learning interventions can take place which allows the learners to master the required skills and knowledge. Formative evaluation is also useful in analyzing learning materials, student learning achievements, and teacher effectiveness. In this sense formative evaluation is a part of the instructional process, underpinning the importance of student involvement. Students need to be involved both as assessors of their own learning and as resources to other students bringing into focus the importance of self and peer assessment besides teacher assessment. Research shows that the involvement in and ownership of their work increases students' motivation to learn. The most significant advantage of formative evaluation is that it makes learning an enjoyable experience because of student involvement, enhanced learning.

Formative evaluation is a tool used by the teacher to continuously monitor student progress in a non threatening, supportive environment. It involves regular descriptive feedback, a chance for the students to reflect on their performance, take advice and improve upon it. It involves students' being an essential part of assessment from designing criteria to assessing self or peers. If used effectively it can improve student performance tremendously while raising the self esteem of the child and reducing the work load of the teacher.

4.1.4(b) SUMMATIVE EVALUATION

All assessments can be summative (i.e., have the potential to serve a summative functions.

-Scriven(1967)

The summative evaluation (sometimes referred to as external) is a method of judging the worth of a program at the end of the program activities (summation). The focus is on the outcome. The

various instruments used to collect the data are questionnaires, surveys, interviews, observations, and testing. The model or methodology used to gather the data should be a specified step-by-step procedure. It should be carefully designed and executed to ensure the data is accurate and valid.Questionnaires are the least expensive procedure for external evaluations and can be used to collect large samples of graduate information. They should be trialed before using to ensure the recipients of the questionnaire understand their operation the way the designer intended. When designing questionnaires, keep in mind the most important feature is the guidance given for its completion. All instructions should be clearly stated...let nothing be taken for granted. Summative evaluation constitutes a public recognition of achievement and we are fairly familiar with most of the tools and procedures of summative evaluation. However, many teachers may find it a challenge to develop effective formative evaluation tools; they may also experience some difficulties in integrating them with classroom instruction.

Summative evaluation is carried out at the end of a course of learning. It measures or 'sums up' how much a student has learned from the course. It is usually a graded test, i.e., it is marked according to a scale or set of grades. Assessment that is predominantly of summative nature will not by itself be able to yield a valid measure of the growth and development of the child. It, at best, certifies the level of achievement only at a given point of time. The paper pencil tests are basically a one-time mode of assessment and to exclusively rely on them to decide about the development of a child is not only unfair but also unscientific. Over emphasis on examination marks focusing on only scholastic aspects makes children assume that assessment is different from learning,resulting in the 'learn and forget' syndrome. Besides encouraging unhealthy competition, the overemphasis on Summative Assessment system also produces enormous stress and anxiety among the learners.

Check your progress

Read the following and answer the question:

Q2)Distinguish between Formative and Summative Evaluation?

4.1.5 Tools and Techniques of Formative Evaluation and Summative Evaluation in Science

Formative Evaluation(Flexible Timing)		Summative Evaluation (Written-End of term)
Tools	Techniques	
Objective type	Tests	Objective type
Short Answer	Assignments	Short Answer
Long Answers	Quizzes and Competitions	Long Answers
Questions	Projects	
Observation schedule	Debates	
Interview schedule	Elocution	
Checklist	Group discussions	
Rating scale	Club activities	
Anecdotal records	Tests	
Document Analysis	Assignments	
Tests and inventories	Quizzes and Competitions	
Portfolio analysis		

Activity

Read the following and answer the question:

Write down about the various types of Evaluation in Science?

Evaluation -Suggested Assessment Tools and Techniques in Science

Experiments, Information gathering and deducing, Presentations on science concepts/ experiments, Investigations for stated problems,MCQs and Science Quiz, Simple and interesting assignments, Group assignments and projects, Model Making, Science symposium/ seminar, Preparation of various compounds/salts, Explanation of different natural phenomenon using scientific principles.

• Class Response Assessment worksheets

Demonstration based, Graph based, Diagram based, Numerical based, Flow chart, Crossword puzzle/games, Writing of Balanced chemical Equations/Formulae/Units,MCQs

• Active-learning assessment tools

Model making, Chart making,Assignments,Popular Science Book Review, Current Science events/news report, Hands-on practical examination, Class work/home work Assessment, Group work - Seminar/Symposium/Presentation/Bulletin Board Display/Role Play, Survey/Field Visit, Project Work-Group or individual, Short formal written Paper-pen test.

SUMMARY:

Evaluation is an act or a process that allows one to make a judgment about the desirability or value of a measure. Educational evaluation is defined as a systematic, continuous, comprehensive process of determining the growth and progress of the pupils towards objectives or value of the curriculum. Formative evaluation is thus carried out during a course of instruction for providing continuous feedback to both the teachers and the learners for taking decisions regarding appropriate modifications in the transactional procedures and learning activities. Summative evaluation is carried out at the end of a course of learning. It measures or 'sums up' how much a student has learned from the course. It is usually a graded test, i.e., it is marked according to a scale or set of grades. Thus, there are many Implications of Evaluation: namely it helps the administrator-recognize learner's needs, guidance, helps the teacher-diagnosis, modification of the curriculum, helps the learner-unfolding of the learner's abilities, helps the parents-feedback to take relevant steps.

4.2 DEVELOPMENT OF OBJECTIVES FOR ACHEIVEMENT TESTS IN SCIENCE

The purpose of achievement testing is to measure some aspect of the intellectual competence of human beings: what a person has learned to know or to do. Teachers use achievement tests to measure the attainments of their students. In any circumstances where it is necessary or useful to distinguish persons of higher from those of lower competence or attainments, achievement testing is likely to occur. The varieties of intellectual competence that may be developed by formal education, self-study, or other types of experience are numerous and diverse. There is a corresponding number and diversity of types of tests used to measure achievement. In this article attention will be directed mainly toward the measurement of cognitive achievements by means of paper and pencil tests. The justifications for this limitation are (1) that

cognitive achievements are of central importance to effective human behavior, (2) that the use of paper and pencil tests to measure these achievements is a comparatively well-developed and effective technique, and (3) that other aspects of intellectual competence will be discussed in other articles, such as those on motivation, learning, attitudes, leadership, aesthetics, and personality.

4.3 OBJECTIVES FOR ACHEIVEMENT TESTS IN SCIENCE:

1) To test the understanding of the pupil to the world in which he lives and the impact of science on society so as to enable him to adjust himself to his environment.
2) To test the acquaintance of the pupil with the scientific method and to enable him to develop the scientific attitude.
3) To test the acquisition of experimental skills such as_
   a) Handling the apparatus and the instruments.
   b) Arranging the apparatus for an experiment
   c) Preserving apparatus , chemicals, specimens, models etc.
4) To test the acquisition of instructional skills such as:-
   a) Improving simple instruments and appliances
   b) Repairing certain instruments and appliances of everyday use.
5) To develop drawing skills such as:-
   a) Drawing and sketching certain objects and instruments
   b) Photography in certain objects and specimens.
6) To test the power of oral expression in science so as to discuss, argue, describe and raise questions using scientific terminology.
7) To test the interest in scientific reading and Hobbies.
8) To test the appreciation of the impact of science on life, both personal and social, the struggle trough which science has advanced and the inspiring work done in the field of science.
9) To test the role of Indian scientist in the development of science.
10) To test the knowledge of judicious use of natural resources and avoid any wastage of natural resources.
11) To test the experimental skills such as to prepare simple useful materials like soap, boot-polish, ink, kaleidoscope, simple camera, magnetic compass, models etc.

Check your progress

Read the following and answer the question:

Q1) ***What is the purpose of evaluation in science?***

Q2) ***Compare formative and summative evaluation?***

Q4) What is the purpose of achievement testing in science?

Q5) Discuss the objectives for development of achievement tests in science?

Answers to Check Your Progress

Ans1) **----------4.1.3**

Ans2) **----------4.1.5**

Ans3) **----------4.2**

Ans4) **----------4.3**

Suggested Readings:

Ebel, R.L. : Essentials of Educational Measurement, Prentice Hall.

Garrett, H.E. : Statistics in Psychology and Education, Vakil-Feffer.

Anderson, Hans : Readings in Science Education for Secondary School

Bhandu, N. : Teaching of Science

Gupta, S.K. : Teaching Physical Science in Secondary Schools

Kohli, V.K. : How to Teach Science

Kumar, Amrit : Teaching of Physical Science, Anmol.

Mann, S.S. : How to Teach Science

Sharma, R.C. : Modern Science Teaching

Mohan, Radha : Innovative Physical Science Teaching Method, P.H.I., New Delhi.

UNIT-5

SCIENCE TEXT BOOK AND SCIENCE CLUB

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5.1 INTRODUCTION

The textbook occupies an important place in the curriculum and the teaching-learning process. In the teaching –learning process, the textbook occupies an important place. A good textbook can even replace classroom teaching. The science textbook should aim at aiding the pupils in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely their minds with facts.

5.1. a. Objectives/Learning Outcomes

- To explain the essential characteristics of a science textbook.
- To make effective planning for setting up of science laboratory.
- To develop competency through effective presentation of projects for science exhibition.
- To explain the aims and objectives for organizing of science club.
- To develop competency through various activities of science club.

5.2 ESSENTIAL CHARACTERSTICS OF A GOOD TEXTBOOK OF SCIENCE.

1. THE AUTHOR: A good textbook is judged at face, by the author, his qualification and experience.

2. MECHANICAL FEATURES OF THE TEXTBOOK:

The print and paper used and the binding should be attractive, hard and durable. The printing should be clear, legible and appropriately spaced. Pictures, photographs, drawings, or diagrams add much to any material developed for children. These should be as carefully selected, prepared, or considered as the written word. They should be simple without being inaccurate if at all possible. They should be fitted carefully to the script, and as far as possible do what the written word cannot do. The location of the pictures, illustrations, or diagrams is also important. It should be easy for the reader to find the picture and then refocus on the text without loss of time or delay in thought development.

3. VOCABULARY

Vocabulary should also be considered carefully for the older, even high school, readers. Older readers can handle more difficult vocabulary, including sophisticated scientific terms and constructions, and take great pride in so doing. However, they are able to read and participate more actively if they find the reading intriguing, challenging, and, at the same time, not difficult.

4. THE SUBJECT MATTER-ITS NATURE AND ORGANIZATION:

The subject matter should be developed as far as possible in psychological sequence, Care must be taken of the mental growth and interest pupils. There should be consistency of the subject matter and the textbook should satisfy objectives of science teaching. Each chapter should begin with an

introduction and end with a summary. Subject matter should lead to the inculcation of scientific attitudes, disciplinary and cultural values. Each chapter should contain assignments at the end. There should be an inclusion of Edutainment activities for enrichment of science. Headings and sub-headings are given in bold letters. Science as a subject should be correlated to other subjects and accompanied by a laboratory manual.

5. EXPERIMENTATION

Many basic processes such as those described or indicated are included in experimentation. Any time an author has included descriptions of experiments already done or can propose experiments to be done, interest is heightened for most young readers. Children get a lot of pleasure and excitement from what they believe to be "a real science experiment." Because of this the word has often been used in less than appropriate ways, and care should be exercised in the use of the word "experiment."

6. EVALUATION:

A real plus in evaluation for any book for children is the knowledge that it will continue to be functional for them after they have "put the book down." After they have finished reading the book they may spend considerable time thinking about what they have read, asking questions based upon what they have read, duplicating some of the activities or experiments described, or developing related activities or experiments in a creative way.

Check your progress

Read the following and answer the question:

Q3) What are the essential characteristics of a good textbook of science?

5.3 SCIENCE LABORATORY

A laboratory is a space devoted to education, analysis, research, experimentation, and production. Laboratories handle a variety of different materials, from gases and chemicals, from drugs to living materials.

Laboratories vary significantly depending upon several factors, including their intended function, the types of materials that will be handled in them, and how many people they will accommodate. To that end, the design of a laboratory is extremely important.

The first consideration when designing a laboratory is selecting a site. When sitting a lab, it's important to review important criteria such as the health and safety of the population in the surrounding area of the laboratory, public perception, and environmental concerns, as well as engineering and operations plans. The impact of both building and operating the laboratory should be examined carefully. Sites should be chosen so that accidental contamination will have the smallest effect possible and will be able to be dealt with expediently.

Lot size and topography are also important to choosing a laboratory site, as are zoning and covenant requirements and restrictions. The laboratory should be accessible, properly sized, and conveniently located near — or have easy access to — all suppliers.

Once a site is chosen, the next step is to design the laboratory room(s). The first order of business during this step is to determine the preferred room arrangement based on data collected. Things that should be taken into consideration include room size(s) and hood requirements, and how those will affect the room's layout, as well as the locations of exit doors, eye washes, and emergency showers. Another thing that must be determined during this stage is the fire and explosive hazard levels of each room. This information will be incorporated into the architectural planning in order to ensure that the lab design is not only efficient, but safe.

Once the laboratory room is designed, the next step is to work on designing laboratory wings. Laboratory wings are groups of rooms that are organized into blocks, based on the rooms' similarities in function and requirement. There are six major areas of consideration to be looked at when arranging blocks into laboratory wings. These include: number of floors, adjacencies and separations, flexibility and expansibility, windows, services and utilities, wing location and orientation, and the location of fume hood exhaust stacks.

There are several principles that should be considered during the design phase of a laboratory facility. For example, functions, hazards, and risks will all have to be identified, so that laboratory activities can be grouped or separated as needed. Things like wind direction, and potential cross-contamination between rooms, blocks, and wings, should be taken into consideration, as should the relationship between fresh-air intakes and exhaust stacks.

While it may seem peripheral, at this stage it is important to determine the materials to be used in framing, windows, exterior and interior doors, and corridors. These will mostly be determined by the type of work being done in the laboratory, as well as the type of materials that these areas will be exposed to. Depending upon the use of the laboratory, some materials will be safer and more efficient than others.

Another detail, but an important one, nevertheless, concerns furniture and casework. These items are available in a wide variety of materials, including steel, wood, and polypropylene. Again, the use of the laboratory will determine which materials are best. At this point, lab furniture and casework layouts will have to be determined, as well as whether it makes sense to have a fixed or flexible arrangement. The number of cabinets, refrigerators, and freezers used to store various materials, as well as where they should be placed, will also be decided at this stage.

When designing a laboratory, it always makes sense to call on the services of architects and engineers who specialize in this type of building. There are many issues that are specific to the design and construction of laboratories, and many complex problems to solve. Using qualified professionals will help to ensure the safety and efficiency of the laboratory, regardless of its intended use.

5.4 Science Exhibition-

Science Exhibition are valuable for students' cognitive and affective development.

5.4.1 It is important that schools recognize this and support teachers' use of these opportunities to facilitate achievement of learning outcomes. However the enthusiasm of the teachers for visits varied from highly enthusiastic to disillusioned. A major factor expressed for this disillusion was the perception of school administrations as discouraging Science Exhibition. These teachers felt discouraged because they felt the administrative procedures within the school were burdensome and designed to thwart teachers preparing for Science Exhibition. They also felt that there were hassles with having to get appropriate-sized materials (usually commercially, ecofriendly products), the cost of organizing Science Exhibition.

These issues need to be addressed by schools. Administrative procedures should reflect departmental requirements, yet provide both legal and professional support for the teacher. The wider issue of 'duty of care' needs to be better articulated between teachers and schools. The provision of materials and transport for Science Exhibition and their funding have to be seen as part of the schools overall finances and procedures.

5.4.2-BENEFITS OF SCIENCE EXHIBITION

The researchers found that, in the opinion of teachers, the positive benefits derived from Science Exhibition were

- Hands-on, real world experiences
- Quality of education, positive attitudes to science and motivation towards the subject

 Improvement of the socialization between students, which would impinge on the classroom, and development of rapport between teachers and students
 Enabling teachers to utilize other learning strategies such as cooperative learning.
Idea of making and Display of Exhibits and teaching aids.

Check your progress
Read the following and answer the question:
Q3) State the benefits of science exhibition?

---

awareness about science.

5.5.1-Need & Importance

Progress & prosperity of a nation are essentially linked with the outcome of the results of the teaching of science in its school. We cannot expect much from classroom teaching. A Teacher in a formal classroom situation hardly finds time to go beyond the syllabus. If we really want some positive outcome we need to have some other platform to supplement & enrich classroom teaching & can be very well done by establishing a science club.

5.5.2- Aims or objectives of a science club

Aims

1. To help students acquire basic knowledge of Science.
2. To help students develop a scientific way of learning.
3. To develop students' awareness of and concern for scientific issues in personal, social, environmental and technological contexts.

Objectives

1. To arouse and cultivate students' interest in learning Science.
2. To encourage student to participate actively in the activities organized by the Science Club.
3. To promote the use of IT in learning Science.
4. To understand scientific knowledge through experiments.

5.4.3-Organisation of the club

1. Principal/Head master as patron
2. A senior but interested teacher of science as sponsor
3. The following student posts being elected from members for each academic year.

President, vice president, secretary, Treasurer, Student members

5.4.4-Set up of a science club

- Approval of Head of the institution
- Proposal for teachers interested to join the club
- Awareness of the students about the purpose of club
- Name to the club
- Holding meetings to take proper decision
- Activities to be discussed & planned properly
- Means to finance the club
- General & specific aims of the club
- Eligibility of the membership
- Rules of electing office bearers & their duties

Check your progress
Read the following and answer the question:
Q3) Discuss the Organization of a science club?

5.4.5-Activities undertaken by a science club

Enrichment activities

- Conducting Workshops
- Helping in establishment of science laboratory
- Organizing Guest lectures
- Extra reading materials (books, magazines, encyclopedia),
- Organizing seminars on career options
- Allotting project work.

Entertainment activities

- Celebrating days and events of mathematicians
- Organizing debates, quiz, symposium
- Organizing visits & excursions to the places of mathematical interest
- Organizing science exhibitions & fairs

Maintenance activities

- Science laboratory
- Bulletin boards
- Administration of club

Extension activities

- Service to weaker students of community
- Donation of educational activities etc….

5.4.6 ADVANTAGES OF SCIENCE CLUB

1. Helps in proper utilization of leisure time
2. Helps in arousing and maintaining interest of the students in the study of science
3. Helps in proper development of heuristic and problem solving attitude among the students
4. Helps in developing the habit of self among students.
5. Helps the students to be acquainted with the latest knowledge and developments in the subject of science
6. Provides the opportunity to students to work together
7. Helps in discussion of classroom topics in detail & thereby know in depth about the subject
8. Provides inspiration & incentive for independent research work
9. Brings parents, teachers, students (society close to school)
10. Helps in the satisfaction of the interests and needs of the gifted children in science.

Check your progress

Read the following and answer the question:

Q1) ***Enlist the criteria for a good textbook of science.***

Q2) ***Why schools need to conduct science exhibition***

Q3) What are the activities conducted by a science club?

Q4) Discuss the advantages of a science club?

Answers to Check Your Progress

Ans1) **----------5.2**

Ans2) **----------5.4.1**

Ans3) **----------5.4.5**

Ans4) **----------5.4.6**

Suggested Readings:

- Mangal, S.K.: Teaching of Science. New Delhi: Agra Book Depot, 1982.
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UNIT 7 METHODS IN SCIENCE TEACHING-LEARNING

Unit Structure

7.1 INTRODUCTION

As a science teacher, when you plan your teaching-learning, apart from approach and media, you also plan the method which is appropriate to transact the content in classroom. Previous units of this block i.e. Units 5 and 6 have provided you a fair understanding of various steps of planning and learning approaches being followed across the globe by science teachers. Present unit will discuss in detail about various methods, which you can use in your science classroom. You are advised to go through the Unit 10 of course BES-123: Teaching and Learning, where we have discussed in detail about various teacher-centered, learner centered and group centered methods. In this unit, our discussion will be on those methods which are of more use to a science teacher. In present unit, our focus will remain on application dimension i.e. which method is appropriate for what kind of content and how can you use it in your science classroom effectively.

7.2 OBJECTIVES

After going through this unit, you will be able to:

- dentify the appropriate method for science teaching-learning;
- improvise traditional teacher-centric methods for effective teaching-learning;
- use suitable learner-centered method for specific nature of content;
- promote cooperative learning methods for science teaching-learning; and
- examine the effectiveness of various method of teaching-learning in Science.

7.3 TEACHER CENTRIC METHODS

Recall the discussion held in unit 10 of BES-123: Learning and Teaching, you will find that we have discussed in details about merits and demerits of methods like lecture, demonstration and team-teaching. In Science teaching-learning at secondary level, teacher centric methods are not being promoted much but keeping in mind the situation of classroom in Indian schools, few methods are still being suggested, which are being used frequently by teachers. Let us discuss few of them in details.

7.3.1 Demonstration Method

Demonstration method is an activity-centered method which is being used frequently in a science classroom. There are a number of concepts and theories in science, which can be explained to learners only by demonstration. Demonstration helps learners to learn through observation. Demonstration method in general has been discussed in unit 10 of BES 123. The question is how you can use it effectively as a science teacher. You will agree that a well planed demonstration can help learners to understand a concept/process or mechanism better. Here are some important considerations, suggested by O'Brien, (1990), which you can keep in your mind while planning for demonstration:

- The concept which you want the demonstration to illustrate
- What kind of demonstration will help better learning of the concept?
- Where should the demonstration take place i.e. in the class, laboratory or field?
- What should be known to learners before the demonstration?
- What should be the role of learners(i.e. participatory or only active observer)?
- How will the demonstration take place (i.e. steps and process)?
- What kind of questions should you ask to learners for active engagement of learners in demonstration?
- What should be assessment technique/ follow-up questions to assess the learner's understanding about the concept?

You should also be careful about size of the class, place of demonstration and risk involved, so that all learners can benefit through your demonstration.

Steps of Demonstration

Let us try to understand the steps of demonstration with the help of an example.

Kamya, a Science teacher in a secondary school at Siliguri (Assam) decided to demonstrate an experiment on change in state of matter due to temperature. She identified the content from Class IX textbook, arranged required material from Science Laboratory and arranged a demonstration table at a platform so that all learners in her class can see it.

Before starting the demonstration, she enquired about states of the matter. She asked questions to develop enquiry and to motivate learners and give directions for observation and its recording to all learners. She arranged the apparatus and demonstrated the experiment, in which:

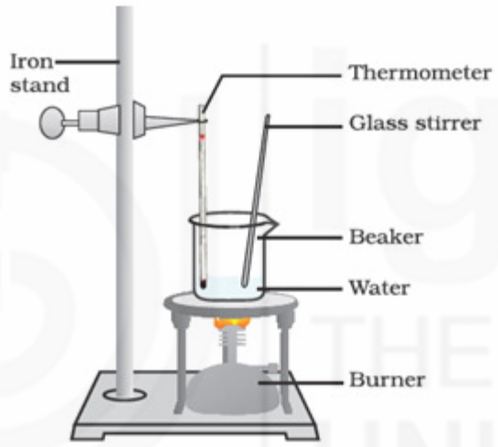

Figure taken from NCERT Textbook, Class IX

Ice melted into water while increasing the temperature and later water converted into vapors. Learners keenly observe the changes and noted down the change in temperature along with change in state. She asked them to explain their observation and then introduced the concept of melting point and boiling point.

Read the above example and try to fill the columns in the table given below:

Steps	**Activity**
Planning	
Introduction	
Preparation	
Demonstration	
Recording	
Discussion	

When you fill the table, you will be able to comprehend the steps involved in a demonstration.

Activity 1

Identify a topic for demonstration from Class IX or X textbook of science and execute it. Prepare a report highlighting your as well as learners' observation at every step of demonstration.

7.3.2 Lecture-cum-demonstration

Lecture-cum-demonstration is an improvised version of both the methods, as there are chances that learner may remain passive during demonstration. If a science teacher uses lecture-cum-demonstration method in a science class, it helps a lot in explaining the concepts and theories associated with the demonstration. Some times, teacher uses lecture-cum-demonstration when s/he blends a short demonstration during lecture to explain any concept. Lecture-cum-demonstration can be used in two ways i.e. primarily a lecture with some demonstration or a demonstration with some lecturing/discussion or explanation. It depends upon nature of content and level of learners.

Most of the steps of demonstration remain similar as discussed in point 7.3.1 but teacher and learners become more active verbally also as they question/answer/explain/discuss the events/phenomenon along with demonstration.

For example, a teacher while teaching about properties of colloidal solution, demonstrate the Tyndall effect and asks learners to site examples from their experiences of cinema hall or scattering of light in a dense forest.

Activity 2

Identify a topic for lecture-cum-demonstration from Class IX or X textbook of science and prepare a plan how you will use it in your classroom. What are the precautions you will keep in mind while executing it?

7.3.2 Laboratory Method

Laboratory method is one among the most widely used teacher-centric methods for teaching science. This method is being used to provide hands-on experience to each and every learner; as in demonstration or lecture-cum-demonstration there are little chances of learner getting an opportunity to do or feel the experiment.

Laboratory method follows the principle of '**learning by doing'** and it is a common saying that the best way **'to learn science is to do science'**.

Though in this method, learners are more active and doing experiments on their own but they are fully guided and instructed by their teachers. They mostly follow the instructions given by the teacher or written in the experiment manual, which has

also been prepared by some teacher. That's why; this method is a teacher-centric method.

Learners can be provided the opportunity to work in small groups or individually in the laboratory; it depends upon nature of experiment, availability of equipments and objectives of the learning.

It is the teacher who decided when to use the laboratory. Teacher decided the nature of experiment, nature of laboratory activity (individual or group), time and place. Teacher prepares the instructions for the learners to be followed in the laboratory. According to Hodson (1993), laboratory method helps teachers in:

- motivating learners through stimulating their interest and increasing their enjoyment
- teaching laboratory skills
- assisting concept acquisition and development
- developing and understanding of scientific inquiry and developing expertise in conducting inquiries
- encouraging social skills development
- inculcating the scientific attitudes

How to Use Laboratory Method?

Generally in a secondary school, there is a common science laboratory whereas you may find separate laboratories of physics, chemistry and biology in a senior secondary school.

- For using laboratory method, it is advised that learners should be divided in to small groups not more than 20 in a group. A timetable should be made so that each group can have equal opportunity to work in the laboratory.
- You have to enlist and identify the equipments and resources available in your laboratory and accordingly identify the concepts for which experiments are possible in your laboratory.
- Equipments and other materials (chemicals, specimens, etc.) should be placed in such a way so that learners can get them easily and there is no wastage of time.
- Prepare a list of do's and don'ts in the laboratory so that safety of learners can be ensured.
- Always provide instructions to learners before handing over them the equipments and materials for experimentation.
- A teacher generally provides a manual or steps to be followed while doing experiments.
- Learners are asked to record the observation while doing the experiments.
- Though learners do the experiments on their own but a vigilant teacher's presence is necessary in the classroom.
- Generally learners test the hypotheses; they framed during discussion on any topic/problem. It is advised that you should ask learners to test their hypotheses one by one and record their observations.

Activity 3

Suggest some topics/concepts for which laboratory method is appropriate. Also enlist the equipment required and process to be followed in the laboratory.

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

1) Compare the role of a teacher in demonstration method and laboratory method?

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7.4 LEARNER CENTRIC METHODS

In the teaching-learning of science, learner centered methods are more in use. We have already discussed in the unit 10 of the course BES – 123, that learner centric instructions grew out of the humanistic movement in psychology. In these methods, learners acquire skills and abilities through activities under guidance of teacher. Here, teachers' role is more of a facilitator. We have discussed few learner centered approaches like inquiry and problem solving. In this section our focus will be on methods like investigatory projects, heuristics method, discussion, and experimentation, which are being used for developing science process skills among the learners.

7.4.1 Investigatory Projects

In science teaching-learning, investigatory projects is method, which provides opportunity to learners to examine and explore their ideas in their surroundings. This method helps learners to explore science in their immediate environment on their own.

In this method, learners frame their questions and test them in various situations to arrive at a conclusion. Their question may be like:

- Do plants grow in dark?
- What are the factors affecting environmental temperature?
- Does sound pass equally from different material? etc.

Learners are asked to follow the steps of scientific method to find out the answers of their questions.

How to do an Investigatory Project in Science?

- Investigatory projects use scientific method. It starts with asking questions about something learners observe. When learners frame questions about their observation, they should be encouraged to arrive at a testable and precise question or the question on which they do their project.
- After this, they are advised to carry out some research i.e. searching and searching books in school library. Learners identify the resources required, process to be followed, support required from peers/teacher/parents or other members of the society etc.
- After researching, they frame hypotheses, i.e. the possible answers for their questions. Generally, learners use the terms like 'if'/ 'then' to convert the question into hypothesis.
- When they frame hypotheses, they started thinking on the experimentation. How will they carry out the experiment? They plan and do the experimentation.
- While doing experimentation, learners record the observations and analyze them in order to find out the answer of their question. Sometime, the hypotheses may be right and some times it may be wrong. If the hypothesis is wrong, they again reframe a new hypothesis and test it.
- Learners report their findings in clear terms in either case i.e. hypothesis is accepted or rejected.

Activity 4

Here are few suggestive topics on which you can develop investigatory projects for your learners. Complete the following table while planning investigatory projects for your learners.

S#	Topic	Investigatory Question	Hypothesis
1	Types of Tissues		
2	Cropping Pattern		
3	Forms of Energy		
4	Methods of separation		

You can develop projects on many other topics from Class IX and X Science curriculum. Give any one project to few learners of your class as group project and prepare a report on how they carried it out.

7.4.2 Heuristics Method

Term 'Heuristic' has its origin in a Greek word 'Heurisco' means "I find out'. In this method learners are independent investigators. It has a distinguished difference from project method where learners do their work in continuous observation and guidance of teacher but in heuristic method no help or guidance is provided by teachers once problem is identified. Teachers only help to find a problem by creating an environment or exposing learners to a problematic situation. In the words of H. E.Armstrong, ***"Heuristic methods of teaching aremethods which involve our placing students as far as possible in the altitude***

of the discoverer - methods which involve their finding out instead of being merely told about things".

While using this method, teacher should present every lesson to learners in form of an inquiry. Learners are asked to identify the problem and work as independent enquirers. They can discuss with their peers, teachers and other before starting their investigations. Teacher may provide them some written instructions like what should be followed and what should be avoided. Learners are asked to keep the record of their each and every step and show it to teachers after finishing their investigation.

Steps of Heuristic Method

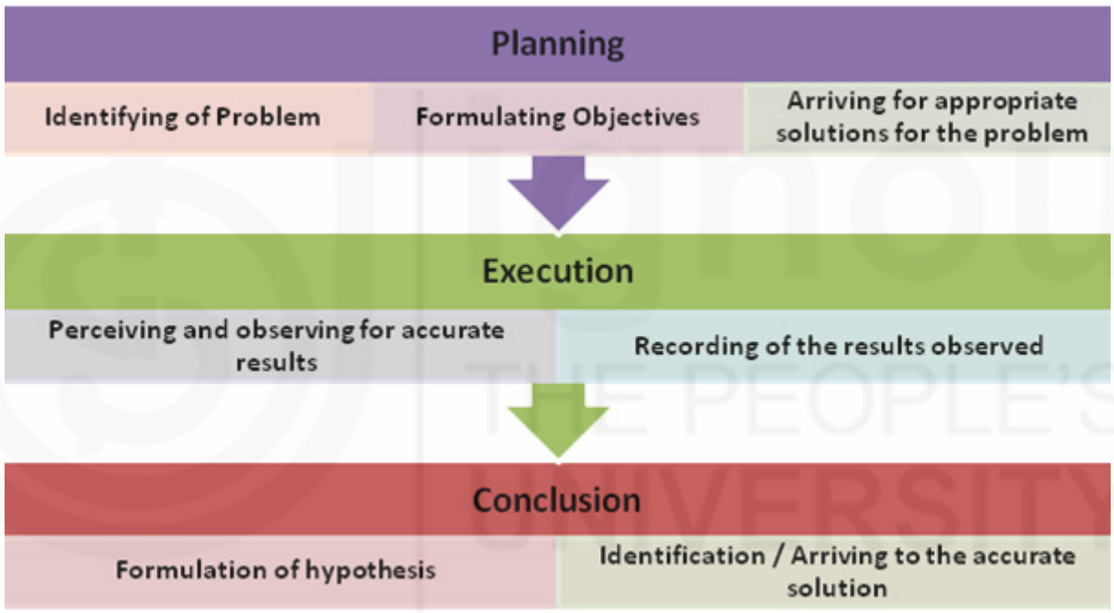

Figure 7.1. Process of Heuristics Method

Role of Teacher

- Teacher helps in indentifying the problem, which is to be investigated by the learners.
- Teacher encourages learners to give ideas, to test ideas and to challenge their own ideas.
- Teacher never gives any suggestion or solution to the learners.
- Teacher remains sympathetic, courteous and open for all types of views and ideas.
- Teacher supports and guides only if learner requires it and s/he asks for it but always supervise learners work without any interference.

This is to be noted here that this method is good when number of learners in a class are less. This method is good for developing scientific skills and scientific temper among learners.

Let us understand this method with the help of an example:

Mr. Atif, a science TGT in a Government Inter College of Uttar Pradesh decided to use heuristic method in his class. He selected the topic "Acid, Base and Salts".

In **First step**, Mr. Atif prepared an **Information Sheet**, in which he depicted problems like:

- What are foods which may be of acidic nature?
- Name the fruits which are acidic in Nature.
- Which acid is present in orange juice? etc.

He also provided some notes to the learners mentioning that the food items of sour taste are of acidic nature. And learners can use blue litmus paper to confirm that the food item is acidic or not.

In **Second step**, learners were asked to conduct the experiment to find out the answer/solution of the questions given in the worksheet by teacher.

Learners conducted the experiment and recorded their observations as follows in their worksheet/assessment sheet.

Experimenting:

Learners were aware of the fact that sour tasting food items will be acidic in nature. They tasted substances like lemon juice, orange juice, vinegar, curd, tamarind solution and found that these are acidic in nature.They confirmed the acidity of these substances by using blue litmus paper. They put all substances in separate beakers and blue litmus papers were inserted in each beaker. They observed that blue litmus changed its color to red, which confirmed that the substance which they tested, are acidic in nature.

Third Step: Recording and Reporting

Learners reported the objective, material/apparatus used, process of experimentation, observations and conclusions in the worksheet/assessment sheet. Learners confirmed that acidic substances are sour in taste and turn blue litmus to red.

Example adopted from https://jtmadhavan.files.wordpress.com/2009/09/heuristic-method1.pdf

Activity 5

Identify some topics/themes from science textbook at secondary level and use heuristic approach for teaching-learning. Report your experiences while using heuristic method in Science.

7.4.3 Natural Exploration

Natural exploration is another learner-centered method which is suggested for science teaching-learning. National Curriculum Framework-2005 emphasized that learners at secondary stage should be engaged in learning science through analysis on issues surrounding environment and working on locally significant projects.

In Science teaching-learning, there should be ample opportunities for exploration of the environment, to interact with it and to talk about it. Science learning starts with curiosity and learners are always curious about the nature, their experiences through various encounters with nature. They want to find the cause and establish a cause-effect relationship. Natural exploration helps learners in arousing and maintaining their curiosity about science behind natural events/happenings.

As a science teacher, you should promote their curiosity and provide them opportunity for exploration.

Concepts, Principles or Laws in Science were not indentified or developed in isolation. They emerged as explanation of various events. For example, Law of Gravitation is an outcome of an observation of falling of apple on ground.

As science teacher, it is your responsibility to identify such incidents/situations/events where learners can get the opportunity to explore some scientific concepts/theories/laws through natural observation.

While using natural exploration as method of teaching-learning in science, role of teachers is only to identify some situations/events to which learners can be exposed.

Learners are asked to get first-hand experience of the situation/event. They formulate their own questions and explore the situation/event to find out the solution. As it takes place in natural setting, learning outcomes are also natural so that there is no artificiality of knowledge.

Steps of Natural Exploration

- Identification of Situation/Event
- Exposure to Learners
- Recording the Observation
- Linking Observation with Scientific principals/theories/laws
- Explaining principals/theories/laws

From second to last step, it is the learner who is active, whereas in first step, a teacher is active. Let us see an example:

> Kaiesha, a Science Teacher in Meghalaya, tried to use natural exploration as a teaching method to explain concepts of "Forms of Energy" in her IXth class. There was a "tribal fair" to be organized near her town in coming days where various tribal communities will come and showcase their talents, traditional equipments, war-techniques, music, etc. Kaiesha thought it will be an exciting event and learners will be able to learn many things along with some examples on various forms of energy.
>
> She sent the learners to the event in small groups of 4 each and asked them to enjoy the events along with exploring the examples, where they feel energy is being used in various forms.
>
> When learners returned from the event, they cited examples of a Bow made up of bamboo Stick, Sling, Use of 'Y' shaped Pellet Bow (Gullail) made up of branches and many such things, which they found being used by various tribal communities. They explained the concept of kinetic energy, potential energy and transfer of energy with such examples.

As a science teacher, you can also identify many such events/incidents where learners can learn the scientific principles/laws/theories through natural exploration.

Activity 6

Identify the opportunity of natural exploration for following Laws/Principles:

- Bernoulli's Theorem
- Laws of Reflection
- Classification of Animals
- Monocot and Dicot Plants

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

2) How are the investigatory projects useful for science learning? Explain.

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3) The best way 'to learn science is to do science'. Justify the statement in light of learner-centered methods of science teaching-leaning.

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7.5 COOPERATIVE LEARNING METHODS

Cooperative learning methods are being advocated as it has been established that learners learn better with cooperation. There is a paradigm shift from competitive learning environment to cooperative learning environment in schools. Cooperative learning has gained momentum and being practiced in classrooms around the globe. As a science teacher, you need to be aware of these methods so that you can use these for effective teaching-learning in your science class.

In General terms, Cooperative learning is an instructional method in which learners are supposed to work in small groups to achieve a common learning goal under the guidance of a teacher.

Cooperative learning methods are different from traditional group work as there are some distinct features of these methods:

- Learners positively depend on each other in a team to achieve a mutual learning goal.
- Learners engage in face-to-face interactions.
- Learners are assessed individually and held accountable for equally sharing and contributing to the mastery of learning goals.
- Learners use and develop appropriate collaborative and interpersonal skills to teach and encourage each other to learn.
- Learners reflect and assess the effectiveness of group functioning for future learning (Johnson and Johnson 1999; Kagan 1994).

Cooperative Learning in Science

Cooperative learning methods help science learners in following ways:

- Cooperative learning helps learners to construct their own understanding of scientific phenomenon by examining, sharing, and learning from peers which results in strengthening their knowledge of the topic.
- Cooperative learning provides opportunity to learn through sharing of ideas, exploration, refining, and questioning their ideas as well as new ideas of others.
- These methods encourage learners' involvement and engagement. Learners start taking responsibility for their own learning and are not dependent solely on the teacher.
- Cooperative learning allows learners to make their thought/ideas public as they share it with other and refine after getting benefited from other's views.

There are number of cooperative leaning methods, which are being practiced. We will discuss few important one here to facilitate you in your teaching learning.

7.5.1 JIGSAW

JIGSAW is most common cooperative learning method, in which learners work in groups to achieve a common group goal. In Science teaching-learning, this method is useful for exploration, experimentation as well as for project work.

In JIGSAW, learners share their expertise with other members of the group and contribute in completion of a group task.

Let us see an example:

> Mr. Ashish, a TGT (Science) in Uttarakhand decided to use JIGSAW technique in his science classroom for the topic "Types of Tissues'.
>
> He divided his class in JIGSAW Groups of 4 learners each. While formulating the groups, he kept in his mind that each group is heterogeneous in nature i.e. out of four learners, one may be good in communicating things, one may be good in collecting information, one may be good observer and one may be good writer. He appointed one member of each group as group leader and asked groups to choose the sub topics of their choice. He distributed topics

like Plant tissues: Meristematic tissue, Permanent tissue, Animal tissues: Epithelial tissues, Connective tissue, Muscular Tissue, Nervous Tissue, etc.

In next step, each member of the group is asked to choose the task form him/her like collection of information, examples, explaining structure of the tissue and its use. The group one was working on Meristematic tissue distributed the work as follows:

Member 1: will bring onion bulbs with some roots

Member 2: will prepare slides.

Member 3: will draw the figure on chart paper

Member 4: will explain the function of tissue

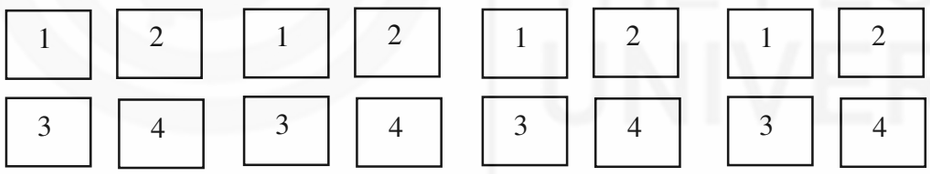
Similarly, members of other groups also distributed the tasks among themselves.

Each group completed the tasks, distributed within their groups and gained knowledge about one tissue.

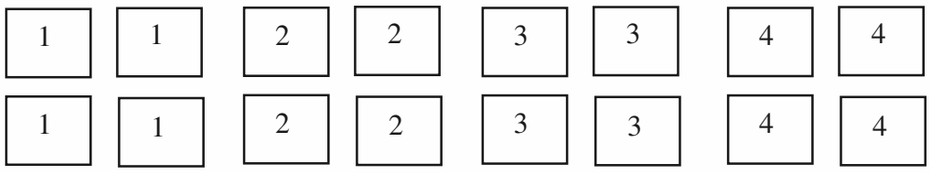
Again, Groups are redistributed so that one member from each becomes part of new group where they shared with each other their group findings.

Jigsaw Group Formation

1) Formations of Groups



2) Reformation of Groups to Share the Group Findings with Others



IN JIGSAW, role of teacher is very important. Here teacher plays role of a facilitator who helps learners in identifying the topics, framing the groups, explaining the nature of activity and create an environment where free flow of ideas is being encouraged. S/he monitors the progress of groups and helps them to share with each other.

Activity 7

Identify a topic from a secondary level Science textbook and plan a JIGSAW Activity. Execute it and report your findings.

7.5.2 Think-pair-share

It is another popular cooperative learning method, which is being used in science classroom quite frequently. Teacher's role is of a facilitator but all the tasks are to be accomplished by the learners themselves.

Think-Pair-Share is a three step method.

Think: Learners are asked to think independently on the question/problem/issue which has emerged. Learner does brainstorming, survey, collection of ideas and frames his/her own ideas about the problem.

Pair: Once thinking is over, learners are asked to make pairs with their peers to share their ideas with each other. In this step, both the learners in the pair listen carefully to each other's/ ideas. They question, argue, challenge, explain and arrive at a conclusion by considering views of both.

Share: Learners are asked to share their ideas as pairs with whole class. Presenting ideas as a pair help learners as they become more comfortable and partnership support is in it. Group is asked to reflect on the ideas presented by pairs in this way the ideas of individuals get more refinement and they comeout with a better solution.

Role of Teacher: While using think-pair-share method, it is expected from you as a teacher that you act as a facilitator and facilitate learners in pairing, allotting time for each step and organizing classroom discussion during sharing in a conducive learning environment. You can record their ideas on blackboard to facilitate them in summarizing the discussion.

As a science teacher, you should be very clear that for what kind of topics you can use think-pair-share method. For example, you can use this method to introduce the concepts of weather, formulation of chemical equations, explaining a natural phenomenon or disaster like earth quake, cyclone, etc.

7.5.3 Other Methods

Apart from this, there are many other cooperative learning methods, which a teacher can use in her/his classroom while teaching science. Let us discuss in brief about all these.

Three-Step Interview

This is a method which is used when learners are dealing with a problem which has no definite answer. This method involves three steps:

Step I: Teacher presents the issue/topic in front of class along with various views/explanations available on the issue. S/he asks several questions to initiate the process.

Step II: Learners form pairs. One member in pair becomes the interviewer and other one, interviewee. They interview their peer and record his/her observations/views on the issues.

Step III: Learners switch their role with in the pair i.e. Interviewer become interviewee and vice-versa. After this second round of interview, every pair presents the views in front of the class. Class discusses, argues and questions the ideas so that whole class can arrive at a consented view.

Round-Robin Brainstorming

This is also known as Rally Robin. In this, class is divided into small groups and one learner is assigned the duty to act as a recorder. Teacher raises a query or a question with many possible answers and learners are asked to think about answers in their group. Each member in the team presents his/her views one after other in round-robin style and recorder takes note of each response. After all learners present their views in the group, one member from group (generally the one who is acting as recorder) present the views of the group in whole class.

Three-minute Review

This method can be used by science teachers when they are explaining or discussing about some complex processes. For example, if you are explaining the respiratory system in your biology class, you can stop in between your discussion anytime and ask learners to form the teams and review in three minutes about what has been discussed so far? Learners can discuss within their groups and ask questions to clarify their doubts to other members of the group, or other group or to you.

Numbered Heads Together

Numbered Heads Together is another cooperative learning method, in which learners are arranged in small groups. Each member of a group is assigned with a number. When teacher asks a question, learners with same number come together and start discussing the possible answer of the question. They work in groups. The specific numbered learner as suggested by teacher or decided by the group becomes the group leader and presents group's idea to whole class. As learners with specific assigned number come together, this strategy is known as "put heads together" strategy.

Team Pair Solo

In this method, a problem is identified by the learners or sometimes may be assigned by the teacher. All learners work on the problem as a team. Later they regroup themselves as pairs and work on same problem and at the end they started thinking solo. This method is used when a problem is initially beyond the capacity of an individual. Learners explore the possible solutions in groups and then discuss in pair and experiment on their own as an individual. This approach is very useful in laboratory experiments in science teaching.

Circle the Sage

This method is used when a specific knowledge or information is available with very few learners. For example, a few learners of your class have visited a Science Museum or a wildlife Museum. You can ask the learners who can explain all the things they have witnessed in the museum. The learners ready to share their views will be marked as "sage". Rest of the class will be divided into small groups and each group will encircle one sage i.e. one learner. The sage will explain to the group around him/her all the details. When learners will be back to their group, they share what they have learnt from sage and thus by sharing ideas, their knowledge will enhance.

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

4) Cooperative learning methods help to develop collaborative and interpersonal skills. How?

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5) What are the steps of JIGSAW?

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7.6 INCLUSION IN SCIENCE CLASSROOM*

As a teacher to teach science in an inclusive classroom, you need to understand the best inclusive practices. A diverse classroom having different types of learners is no more an exception; rather it is a reality and the norm. The changing face of our classroom is the trend towards inclusion.

7.6.1 Adaptation in Inclusive Classroom

In an inclusive classroom, you have to bring many types of adaptations in your classroom. Adaptations made in the regular classrooms often include four main categories: time, learning styles and instructional delivery, environment, and adjustments in content. You can consider the following modifications and examine oneself how these points help us in our classroom teaching learning process:

- **Modifying instruction**: This includes classroom demonstrations, adjusting lesson pace, and using multiple instructional modalities;
- **Modifying class work and homework**: This includes providing models, reducing amount of work and lowering difficulty levels;
- **Accommodating the student's difficulty**: Adapt the time allowed for learning, task completion or assessment and increase the amount of individualized assistance for the child;
- **Altering instructional materials**: This includes providing alternate materials, audio-visual aids, worksheets and even use ICT;
- **Varying instructional grouping**: This includes the use of peer tutoring and cooperative groups.

* This section has been taken from Unit 9 of BES-019, IGNOU

- **Enhancing behaviour**: This includes praise, behavior contracts, and reward systems.
- **Altering curriculum**: This includes lowering the difficulty level of content.
- **Facilitating progress monitoring**: This includes reading tests orally, providing study guides, retaking tests and modifying grading criteria.

Teachers in effective inclusive classrooms may use one or a combination of several of these adaptation types to meet the needs of diverse learners in the content areas. Classroom teachers should choose adaptations that allow children to remain actively engaged and participating in the lesson and any corresponding activities whenever possible.

Since science classrooms often involve hypothesis development, research, experimentation, data collection, analysis, and conclusion-drawing, a high degree of organization is needed. Organization of materials, procedures and data are all important parts of a science classroom. Often, children are required to do large amounts of reading and comprehension, apply mathematical concepts, handle equipment and recall and communicate concepts. This places a burden on the teachers when planning for effective accommodations for students with special needs. Some of these accommodations are easier than others to provide in the regular classroom.

Table 7.1: Examples of Some Accommodations

Difficulty	Benefits from Accommodation
Following multiple step instructions	Simplify, repeat or clarify directions; call attention to key words in directions; have student repeat or paraphrase directions
Understanding concepts	Provide additional activities (which accommodate for multisensory learning styles) and which help to clarify content information; extend background information with organization of materials, thoughts, data. Provide charts and graphs which might help to organize collected data
Reading and comprehending material	Extend background information; provide audio tapes, outlines, and/or study guides of reading material with language and/or vocabulary Suggest advanced organizers which help students focus on necessary vocabulary or help them utilize previous knowledge; reduce content information and vocabulary required to critical items only.
Recalling and communicating information learned	Provide mnemonics to aid in prompting memory of concepts taught; provide additional review (in game format to motivate)
Applying math concepts	Limit math skills required to functional concepts only; allow use of calculator
Completing tasks on time	Provide additional reminders of due times/dates; help students organize tasks by setting small goals leading to accomplishment of task
Staying in class and focusing on task	Organize activities into smaller chunks, limiting the number of materials in front of a student and limiting the number of multi-step procedures to follow

Difficulty in hearing	Allow preferential seating, outlines of information provided in class, and visual cues from teacher to signal key events such as class transitions
Difficulty with vision	Provide alternative procedures which allow for greater use of the other senses - especially the sense of touch
Performing gross and fine motor tasks	Provide for use of additional or alternative materials which are increased in size, are of lighter weight, do not require fine motor skills, or provide greater safety.

The above ways of content presentation shall be appreciated by all students in your classroom. When a teacher presents the science content through different ways by involving multi-sensory approach and also by taking care of affective aspect; then this can be referred as good teaching not only for children with special needs but also for those who do not have. In the next section we have discussed various techniques in detail for those students who are more challenging.

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

6) What accommodation techniques you would use while teaching science to slow learners or children with learning difficulties?

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7.6.2 Strategies of Teaching Science in Inclusive Classroom

Inquiry

Inquiry is the most appropriate vehicle for accommodating all learning modalities. Inquiry teaching is a means by which all children are able to construct processes, products, and attitudes in a unique and valid ways that result in meaningful and lasting learning. Constructivism says that all children learn in different ways and inquiry provides the means. Inquiry methodology allows children to develop their own investigations to address questions they raise themselves. It encourages children to take charge of their own learning and children who take charge of their own learning have a greater tendency to develop an internal locus of control.

There are 10 inquiry skills that you should include regularly in science instruction. The first is *observation*. Children must employ this sense to find out/ take information about a topic/subject. Next is *measurement* so they can make observations that are quantitative. Children will need to *classify* things according to similarities and differences and be able to *communicate* their information and ideas to others. They need to *collect, organize*, and *graph* data and explain (*infer*)

their findings. Then they will be better able to *predict* future events and conditions based on their findings. The ability to *interpret data* (find patterns) will help them *construct hypotheses* and conduct *experiments* to test these hypotheses. When teaching science to all learners, these guiding principles are offered. We have already discussed about inquiry based teaching learning in unit 6 of this block.

Peer Tutoring

The children with better knowledge are used as coaches/tutor for their classmate. We know that the child who is the tutor will also enhance his/her knowledge and performance levels as well his/her classmate who is being tutored.

Science classes are great places to implement peer buddies or peer tutoring. Children can be paired with matching of their physical, cognitive and social needs. You may pair a child who is very active with someone who is less active. Some guiding principles for you to use peer tutoring are:

- You need to clearly establish the goal (what exact activity that the pair would do);
- Use a peer as tutor that who you think has mastery over the concept or skill to be taught;
- You must talk to the tutors about kinds of questioning, prompts, feedback or any special adaptations a child (classmate) might need;
- Last but not the least; you must monitor the progress systematically.

You as a teacher can search more strategies which could be beneficial for teaching science in an inclusive classroom.

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

7) Write any three benefits of peer tutoring strategies while teaching science in inclusive classroom?

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7.7 ADOPTING CRITICAL PEDAGOGY

In Indian teaching-learning scenario, critical pedagogy is advocated through National Curriculum Framework (2005). It states:

> *Critical pedagogy provides an opportunity to reflect critically on issues in terms of their political, social, economic and moral aspects. It entails the acceptance of multiple views on social issues and a commitment to democratic forms of interaction. A critical framework helps children to see social issues from different perspectives and understand how such issues are connected to their lives. Critical pedagogy facilitates collective decision making through open discussion and by encouraging and recognizing multiple views.*
>
> -(NCF, 2005, p. 23)

As a science teacher, you should understand that when we are talking about adopting critical pedagogy in science teaching-learning, our focus is on facilitating learners to challenge, question and analyze the established beliefs. Critical pedagogy nurtures the learners' ability to enquire about things/events/incidents. It helps in contextualization of scientific knowledge. Science is not something which comes from some other world. Learners should be encouraged to enquire about the happenings around them in their immediate environment and adopt scientific method to analyze, question and explore them.

There is a term "Praxis", which is one of the most important elements of critical pedagogy. Praxis means thoughtful examination. Critical pedagogy helps learners in questioning and challenging established norms and motivate them for testing. Recall the discussion held in Unit 3 on process skills in science, critical pedagogy advocates development of process skills among science learners. Critical pedagogy focuses on one more dimension i.e. analyzing in social context and sharing of knowledge.

As a science teacher, you have to provide such environment to your learners where they can learn through variety of ways, like experimenting, exploring, discussing, reflective-thinking, sharing ideas with peers, teachers and other community members.

You should adopt the teaching methods which are promoting critical thinking, observation, analysis of events, inductive-deductive reasoning, critical observation, problem solving etc. so that they can internalize scientific concepts and principles with a critical understanding.

Check Your Progress

Notes: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

8) Enlist the teaching methods, which you will use for adopting critical pedagogy in Science?

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7.8 LET US SUM UP

As a science teacher, discussion of teaching methods will help you to identify and adopt suitable teaching method for your-teaching learning. Teacher centered teaching methods are not being encouraged much at secondary and senior secondary level in science teaching, but methods like demonstration, lecture-cum-demonstration and laboratory are being used extensively in Indian schools. You can use these methods with caution and improvisation. Learner-centric methods like investigatory projects, heuristic, natural exploration are of much use. You should use these methods more as these methods facilitate construction of knowledge by learners themselves. Cooperative learning methods facilitates social cohesion and learning with cooperation. You can use many methods as part of your classroom teaching. Now-a-days, every classroom is an inclusive classroom. Discussion on adaptations and strategies will facilitate you in making your science classroom inclusive. You should adopt critical pedagogy as it facilitates in acquiring process skills among your science learners.

7.9 UNIT END EXERCISES

1) Compare Lecture and Lecture-cum-demonstration methods. Enlist the merits and limitations of both methods.
2) How will you organize investigatory projects in your secondary level science class? Explain with help of a project plan.
3) Identify few topics in which natural exploration can be used as method of study? Explain the process with the help of any one topic.
4) How can you integrate cooperative learning methods in your science teaching-learning? Explain with examples.

7.10 SUGGESTED READINGS AND REFERENCES

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7.11 ANSWERS TO CHECK YOUR PROGRESS

1) Answer on the basis of your understanding.
2) This method helps learners to examine and explore their ideas in their surroundings. This method asks learners to explore science in their immediate environment by using scientific methods.
3) Answer on the basis of your understanding.
4) Answer on the basis of your understanding.
5) Identification of topic, formation of groups, discussion within group, regrouping, discussion in new group, presentation to whole class
6) Enlist the techniques, which you will use in your science class.
7) & 8. Answer on the basis of your understanding.