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Printed at:
# COURSE: BES-141 Pedagogy of Science

## BLOCK 1: UNDERSTANDING SCIENCE
- **Unit 1** Science: Perspectives and Nature
- **Unit 2** Aims and Objectives of Science Teaching-Learning
- **Unit 3** Process Skills in Science
- **Unit 4** Science in School Curriculum

## BLOCK 2: TEACHING-LEARNING OF SCIENCE
- **Unit 5** Organizing Teaching-Learning Experiences
- **Unit 6** Approaches in Science Teaching-Learning
- **Unit 7** Methods in Science Teaching-Learning
- **Unit 8** Learning Resources in Science
- **Unit 9** Assessment in Science

## BLOCK 3: CONTENT BASED METHODOLOGY-I
- **Unit 10** Food
- **Unit 11** Material
- **Unit 12** The Living World
- **Unit 13** How Things Work

## BLOCK 4: CONTENT BASED METHODOLOGY-II
- **Unit 14** Moving Things, People and Idea
- **Unit 15** Natural Phenomena
- **Unit 16** Natural Resources
BLOCK 2  TEACHING-LEARNING OF SCIENCE

Introduction to the Block

In Block-1, we discussed about various aspects of science in order to understand the nature of science. We discussed the aims and objectives and also about process skill, which are to be developed through science teaching-learning. In this block, our focus is to facilitate you in developing process skills among your learners and achieving the objectives of science teaching-learning. This block has 5 units.

Unit 5: Organizing Teaching-Learning Experiences focuses on facilitating you in linking the process skills with the content. Unit will discuss formulating learning objective, using concept map as a tool for unit planning and developing lesson plans based on 5-E approach. Unit will also facilitate you in using laboratory for effective instruction in science. Various examples of lesson plans have been given to guide you in developing your own lesson plan.

Unit 6: Approaches in Science Teaching-Learning will discuss various instructional approaches, which are being used for science teaching-learning. Unit discusses Inquiry approach, which is most frequently used approach for science teaching. Discussion on problem-solving approach will help you in designing your instructions in such a way that you are able to develop problem-solving skills among your learners. Cooperative learning, concept mapping are the approaches which are being used now days. You will be able to adopt these in your teaching-learning.

Unit 7: Methods in Science Teaching-Learning is in continuation of Unit 6, where specifically various teaching methods will be discussed under the themes: learner centric methods, teacher centric methods and cooperative learning methods. Examples are given at appropriate places to facilitate you in adopting the appropriate method. A brief discussion about making your science classroom inclusive and making adaptations will help you to deal effectively in an inclusive classroom. Unit also discusses the importance of adopting critical pedagogy in science classroom.

Unit 8: Learning Resources in Science will deal with various types of resources, which you can use as a science teacher for your teaching-learning. Unit starts with discussion on how to select appropriate learning resource. It talks about various traditional learning resources, as well as classroom as learning resource in science. It also facilitates you in adopting various ICT resources in your teaching-learning. Unit also discusses in brief about innovations in science teaching-learning and professional development in science.

Unit 9: Assessment in Science talks about nature of assessment in science. It facilitates you in designing assessment tools and assessment indicators for various process skills. It motivates you to use variety of assessment tools. This unit highlights the importance of diagnostic testing in science and also discusses in brief various schemes promoting scientific attitude among learners.
UNIT 5 ORGANIZING TEACHING-LEARNING EXPERIENCES

Structure

5.1 Introduction
5.2 Objectives
5.3 Linking Process Skills with Content
5.4 Formulating Learning Objectives
5.5 Unit Planning in Science
   5.5.1 Using Concept Map as a Tool for Planning
5.6 Lesson Planning in Science
   5.6.1 Traditional Methods of Lesson Planning
   5.6.2 5-E Approach of Lesson Planning
5.7 Using Laboratory for Teaching-Learning
5.8 Let Us Sum Up
5.9 Unit End Exercises
5.10 Suggested Reading and References
5.11 Answers to Check Your Progress
5.12 Annexure: Examples of Lesson Plans

5.1 INTRODUCTION

When you organize the teaching-learning in science, you have to plan certain things in advance as a Science teacher. We have already discussed the nature of science in Unit 1 of block 1 and also discussed in detail about aims and objectives of science teaching at various levels in unit 2 of the same block. Here, in this unit our focus will remain on helping you in planning of teaching-learning situations in a science classroom. How will you identify the objectives? How will you select appropriate process skills to be developed and how is the content to be integrated for the same? What should be the transactional strategies? These are the major questions to be answered through this unit. Unit will also explain some prototypes of lesson planning, which could be used by you with required modifications in your class. The unit will remain focused on constructivist pedagogy and help you to organize teaching-learning situation, where young minds can construct scientific knowledge, on their own.

5.2 OBJECTIVES

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

- identify the appropriate process skills to be developed through a particular content;
- formulate learning objectives in sync with process skills;
- use concept map as a planning tool in science teaching-learning;
• compare the traditional lesson planning with 5-E Model of planning;
• develop lesson plan for variety of content in 5-E format; and
• use laboratory as a place for construction of scientific knowledge.

5.3 LINKING PROCESS SKILLS WITH CONTENT

It has been discussed already, that the curriculum of science upto the class X is thematic i.e. disciplinary classification for content like physics, chemistry, zoology, botany, etc., has not been exercised. You must have studied the basis for thematic approach adopted at elementary and secondary level during your elementary teacher training programme. Keeping in view the cross-disciplinary nature of science, curriculum of science, from classes VI to X has been designed around some basic themes like Food; Materials; The world of the living; How things work; Moving things; People and ideas; Natural phenomena and Natural resources.

You must have observed a change in approach at the secondary level. At the secondary stage, more emphasis has been given on abstraction and quantitative reasoning as compared to the elementary stage. Higher order skills are to be developed among learners and content has been designed keeping this in mind.

As a science teacher, it is important for you to understand the nature of content as well as skills to be developed while designing your instructions. In Unit 3, we have discussed about various process skills, which are to be developed among learners at secondary level. Here our focus will be on identifying appropriate content for a desired process skill or vice-versa but both are important before entering in the class.

While planning any teaching-learning strategy, first thing on which you have to focus is the nature of content and which skill can be developed through it.

Let us try to understand it with an example.

<table>
<thead>
<tr>
<th>Major points to be covered</th>
<th>Skills to be involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin of Cell</td>
<td>Observation</td>
</tr>
<tr>
<td>Basic structure of Cell</td>
<td>Observation</td>
</tr>
<tr>
<td>Types of Cell: Prokaryotic and Eukaryotic</td>
<td>Observation and Comparison</td>
</tr>
<tr>
<td>Difference between plant cell and animal cell</td>
<td>Observation, Comparison and Critical Thinking</td>
</tr>
<tr>
<td>Cell organelles and their function</td>
<td>Observation and Critical Thinking</td>
</tr>
<tr>
<td>Structure and functions of microscope</td>
<td>Precision and Experimentation</td>
</tr>
</tbody>
</table>

While going through any content, you also need to have a look on what skills are required for dissemination. If you identify and develop a link between skills required and nature of content, it will help you to design your instruction more effectively.
Activity 1

Select any one chapter of science from the textbook of class 9 or 10 and identify the major content to be covered and associated skills.

Once you are able to identify the content and associated skills, you will be able to locate the nature of knowledge to be created. In science, it may be factual, conceptual, procedural or meta-cognitive. Let us understand this with the help of following table:

<table>
<thead>
<tr>
<th>Types of Knowledge</th>
<th>What Comes under it?</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>Facts, terms, definitions, laws, vocabulary, etc.</td>
<td>Wood, water, brick, colloid, law of gravitation, Ohm’s law, etc.</td>
</tr>
<tr>
<td>Conceptual</td>
<td>Concepts, theories, generalizations, interpretations</td>
<td>Mixture, valency, evaporation, solution, Mole, Bohr’s model, etc.</td>
</tr>
<tr>
<td>Procedural</td>
<td>Activities, processes, cycles, experiments, etc.</td>
<td>Sublimation, separation of mixtures, writing chemical formula, digestive system, water cycle, etc.</td>
</tr>
<tr>
<td>Metacognitive</td>
<td>Awareness and knowledge about one’s own cognition. It includes knowledge of general strategies that might be used for different tasks, knowledge of the conditions under which these strategies might be used, knowledge of the content to which the strategies are effective and knowledge of self.</td>
<td>Reading, writing, working together, doing activities, psychological characteristics, etc.</td>
</tr>
</tbody>
</table>

Check Your Progress

Note: a) Space is given below to write your answer.

b) Compare your answer with the one given at the end of this Unit.

1) Why is it essential to associate the content with process skills?

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
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........................................................................................................................................
5.4 FORMULATING LEARNING OBJECTIVES

Once you identify the desired process skills associated with the content, you have to move to the next step i.e. formulating the learning objectives of the identified topic.

While formulating the learning objectives, your focus should be on the existing knowledge and background of your learners. You have to plan objectives in such a way so that you can facilitate learning as per the abilities of the learners as well as to develop their competence and potential.

When you are formulating the learning objectives, you should keep in mind the aims of science education prescribed at the secondary and senior secondary level (as discussed in Unit 2). Unit 2 has also discussed a classification of learning objectives, suggested by Anderson and Krathwohl, which is a revision of Bloom’s taxonomy. We will focus here only on this revised taxonomy.

While formulating learning objectives, a teacher should keep in mind the following:

- Learner should be the center of objectives.
- Language of objectives should be simple, direct and easily understandable for teacher and learner both.
- Objectives should be observable i.e. observable behavioral terminology should be used.
- Objectives should facilitate learner to acquire knowledge or develop the desired process skills.

Let us see an example:

Benjamin, the science teacher in a secondary school of Panaji tried to formulate the learning objectives for a topic “Nutrition” in the chapter 6: Life Processes. He discussed the topic and major content with his learners in the class and formulated the following objectives:

**SET-I**
- identifying different types of nutrition in the plants and animals;
- differentiating autotrophic and heterotrophic nutrition with examples;
- establishing relationship of type of nutrition with immediate environment of animals and plants; and
- exploring various methods of getting nutrition in various organisms.

**SET-II**

Now compare these objectives with the following:

- to explain various types of nutrition in plants and animals.
- to differentiate autotrophic and heterotrophic nutrition.
- to demonstrate the relationship of type of nutrition with immediate environment of animals and plants.
- to explain various methods of nutrition.
If you examine the two sets of objectives, you will be able to understand the differences between the two sets. One major difference is that Set-1 objectives are learner centered, while Set-2 objectives are teacher centered. Set-1 objectives are reflecting the activities to be undertaken by the learners whereas Set-2 objectives are reflecting the activities to be undertaken by the teacher.

In Set-1, while framing the objectives, Benjamin has engaged his learners actively which will motivate learners to achieve these objectives.

Here is one more example in which teacher has tried to match the procedural knowledge with cognitive processes.

### Writing Learning Objectives

We have already discussed that while writing learning objectives, we should keep in mind the previous knowledge and background of the learners, process skills to be developed and knowledge dimension.

Here are few examples of learning objectives, which you should go through.

<table>
<thead>
<tr>
<th>Cognitive process</th>
<th>Learning Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remembering</td>
<td>- Listing the types of state of matter</td>
</tr>
<tr>
<td></td>
<td>- Defining evaporation</td>
</tr>
<tr>
<td></td>
<td>- Labelling the cell organelles in the diagram of cell</td>
</tr>
<tr>
<td></td>
<td>- Enlisting hierarchy of classification of living beings</td>
</tr>
</tbody>
</table>
### Teaching-Learning of Science

<table>
<thead>
<tr>
<th>Understanding</th>
<th>Applying</th>
<th>Analyzing</th>
<th>Evaluating</th>
<th>Creating</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Describing the process of sublimation</td>
<td>- Explaining solubility of sugar in water</td>
<td>- Identifying acid and basic radicals in a given compound.</td>
<td>- Inferring a conclusion from a graph</td>
<td>- Developing a model of plant cell.</td>
</tr>
<tr>
<td>- Distinguishing between speed and velocity</td>
<td>- Demonstrating centripetal and centrifugal force by using a stone attached with a thread.</td>
<td>- Comparing the animal cell with plant cell</td>
<td>- Writing hypothesis for an experiment</td>
<td>- Making a device from household goods to explain any scientific phenomenon.</td>
</tr>
<tr>
<td>- Giving examples of conservation of momentum</td>
<td>- Computing the distance to hear the echo</td>
<td>- Illustrating the process of digestion in human beings</td>
<td>- Justifying any statement/principle/theory with arguments and counter arguments.</td>
<td>- Devising a crossword puzzle on concepts related to light</td>
</tr>
<tr>
<td>- Representing ray diagram for reflection from concave mirror</td>
<td>- Balancing the chemical equations</td>
<td>- Solving a numerical problem using more than one formula</td>
<td>- Relating the density of medium with distance to be covered by sound waves.</td>
<td>- Designing a role play to demonstrate relation of the sun and planets.</td>
</tr>
</tbody>
</table>

Above table is just showing some examples of learning objectives, which can be formulated by you. You can formulate objectives keeping in mind the category of cognitive process and knowledge dimension.

### Activity 2

Select any one topic of science from the textbook of class 9 or 10 and formulate some learning objectives based on the discussion held in above section.
Check Your Progress

Note:  
a) Space is given below to write your answer.
   b) Compare your answer with the one given at the end of this Unit.

2) What are the key considerations while formulating learning objectives?

..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................

3) Why is it important to consider knowledge dimension while formulating learning objectives?

..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................
..............................................................................................................

5.5 UNIT PLANNING IN SCIENCE

Unit planning reflects the planning of units prescribed in the syllabus, according to which a teacher normally plans the lessons. Unit plan not only includes the planning of content but also reflects upon the activities to be undertaken and the evaluation procedure to be adopted to evaluate the success in achieving the desired objectives.

Unit plan includes concepts and learning objectives, which are to be taught in various lessons reflecting the inter correlation of concepts of subject as well as experiences and issues, often across the subject area.

Unit planning is a practice, which can help a teacher in planning teaching and learning activities logically in a boarder sense. Generally, a teacher practices lesson planning as a regular activity but isolated lesson planning can create a kind of a separation in the correlated content elements. Unit plan provides an opportunity not only to plan in advance but to plan whole unit in a comprehensive way, so that lessons are presented in a lucid and interrelated manner.

If unit planning is done effectively, the learning experiences for learners can be maximized and multiplied. Unit plan provides an opportunity to interact with teachers of various disciplines, to work with them and provide multimodal exposure to learners.
Characteristics of a unit plan
- Unit plan is mapped around a central problem or purpose.
- Unit planning includes learners’ participation.
- It considers all the related concepts around the main theme of the unit.
- It brings a continuity and comprehensiveness in the classroom teaching practices, so that a learner can learn any concept with all its related aspects.
- It basically helps teachers to plan daily lessons, according to the path shown in unit plan.
- Unit plan helps teachers to consider the objectives, classroom processes and evaluation techniques in a holistic manner.
- Unit plan guides teachers to arrange the resources according to the need in everyday lesson.

General Steps of a Unit Plan
Generally, when you plan to develop a unit plan in science or in any other subject, you need a general framework or guidelines to structure your unit plan. Teachers use various formats and approaches for constructing unit plans. In the traditional approach, some steps have to be followed while constructing a unit plan. The essential steps of unit planning are as follows:

![Fig. 5.1: Steps of a Unit Plan](https://via.placeholder.com/150)

5.5.1 Using Concept Map as A Tool for Planning
Concept map is a tool which is being used for planning teaching learning experiences. We have already discussed about concept map and its use in planning in unit 9 of the course BES-123. Learning and Teaching.
In this unit we will focus on use of concept map in planning. Concept map is a tool which is very useful for unit planning. It helps in linking various concepts and their relationships. You as a teacher can distribute your lesson accordingly and establish linkages between various lessons planned for the unit. Here is an example, in which a Science Teacher from Kerala, Ms. Uzma is using concept mapping for unit planning.

Ms. Uzma has distributed her plans after this concept mapping in the following order:

**Fig. 5.2: Concept Map on Atom**
This table is illustrating how to use concept map for unit planning. You already have an idea about unit planning, now you can compare which one is more learner friendly and why?

### Activity 3

Select any one topic of your choice from science textbook of class 9 or 10 and develop a concept map followed by description table for unit planning.

For developing a concept map, you can also use software available like MindMap, cMap, etc.

### 5.6 LESSON PLANNING IN SCIENCE

The term lesson is interpreted in different ways by different people. Generally, teachers take it as a job to be covered in a class period which runs over 40-50 minutes or in two or three periods. A lesson is defined as a blueprint, a guide

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Topic</th>
<th>Sub-concepts</th>
<th>Activities/strategies</th>
<th>Teaching-learning Material</th>
<th>Assessment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic Structure of an Atom</td>
<td>- Charged particles i.e. Electron and Proton.</td>
<td>Activities to show charge in particle, role-play on subatomic particles</td>
<td>3-D model of an atom</td>
<td>Crossword puzzle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Neutral particle: Neutron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Nucleus of atom and basic structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Distribution of Electrons and Valency</td>
<td>Orbits, Distribution of electrons, Bohr-bury Scheme, Concept of Valency</td>
<td>Brainstorming and discussion on possible structure of an atom, exercise on filling electrons in orbits, role-play</td>
<td>Model of nucleus and orbits, placards on electron, orbits and nucleus</td>
<td>Unit test of 10 marks</td>
</tr>
<tr>
<td>3</td>
<td>Atomic Models</td>
<td>Thomson Model, Rutherford Model and Bohr’s Model</td>
<td>Demonstration of atomic models and discussion</td>
<td>Video animation on atomic models</td>
<td>Pictorial demonstration of atomic models</td>
</tr>
<tr>
<td>4</td>
<td>Atomic Number and Mass Number</td>
<td>Atomic Number, Mass Number, its symbolic representation, Isotopes, Isobars</td>
<td>Examples and exploration of ideas, numerical practices</td>
<td>Video demonstration, examples from daily life utilities of isotopes and isobars</td>
<td>Small project on exploring use of isotopes and isobars</td>
</tr>
</tbody>
</table>
map, a plan for action in the near future. Lesson planning refers to sequencing of teaching acts or events or episodes, that we plan, organize and carry out in order to generate a learning environment for our learners.

N.L. Bossing in his book “Teaching in Secondary Schools” proposes the following definition of a lesson plan:

“Lesson plan is the title given to a statement of all achievements to be realized and the specific means by which these are to be attained as a result of the activities engaged day to day under the guidance of the teacher.”

The Dictionary of Education defines a lesson plan as a “teaching outline of the important points of a lesson arranged in the order in which they are to be presented; it may include objectives, questions to be asked, references to materials, evaluation, assignments etc.”

Now it must be clear in your mind that lesson planning is a product of short term or micro level planning involving:

- identification of specific objectives;
- selection of an appropriate content and activities;
- selection of procedures and methods for presentation of the content;
- selection of assessment exercises; and
- selection of follow up activities; etc.

Characteristics of a Lesson Plan

You may plan your lesson based on any format, but a good lesson plan must have following characteristics:

i) must be flexible;
ii) organized content in the light of attainable objectives;
iii) rich with respect to learners’ activities and evaluation exercises;
iv) has link with the previous and future lesson; and
v) must include relevant home assignment and activities for learners

5.6.1 Traditional Methods of Lesson Planning

There are various approaches to lesson planning. They are Herbartian approach, Unit approach, Evaluation approach and Project approach. A brief description is provided for your sensitization.

i) Herbartian approach is based on perceptive mass theory of learning. The learner is considered to be a clean slate and all the knowledge is to be given from outside. If new knowledge is based on old knowledge of the learner (his previous knowledge or experiences), it may be acquired easily and retained for a longer period. Herbart has given five steps: Introduction, Presentation, Organization, Comparison and Evaluation. The main focus is on content presentation.

ii) Unit approach of Morrison is based on unit planning and transaction. The plan of teaching is cyclic and Morrison has given five steps for this ‘cycle-phase’ of teaching: Exploration, Presentation, Assimilation, Organization and Recitation.
iii) Evaluation approach of B.S. Bloom considers education as objective centered rather than content-centered. It takes into consideration the learning objectives, methods of providing learning experiences on the basis of the objectives and assessing learning outcomes.

Then, a decision can be taken about objectives of learning and these evidences may provide the basis for revision and improving the learning experiences. The focus in this approach is on objective based teaching and testing.

iv) Project approach originated by Dewey and W.H. Kilpatrick stresses on self-activity, social activity and experiences of real life situations; it is also a learner planned purposeful task accomplished in a social environment.

Factors Affecting Lesson Planning

There is no certainty that a lesson plan developed by a teacher for his/her use will be a success at every place and any time. The reason is simple. Many factors influence lesson planning such as:

- location of a school
- size of the class
- age-wise composition of the class
- availability of teaching-learning aids
- the nature of the topic, etc.

This list is not exhaustive. You may add few other factors from your own experiences.

Writing the Lesson

There are various forms of written lesson plans used by practicing teachers. A teacher needs some information about the class, learners and their background before he/she attempts to plan a lesson. Usually a lesson is divided into many stages or steps. When a detailed lesson plan is developed, all these steps are used in some form or the other. In the above section we have given you an idea about some of the approaches of lesson planning. In this section we will help you to write your plans based on different approaches.

A) Herbartian Approach

The steps of the Herbartian approach are given below:

i) General information regarding the subject, topic, class, age level of children, estimated time.

ii) Teaching-learning Objectives

- General Objectives
- Specific objectives

You are aware that different subjects at different grade levels have some general objectives whereas specific objectives are written in behavioural terms as they focus on the expected outcomes of our teaching the topic over a given period of time. These specific objectives, also known as teaching-learning objectives must be measurable and observable. You are required to
identify your behavioural objectives and state them in a clear and unambiguous language.

iii) **Teaching-learning aids**: Select teaching-learning aids which you think are proper for clarifying the concepts to be learnt. List all such teaching aids used in the form of charts, static or dynamic model, real specimens etc.

iv) **Assessing the previous knowledge**: Development of the lesson is based on the previous knowledge of your learners. We have to assume the previous knowledge/entry level behavior of learners related to the content to be taught and assess it through a single direct question.

v) **Introduction**: This step mainly concerns with introducing a topic through introductory questions or by creating the appropriate situation. The focus is on preparing our learners to receive new knowledge by linking it with their previous knowledge.

vi) **Presentation**: Presentation comprises of ways in which relevant content is presented. Most of the teachers develop lessons with the help of developing questions and using learners’ responses for further presentation of the content. This presentation or development stage is interactive in the real classroom situation; it depends on teachers’ communication skills and teaching skills like questioning, explaining, giving demonstration and providing reinforcement on desirable learner behaviour.

vii) **Recapitulation**: Recapitulation of the lesson helps the teacher to find out the extent of learning that occurs during the period of instruction. It can be done by asking several questions. This stage provides feedback to the teacher about his/her teaching-learning process.

viii) **Black Board Summary**: Teacher writes the summary of his teaching points and explanations. It is developed simultaneously when lesson is being developed.

ix) **Home Assignment**: At the end of the session, thought provoking questions or activities must be planned and given to the learners. It gives a chance of repetition or practice to the learners. It also gives an opportunity to them to assimilate, whatever they have learned.

**B) Evaluation Approach**

The design of lesson plan according to this approach consists of three aspects:

(i) Input, (ii) Process, and (iii) Output.

i) **Input level**: It includes the identification of objectives in behavioural terms. They are known as Expected Behavioural Outcomes (EBOs). The entering behaviour of the learners is also identified. The sequence of instructional procedure is determined with the help of these instructional objectives. These objectives are broadly classified into four categories: knowledge, understanding, application and creativity. You have to write objectives in behavioural terms.
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ii) **Process level:** This is an interactive stage when you are actually in the classroom and communicating with your learners. You have to select different teaching strategies, audio-visual support materials for effective presentation of the content.

iii) **Output level:** This aspect of instructional procedure refers to real learning outcomes (RLOs). This is equivalent to terminal behaviour which is usually measured by using oral and written questions. Output aspect is concerned with evaluation of the desirable behavioural change among learners.

![Diagram of Input, Process, and Output]

**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) Give any one difference between Herbartian approach and evaluation approach of lesson planning

...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

**Format of Presentation**

Effective teaching needs proper planning, transactional process and feedback mechanism. Practically there are three stages of a lesson plan: pre-active, interactive and post-active. **Preactive stage** is a stage of planning before going to the classroom. The **interactive stage** is a stage of interaction between teacher and his/her learners in the real classroom situation. **Post active stage** is a stage of self-evaluation of teacher’s own teaching work.

There cannot be a single format for writing a lesson plan because it varies from teacher to teacher and subject to subject, the only thing which can be suggested is that it should be a well-ordered structure which follows some basic fundamental steps and parts of a lesson. Some of the formats based on different approaches to lesson planning discussed in Section 3.4.2 are suggested below for your guidance. You are free to make changes according to the objectives you plan to achieve and the nature of the subject etc.
### i) Herbartian Lesson Plan Format

Subject : Date :
Unit : School :
Topic : Class :
Duration : Period :

1) General Objectives:
2) Specific Objectives:
3) Teaching Aids:
4) Method of teaching:
5) Previous Knowledge:
6) Introduction:
7) Statement of the Topic/Aim:
8) Presentation or Development of the Lesson:

<table>
<thead>
<tr>
<th>Teaching Points</th>
<th>Teacher’s Activity</th>
<th>Learners’ Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Objective</td>
<td>Teaching-Learning Activities</td>
<td>Evaluation</td>
</tr>
</tbody>
</table>

**OR**

9) Recapitulation:
10) Black Board Summary:
11) Home Assignment:
12) Reference:

**Note:**

i) Order of S.No. 1 to 5 may be changed according to your needs.

ii) In presentation/development objectives, teaching-learning activities and evaluation are in relation to particular teaching point/content.

iii) If assessment of learners’ learning is done for each teaching act/episode, then you may ignore recapitulation at the end of the lesson.

iv) Black board summary should be developed as the lesson progresses.

### ii) Bloom’s Evaluation Lesson Plan Format

Date :
Subject : School :
Unit : Class :
Lesson : Duration :
Teaching-Learning of Science

1) Specific Objectives:
2) Previous Knowledge:
3) Introduction:
4) Statement of the Topic/Aim:
5) Presentation:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Teaching-learning Method &amp; Aids</th>
<th>Teacher’s Activities</th>
<th>Learners’ Activities</th>
</tr>
</thead>
</table>

6) Evaluation:
7) Home Work:
8) References:

Note:
- i) The objectives are to be written in behavioural terms.
- ii) The teaching activities are to be related to the learning structures.
- iii) Black Board Summary should be developed as the lesson progresses.

iii) RCEM Lesson Plan Format

Date :
Subject :
School :
Unit :
Class :
Topic/Lesson :
Duration :

1) Concepts:
2) Teaching Aids:
3) Previous Knowledge:
4) Introduction:
5) Statement of the Topic:
6) Presentation:

<table>
<thead>
<tr>
<th>Expected Behavioural Outcomes (EBO’s)</th>
<th>Sequential Learning Experiences/Activities (LEs)</th>
<th>Real Learning Outcomes (RLO’s)</th>
</tr>
</thead>
</table>

7) Black Board Summary:
8) Home Assignment:
9) References:

Note:
- i) RCEM is Regional College of Education, Mysore.
- ii) Concepts are to be identified through content analysis.
- iii) Black Board Summary to be developed as the lesson progresses.
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.

5) Give any two characteristics of an effective lesson plan.
   i) ........................................................................................................
       ....................................................................................................
   ii) ........................................................................................................
       ....................................................................................................

5.6.2 5-E Approach of Lesson Planning
Teaching-learning practices based on Constructivism do not follow the lesson plan developed through a behaviourist approach. They criticize those plans as mechanical plans which do not give opportunity to construct knowledge.

The current focus of Science teaching is on engaging learners in meaningful and authentic learning by providing them opportunities to construct knowledge on their own. Constructivist approach of teaching-learning does not follow fixed steps rather it is flexible. However some educationalists have proposed some specific steps for constructivist planning of teaching-learning. One most accepted model is 5-E Model.

The model helps learners to change their conceptions of phenomenon explored in Science class. The conditions required to enable learners to change conceptions are:
- They must be dissatisfied with existing ideas and
- The new ideas must be viewed as intelligible, plausible, and fruitful

Here, the teacher is expected to help learners to restructure their conception from novice to expert knowledge. This model has five stages of teaching and learning. You have already gone through the basics of 5-E approach in detail in Unit 9 of the course BES-123, Learning and Teaching.

Let us try to understand 5-E approach with the help of an illustration of a lesson plan.

Example of A Lesson Plan

<table>
<thead>
<tr>
<th>CHAPTER: Is Matter Around Us Pure</th>
<th>Class: IX (B)</th>
<th>Duration: 40-45 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of the lesson: Solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material required: Sugar, salt, water, honey, sand, soda/Eno, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key Concepts: Solute, Solvent, Solution, concentration of solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Skills to be developed: Observation, exploration, experimentation, problem solving</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teaching-Learning of Science

CLASSROOM PROCEEDINGS

I- ENGAGE

The class will be divided into 4-5 groups and ask them to enlist their daily experiences/observations where they feel or observe that two or more substances are being mixed to bring out something new. They will be asked to use a table for this task.

(3-5 minutes)

<table>
<thead>
<tr>
<th>Things/substances which may be mixed</th>
<th>Outcome or the new substance</th>
</tr>
</thead>
</table>

After preparation of the table, teacher will choose randomly few examples from the table of each group and ask few learners few questions, which they will try to answer based on their observation/understanding.

- What are the things/substances mixed in lemonade?
- What is the state of substances which are missed to prepare lemonade?
- Are all substances in same state or different?
- Can you recognize/see all substances separately in the lemonade once it is prepared?

Learners will answer and many other similar questions related to other mixtures.

II- EXPLORE (10-12 Min)

Activity 1

Teacher will distribute sugar/salt and water to all groups and ask them to mix and record their observations in another table.

<table>
<thead>
<tr>
<th>What did the learners do?</th>
<th>What was their observation?</th>
<th>Is something new formed?</th>
<th>What are characteristics of the new?</th>
<th>Why do they feel so?</th>
</tr>
</thead>
</table>

Subsequently teacher will provide similar other substances and ask to repeat the activity.

After 2-3 such activities, teacher will ask few questions and encourage learners to discuss and reflect.

Teacher: What are the substances you have mixed?

Learners’ possible answer: water, sugar, salt, honey, soda, etc.

Teacher: Which substance you used as a medium to mix other substances?

Learners’ possible answer: water

Teacher: What are the outcomes or new products?

Learners’ possible answer: sarbat, sweet water, soda-water

Teacher: Can you recognize the substances, which are mixed in the new substance through observation?

Learners’ possible answer: no, we can only see color change in some example

Teacher: When things are similar or evenly distributed in a mixture, what is the name of it?
Teacher will interact and discuss with learners to bring them on desired concepts.

III- EXPLAIN (8-10 Min)
Teacher will discuss and introduce some key terms like solution, solute and solvent. Teacher will encourage learners to define these terms in their own words. Learners will define following words and correlate with their observations during the engagement and exploration phase.

Solution
- Solvent __________________________
- Solute __________________________

IV- ELABORATE (10-15 min)
(In this phase learners will be provided opportunity to experience and explore more about the concepts introduced they will discuss in groups, perform some activities and explore some more examples from their daily life experiences to develop their understanding of these concepts).

Teacher will ask them to do one more activity and ask few more questions to help the learners in exploring more.

Activity 1
Teacher will ask learners to divide the solution of honey and water into two parts. He will give more water to one group and more honey to another group and ask them to mix it in the given solution and reflect on their observation.

Group 1: When we are mixing more water in our solution, it is becoming thin and clearer.

Group 2: When we are mixing more honey in our solution, it is becoming more thick and denser.

Teacher: What should be the name for such solutions?
While discussion with learners, teacher will introduce the concept of dilute and concentrate.

Teacher will introduce the formula (s) with the help of learners’ examples, i.e.
Concentration of solution = Amount of Solute/Amount of Solvent and Amount of Solute/Amount of Solution

Teacher will also introduce that Concentration of solution can be expressed in Mass by Mass percentage and Mass by Volume percentage.

He will use some wrappers of medicines/other solutions which show the concentration in M/V or V/V. Learners will also be encouraged for exploring such examples where they have seen such expressions.

V- EVALUATION (3-5 min)
1) Teacher will give example of solutions and ask learners to identify the solutes and solvent?

2) Teacher will show two solutions of same solvent and solute and ask learners to identify and tag, which is dilute and which is concentrated.

3) A solution of 100 ml. contains 30 ml. Honey. Find out the volume by volume percentage of the solution.
This lesson plan is only an example to facilitate you while you develop your lesson plan. Constructivist practitioners don’t impose any fixed structure. You can see other formats also which are based on constructivist practices, two such examples are given at the end of this units on Topic Faraday’s Laws of Electromagnetic Induction and Sources of Food.

5.7 USING LABORATORY FOR TEACHING-LEARNING

Importance of Laboratory Work

Our teaching should be consistent with the nature and structure of the area of discipline being taught. The demonstration, experiment, project should be developed consistent with the nature and structure of science. Science is both a product (body of knowledge) and process (approaches of acquiring and refining of new knowledge). It is impossible to imagine teaching of science without practical work. We must accept that science teaching in our secondary schools emphasizes the product aspect of science. In other words it is based on providing knowledge of scientific facts, concepts, principles and broad generalizations. Seldom are the learners given an opportunity to work in the laboratory as young scientists. They are restricted to do repetitive type of exercises in which they simply verify the already known knowledge.

No one will disagree that laboratory work should occupy a central position in any programme of science education. Through laboratory activity it is quite possible for you as a science teacher to realize the following process objectives of science teaching:

- development of scientific concepts and principles;
- improving the understanding of various methods and procedures of scientific inquiry;
- development of scientific attitudes, interest and appreciation;
- provide training in scientific method;
- designing and planning an activity in a scientific manner, etc.

Planning of Science Laboratory

To achieve these objectives of laboratory teaching, the science laboratory of your school must be well equipped so that the learners get first hand experiences through direct observations and experimentations. A good science laboratory has most of the following characteristics:

- spacious in size;
- provision of elements of flexibility for effective teacher’s demonstration(s), individual and small group work;
- ample physical and material facilities;
- ample storage facilities for chemicals and equipment;
- arrangements for good lighting and proper ventilation; and
- regular supply of water and gas, etc.
But the science teachers of India cannot be very ambitious about their laboratories because of imperative need for economy. Their dire need is to establish functional laboratory. For this, you should keep in mind the following considerations for determining the total area of a science laboratory:

- number of pupils working at a time;
- minimum space necessary for comfortable work;
- need for ancillary accommodation for storage.

We propose a simple but convenient plan of a science laboratory for our secondary schools (see the layout plan). It has two demonstration rooms and one store-cum-preparation room. The two demonstration rooms can be converted into rooms for experimentation or for science club activities. Only the demonstration table has water taps and sinks. The chemicals and other materials are stored in the store room. Teachers can make improvement in this plan as and when more funds are available. You must remember that “a science lab is never so good that it needs no changes or so bad that it must be abandoned as hopeless.”

**Procurement and Maintenance of Laboratory Equipment**

Every laboratory requires the procurement and maintenance of equipment. What is your basis of procuring laboratory equipment? Perhaps you will agree that it has considerations such as (i) budgetary provision, (ii) specification of needs of various experimental programmes and (iii) replacement of obsolete or unserviceable equipment.

An acceptable streamlined procedure is to be adopted for the procurement of the equipment. First of all you have to make the list of such equipment giving their precise specifications and required quantity. This list will get the approval and sanction of your head of institution. In some states the Directorate of Education approves the names of firms or suppliers with which you may place the order for supply of your needed material or equipment. You must acquaint yourself with the procedure of procurement followed in your institution.

Maintenance of the procured equipment is equally important. The proper care and maintenance by subject teacher, laboratory assistant and learners can increase the life span of equipment.

**Storage of Science Materials**

The chemicals, equipment and other objects and materials are expensive so they are to be placed with care in a store room. Expensive equipment and chemicals must be placed in the safe custody of laboratory in-charge. The store-room must be spacious in size and have many shelves or compartments. There should be separate shelves for glass-ware, acids, chemicals, and other equipment. The items must be stocked in such a way that their quick issuing is possible.

**Management of Safety**

The science laboratory being a place of potential dangers, both teachers and learners must be careful while engaged in laboratory activities. The freedom of the learners in the laboratory has to be considerably restricted. It is important to train learners in the use of laboratory equipment, fire extinguishers and first-aid box. Hazardous chemicals must be placed beyond the reach of learners. One must be aware of the following precautions while working in the laboratory:
Teaching-Learning of Science

- updated and correct knowledge of the nature of materials, especially chemicals, which require considerable care and caution;
- location of fire extinguishers and fire exit;
- location of first aid box;
- location of master shut off controls of the lines for gas, water, electricity; etc.

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) Mention at least two fundamental objectives of laboratory activity for instruction in science.

...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

7) State two considerations which one must keep in mind while procuring the equipment for science laboratory.

...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

5.8 LET US SUM UP

Development of process skills among learners is the key focus area of pedagogy of science. Unit facilitates you to link the content with suitable process skill. Learning objectives are to be formulated keeping in mind the skill to be developed; the discussion of learning objectives will help you in it. Unit has discussed various traditional approaches of unit planning and lesson planning and promoted the use of 5-E approach of lesson planning in your teaching-learning. Apart from classroom teaching, a lot of learning experiences are to be provided to learners in science laboratory. Discussion on using laboratory for teaching-learning will help you in it.

5.9 UNIT END EXERCISES

1) Why cognitive processes should be in sync with learning objectives? Choose any topic from science textbook at secondary level, identify two cognitive processes and develop learning objectives for them.
2) Differentiate between Bloom’s approach of lesson planning and 5-E approach?

3) How can you facilitate learning in science through laboratory?

5.10 SUGGESTED READING AND REFERENCES


5.11 ANSWERS TO CHECK YOUR PROGRESS

1) Core objective of science teaching-learning is to develop process skills among learner. Content should be linked with so that appropriate process skill can be developed with suitable content.

2) While formulating learning objectives, a teacher should keep in mind the following:
   - Learner should be the center of objectives.
   - Language of objectives should be simple, direct and easily understandable for teacher and learner both.
   - Objectives should be observable i.e. observable behavioural terminology should be used.
   - Objectives should facilitate learner to acquire knowledge or develop the desired process skills.

3) Reflect, based on your understanding.

4) Compare and write in your own words.

5) Improving the understanding of various methods and procedures of scientific inquiry; development of scientific attitudes, interest and appreciation

6) Number of pupils working at a time; minimum space necessary for comfortable work; need for ancillary accommodation for storage.
5.12 ANNEXURE: EXAMPLES OF LESSONS PLANS

Example 1 (Taken from BES 019, Unit 7, IGNOU)

**Topic:** Sources of Food  
**Class:** VI  
**Duration:** 40 Min.

**Instructional Objective:**
Children will be able

- to explain the phrase ‘sources of food’;
- list different sources of food; and
- classify food items according to sources

**Teaching-Learning Material Required:** One set of colourful cards

**Pre-Requisite**
The learners are already familiar with variety of foods.

**Step 1- Engage (Group Activity)**
The teacher divides the learners in four groups and asks them to discuss what they eat every day. Make a list of food items that they have taken. Afterward the task-leader of each group reads out what their groups have listed and writes the food items on the blackboard. Then they discuss it and based on this discussion they will find out that some items are common. **These common food items are then listed.**

For example, list may include Bread, Corn Flakes, Milk, Lassi, Dosa, Idly, Chapatti, Dal, Dalia, Rice, ice-cream, sweets, Uttapam, Curd, Chapatti, Poori, Paratha, Vegetable, Rajama, Chola, Pav-Bhaji, Juice, Salad, Chicken, Mutton, Egg, Omelet, Fish, etc.

Then teacher asked each learner to check his/her lunch box and if he/she has any other food item in his/her lunch box other than the listed ones then it should be added. In this way list can be elaborated.

**Step 2- Explore**
Organizing Teaching-Learning Experiences

<table>
<thead>
<tr>
<th>Teacher Activities</th>
<th>Learner Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you take when you came to school?</td>
<td>Bread, Milk, Lassi, Corn flakes</td>
</tr>
<tr>
<td>What do you see in the picture?</td>
<td>These are some food items</td>
</tr>
<tr>
<td>List out the items that you observe in the picture?</td>
<td>Milk, Curd, Cheese, Butter, Ice-cream</td>
</tr>
<tr>
<td>Ok, What is the common attribute in these items?</td>
<td>Curd and Ice-cream is made from milk</td>
</tr>
<tr>
<td>Can anyone tell me from which product cheese and butter are made?</td>
<td>No answer</td>
</tr>
<tr>
<td>Children Cheese, butter, ghee all are made from milk. Tell me how do we get milk?</td>
<td>From Dairy</td>
</tr>
<tr>
<td>Who gives milk?</td>
<td>Cow, Buffalo</td>
</tr>
<tr>
<td>So what is the source of milk?</td>
<td>Animal</td>
</tr>
</tbody>
</table>

Announcement of the topic: After having the above discussion with learners, the teacher announces that today let us discuss about ‘Sources of Food’.

Step 3- Explain

Then teacher asks some question in your class.

<table>
<thead>
<tr>
<th>Teacher Activities</th>
<th>Learner Activities</th>
</tr>
</thead>
</table>
| Now we have a list of food items that we take in daily life. Can these items be divided into different categories? | - Some are liquid and some are solid  
- Raw & Cooked Food  
- Some food are vegetarian and some are non-vegetarian.  
- Some are obtained from plants while others are obtained from animals. |
| Categorize food items into vegetarian and non-vegetarian. | Vegetarian food: Bread, Corn Flakes, Milk, Lassi, Idly, Chapatti, Dal, Dalia, Rice, ice-cream, sweets, uttapam, Curd, Vegetable, Rajama, Chola, Pav-Bhaji, Juice, Salad, fruits  
Non-vegetarian food: Chicken, Mutton, Boiled Egg, Omelets, Fish. |
| How can you divide food into vegetarian and non-vegetarian categories? | Food items that we get from plants are called vegetarian and food items that we get from animals are called non-vegetarian. |
| Now check the list of vegetarian food. Are all the items obtained from plants? | No madam, milk is obtained from animals. |
| So in this context do you agree with the above statement? | No madam |
| Try another way to define vegetarian and non-vegetarian food? | |
| Can anyone divide food items into raw and cooked food | Raw food: Fruits, Salad  
Cooked food: Dosa, Idly, Chapatti, Dal, Dalia, Rice, ice-cream, sweets, Uttapam |
Step 4- Extend

Teacher has a set of colorful cards. On one side she writes the names of food items (Bread, Corn Flakes, Milk, Lassi, Dosa, Idly, Chapatti, Dal, Dalia, Rice, ice-cream, sweets, Uttapam, Curd, etc.) identified by the learners. Then she asks each learner to come one by one and take a card and identify whether it is a raw or cooked food item. If it is cooked then write the sources, from which it is made, on one side of the card. If it is raw food item then write its sources on the other side of the card.

Then she makes a table on the blackboard in the following format and asks learners to come one by one and fill the table.

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Cooked/ Raw</th>
<th>From which item is it made</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>raw</td>
<td></td>
<td>Cow/buffalo/goat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(animal)</td>
</tr>
<tr>
<td>Chapatti</td>
<td>cooked</td>
<td>Wheat grains</td>
<td>Plant</td>
</tr>
<tr>
<td>Bread</td>
<td>cooked</td>
<td>grains</td>
<td>Plant</td>
</tr>
<tr>
<td>Idly</td>
<td>cooked</td>
<td>Rice and pulses</td>
<td>Plant</td>
</tr>
<tr>
<td>Ice-cream</td>
<td>cooked</td>
<td>milk</td>
<td>Cow/ buffalo</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(animal)</td>
</tr>
<tr>
<td>Dalia</td>
<td>cooked</td>
<td>grains</td>
<td>Plant</td>
</tr>
<tr>
<td>Fruits</td>
<td>raw</td>
<td></td>
<td>Plant</td>
</tr>
<tr>
<td>Omelet</td>
<td>cooked</td>
<td>egg</td>
<td>Animal</td>
</tr>
</tbody>
</table>

Stage 5-Evaluate

1) Make a list of items that you have eaten yesterday. Then identify sources of these items.

2) List the various items that are made from milk.
Example 2 (Taken from Pedagogy of Science- Part-II, NCERT)

Class: XII    Topic: Faraday’s Laws of Electromagnetic Induction
Time: 40 Minutes

1) Situation

• What do you expect from students to do and how will students derive meaning?
• Which situation will you arrange for learning based on students’ learning interest and approach?
  – Students perform activities using a magnet, a coil and a galvanometer to observe electromagnetic induction (Fig. 12.6).
  – Students describe the factors on which magnitude of induced current depends.
  – Students explain faraday’s laws of electromagnetic induction mathematically.

Coils, magnets and galvanometers/multimeters will be arranged to perform activities. Video clip of the simulated experiments will also be arranged.

2) Groupings

• How will you facilitate grouping of students?
• How will you arrange grouping of materials that students will use to perform and have collective experiences of learning?

I shall facilitate the class to form six groups, each of five students, taking care that the group is heterogeneous. Six sets of coils, galvanometer / multimeters and magnets will be arranged. Help of students will be taken in making the coils.

3) Bridge

• It is to bridge the gap between pre-existing knowledge and the knowledge students might construct by teaching-learning experiences.
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It can be filled by hands-on activities, discussion, questions, etc. This might take place before grouping or after grouping and it can facilitate growth of knowledge over time.

- Teaching-learning experiences can continually be changed according to the observed gaps in students’ learning.
  - Static charge can produce electric field, static magnet and static coil altogether cannot produce electric field.
  - Comparison of
    - electric field and magnetic field;
    - a conservative field and non-conservative field;
    - electric flux and magnetic flux;
  - story of Faraday’s experimental observation; and
  - performing activity

4) Questions

- What questions can guide you to introduce the situation, make groups and bridge the gap and to encourage reflection?
- What questions you anticipate from the students and you intend to ask?

![Diagram of Magnet in Motion](image)

See the figure, what do you observe? What do you think is the reason for deflection seen in the galvanometer? Do you observe deflection in the galvanometer, if magnet is held stationary inside or near the coil? Does the deflection depend on the speed with which magnet is brought near the coil; the number of turns in the coil; area of the coil and inclination of the coil with respect to magnet? What is the direction of induced current when north and south poles of the magnet are brought towards the coil respectively? Is there...
any difference between the current flowing through a circuit connected to a battery and induced current? Can we use this phenomenon to generate electricity? How is electric field associated with changing magnetic field? Is the electric field generated by changing magnetic field, non-conservative? What is the difference between a conservative and non-conservative field? What if magnet is held stationary and the coil is moved towards it? How can we conclude our observation to get Faraday’s laws of electromagnet induction? How can we explain it mathematically? What is the significance of negative sign in the equation? How can we solve some numerical problems based on Faraday’s laws?

5) Exhibit

- **Students produce evidence of learning by writing, oral representation, performing activity / experiment, making models, etc.**
  1) Performing activity to observe;
     - the phenomenon of electromagnetic induction;
     - how speed with which the magnet is brought towards or away from the coil changes the magnitude of induced current; and
     - the effect of number of turns of the coil on the magnitude of induced current.
  2) Writing report of observation.
  3) Explaining Faraday’s laws of electromagnetic induction mathematically.

- Some students may make coils of different diameters and number of turns/primary and secondary coils for learning the concept of mutual induction in the upcoming class.

6) Reflections

- **Students reflect on what did they know, what they wanted to know and what did they learn.**
- **How did they come to know what they know?**
- **What concepts, skill and attitudes are developed?**
- **What did they learn while explaining the situation and observing the exhibit of others?**

Students do self-assessment. Teacher and students talk about what they have learnt and reflect on their teaching-learning experiences.
### Students knew

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1. Emfs are localized between two terminals of a battery. | • Can magnet/magnetic field produce electric field? | • Emfs can remain distributed throughout the circuit.  
• A changing magnetic flux can produce electric field in a coil. |
| 2. Magnetic field | • What is magnetic flux? | • The electric field associated with changing magnetic fields is non-conservative. |
| 3. Electric field resulted from static charges is conservative. | • How can magnitude of induced current be increased or decreased? | • Magnitude of induced current can be increased or decreased by:  
- changing the speed of the moving magnet;  
- changing number of turns and area of the coil; and  
- changing orientation of the coil with respect to the moving magnet. |

This lesson plan is adopted for demonstration purpose only. This lesson plan has been taken from Teaching of Science, NCERT, pp. 454-457
UNIT 6  APPROACHES IN SCIENCE TEACHING-LEARNING

Unit Structure
6.1 Introduction
6.2 Objectives
6.3 Science as a Process of Construction of Knowledge
6.4 Inquiry Approach
  6.4.1 How to use this Approach
  6.4.2 Advantages and Disadvantages
6.5 Problem Solving Approach
  6.5.1 How to use this Approach
  6.5.2 Advantages and Disadvantages
6.6 Cooperative Learning Approach
  6.6.1 How to use this Approach
  6.6.2 Advantages and Disadvantages
6.7 Experiential Learning Approach
  6.7.1 How to use this Approach
  6.7.2 Advantages and Disadvantages
6.8 Concept Mapping as an Approach for Planning and Transaction
  6.8.1 How to use this Approach
  6.8.2 Advantages and Disadvantages
6.9 Adopting Critical Pedagogy in Science Teaching- Learning
6.10 Let Us Sum Up
6.11 Unit-end Exercises
6.12 References and Suggested Readings
6.13 Answers to Check Your Progress

6.1 INTRODUCTION

We all are living in a scientific era. It is difficult to survive in this era without scientific knowledge and scientific skills. Being a science teacher you must have all the knowledge about science, like, what is the nature of science? Why do we teach science in our schools? How should we teach science effectively in our classrooms? This unit will help you to understand the various approaches of science teaching, and also helps to know how we can use them for effective science teaching and learning.

6.2 OBJECTIVES

After completing this unit, you will be able to:
- describe the various approaches of teaching-learning Science;
- explain how to use various approaches for teaching-learning Science;
- elaborate the advantages and disadvantages of each approach; and
- use appropriate approaches while planning your teaching-learning in Science.
6.3 SCIENCE AS A PROCESS OF CONSTRUCTION OF KNOWLEDGE

Science is the study of processes through the scientific method. We, human beings, are curious by nature and we want to know more about the world around us. The scientific method is a complex process which emphasizes “Doing Science”; in other words, we can say that for knowledge construction one should be an expert in the use of scientific method. Scientific method, through which the knowledge construction occurs, involves the following steps:

1) Observation
2) Formulation of Hypothesis
3) Testing the hypothesis
4) Analysis and Interpretation
5) Conclusion

Knowledge construction starts from a question; when someone is curious to know about the natural phenomena, s/he asks questions. To get answer of his/her questions, s/he formulates the hypothesis. After designing hypothesis, s/he tests the hypothesis to find out the answer of his/her questions. Now s/he analyzes the data, compares these results with previous results and finally arrives at a conclusion and in such a way the construction of knowledge occurs.

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) What are the steps of scientific method?

6.4 INQUIRY APPROACH

The main focus of this approach is to emphasize on ‘how we come to know’ rather than ‘what we know’. This approach is generally used by the science teachers when they want to develop inquiry skills, critical and problem solving skills, and also inquiry attitude among learners. In this approach, the teacher introduces the concept to the learners. Learners ask the questions from their teacher; it motivates the learners for designing the hypothesis. This hypothesis leads to an investigation to verify the hypothesis. Verifying the hypothesis leads to construction of new knowledge which is based on the findings of the investigation. The learners discuss and reflect on the acquired knowledge. This
approach motivates the learners to find out the answers of various questions through various types of inquiries rather than accepting the readymade answers from their teachers. In this approach, the learners actively participate in the construction of knowledge.

6.4.1 How to use this Approach

Teacher introduces the concept for example, “Seed” to the learners. Learners ask the questions. Teacher answers their questions in Yes or No. This interaction continues until the learners start to design hypothesis. Teacher motivates the learners to verify the hypothesis. Learners go through some reference material and do experiments to verify the hypothesis. This verification of hypothesis leads to construction of new knowledge. Let us see following example.

The teacher provides learners with a set of samples include seeds and non-seeds, which s/he has prepared in advance. The teacher passed the seed trays with samples from their seed and non-seed groups. Teacher picked a seed from the seed trays and showed it to the learners. “Is it a seed?” asked one of the learners, after observing the sample. The teacher replied “Yes”. The teacher described that these seed trays have seed and non-seed groups. The learners develop a hypothesis – “There is difference between seed and non-seed groups”. In order to verify this hypothesis, learners start to search for some reference material to do experiments (Dissection of the seeds).

The learner team observes the seed trays over a period of approximately 12 days. They observe that seeds change and begin to grow; two seeds that look alike produce two shoots which look alike and object that look like seeds but do not grow are probably not seeds. After observing the external appearances of seeds the learner team concludes that seeds are things that grow and develop. “Is there any part in seed” asked one of the learners. “I do not know” said the teacher. Now the learners were puzzled and finally learner team dissects and observes the interior of seeds using a magnifier. After observing a number of seeds they conclude that there are common basic elements in all the seeds. They have – the embryo, the food reserves, and the protective coat. They make a definitive distinction between seeds and non-seeds.

6.4.2 Advantages and Disadvantages

Advantages

- Learners become problem solvers rather than teacher’s response followers
- Learners get the opportunity to learn various concepts on their own
- Learners actively participate in the construction of knowledge
- It makes the learner more creative
- Learners learn how to design hypotheses
- Learner learn how to verify hypotheses

Disadvantages

- We cannot use this approach in our structured school settings as it consumes lot of time.
- If all the learners will not participate equally in asking/ framing questions then all the learners will not get benefited.
• For using this approach in a science classroom, a lot practice is required by the science teachers, without practice/training this cannot be used effectively.

### 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) What is the main focus of Inquiry approach?

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3) Write any two advantages of Inquiry approach?

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### 6.5 PROBLEM SOLVING APPROACH

This approach is more relevant and effective in science and mathematics classes. It is a learner-centered approach in which learner should be the active participant in the learning process. In this approach, a problem is presented by the teacher. After selecting problem, the learners (individually or with the help and guidance of teachers) get an opportunity to solve the problem by self-study, experiments and discussions with the following some systematic steps. The steps are as follows:

1) Defining the problem
2) Formulation of hypothesis
3) Testing the hypothesis
4) Analysis, interpretation and evaluation of evidence
5) Formulating Conclusion

#### 6.5.1 How to use this Approach

The teacher starts the lesson with a problem. On the basis of previous knowledge of the learners, they think about the possible solutions of the problem. After it, learners try to find out which hypothesis could be the best solution for this problem. To find out the best solution, the learners do interaction/discussion (learner-learner interaction and teacher-learner interaction), self-study and experiment(s). Learners test their hypotheses one by one, and finally arrive at the best possible solution of the problem. One such example is given below:
Teacher selects a topic ‘Condensation’. Teacher takes a beaker and wipes out its inner and outer surface with the help of a cloth. Now the teacher fills this beaker with ice cubes and waits for some time. After few minutes, some water droplets could be seen on the outer surface of the beaker. Teacher asks the learners that from where do the water droplets come on the outer surface of the beaker. Learners think about it and make their own hypotheses to get the answer of this question. Now all learners discuss their possible answers for this question. They study and conduct experiments. They heat the water in a beaker till it gets boiled and cover this beaker with a plate. After few minutes they see that water drops get collected on the insurface of the plate. With the help of this experiment learners come to know that on cooling water vapours condense and change into water drops.

6.5.2 Advantages and Disadvantages

Advantages

- This approach is effective in developing scientific skills
- This approach is helpful in developing higher order thinking skills
- The learners learn to accept the opinions shared by others
- Learners learn how to formulate hypotheses
- Learners learn how to test hypotheses

Disadvantages

- This approach is slow and time consuming approach.
- With the help of this teachers cannot complete the syllabus within a given timeframe.
- All teachers cannot apply this approach as they are not trained and experienced to use it.
- All learners are not able to learn with the help of this approach.
- Sufficient resources should be available to teacher and learner.

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) Problem solving approach is a learner-centered approach (True/ False)

5) Write any two disadvantages of problem solving method?

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### 6.6 COOPERATIVE LEARNING APPROACH

Cooperative learning approach is a method of teaching, in which learners work together in small groups to achieve a common goal under the guidance of the teacher. This approach requires five major elements:

1) **Positive Interdependence**: all members of the group must cooperate to complete the task.
2) **Individual Accountability**: Each member is accountable for the final outcome.
3) **Interpersonal Skills**: Communication skills, Leadership Skills, Trustfulness, etc.
4) **Face to face interaction**
5) **Processing** (Reflecting on how well the team is functioning and how to function even better).

#### 6.6.1 How to use this Approach

Teacher divides the learners in different informal cooperative learning groups (these groups last for only one discussion or one class period). Teacher gives a problem to these groups. The members of each group work together and they find out their respective solutions for the given problem. These all cooperative learning groups now discuss all possible solutions (solution given by each group) with each other and after this discussion they arrive at a final solution.

Teacher gives an unbalanced chemical equation to the learners of interpersonal groups to make it balance.

\[ \text{Fe}_2\text{O}_3 + \text{C} \rightarrow \text{Fe} + \text{CO}_2 \]

Each group balances this chemical equation and after discussing within the group, they finally have their own balanced chemical equation. All the groups now discuss with each other about their respective balanced equation and the procedure they followed to make it balance. After the discussion, they finally arrive at a balanced chemical equation with the appropriate procedure given below-

\[ \text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2 \]

Here we need to balance the Iron atom first. For balancing it we need to put 4 in front of Fe in the products side. Now in this equation Fe atom are balanced. We will have to balance Carbon Atom now and for it we need to put 3 in front of C on the reactants side and products side as well. Now the Chemical equation is balanced.

\[ 2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2 \]

<table>
<thead>
<tr>
<th>Element</th>
<th>Reactants</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>O</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

40
6.6.2 Advantages and Disadvantages

Advantages

- It develops communication skills and social skills
- It provides an opportunity for intellectual discussion
- It increases understanding of the content
- By using this approach learners learn how to explain any concept in their own words
- It develops critical thinking as learners participate in discussions.

Disadvantages

- It is a time consuming approach as it needs more time for planning and preparation.
- Learners, who dominate the opportunities created for other learners, play the role of teacher/expert while the lower ability learners stay in the role of their helper.
- For a teacher it is difficult task to identify whether the learners in the group are gossiping or doing academic discussions.

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) Write any two elements which are essential for cooperative learning?

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7) Write any two advantages of cooperative learning approach?

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6.7 EXPERIENTIAL LEARNING APPROACH

This learning approach is also known as learning through actions, learning through experiences and learning through reflection on doing. This approach is based on constructivism. In this approach, teacher plays role of a facilitator and guide. Learners learn through their own experiences by doing, reflecting and applying. They themselves evaluate their progress. Experiential learning approach directly
engages the learners in such activities where they learn by doing. These activities develop a clear understanding of the concept. According to Kolb’s experience learning theory, learning through experience is a cyclic process which involves four steps: Concrete experience, Reflective observation, Abstract conceptualization and Active experimentation.

6.7.1 How to use this Approach

Teacher introduces the concept to the learners. Learners design and engage themselves in a realistic experiment. Teacher provides an opportunity to learners for discussing their personal experiences which they have gained during the experiment. Now learners formulate concepts and hypotheses through discussion as well as individual reflection. Again learners engage themselves with the experiment with their formulated concepts and previous experiences. Learner reflects on the experiment and compares these results with previous results; this cyclic process goes on until the learner develops a clear understanding of the concept.

In the classroom teacher introduces the concept of Acid – Carbonate Reaction. When an acid reacts with carbonate, it forms a salt, carbon di oxide and water as products.

\[
\text{Acid} + \text{Carbonate} \rightarrow \text{Salt} + \text{CO}_2 + \text{H}_2\text{O}
\]

The learner himself designs and conducts an experiment to test this type of reaction, what will happen when hydrochloric acid reacts with calcium carbonate?

\[
2\text{HCl} + \text{CaCO}_3 \rightarrow ?
\]

After completion of this experiment, teacher discusses his/her experiences which s/he had gained during the experiment that when hydrochloric acid reacts with calcium carbonate it forms Calcium Chloride, Carbon-di-oxide and water as products.

\[
2\text{HCl} + \text{CaCO}_3 \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}
\]

S/he compares his/her results with others’ results. Now the learner again designs and conducts an experiment to test the alternative explanations which s/he had gained during the discussion like when Sulphuric acid reacts with calcium carbonate; it forms Calcium Sulphate, Carbon dioxide and water as products.

\[
\text{H}_2\text{SO}_4 + \text{CaCO}_3 \rightarrow \text{CaSO}_4 + \text{CO}_2 + \text{H}_2\text{O}
\]

The learner again gains experiences with this new experiment and compares these results with previous results. This cyclical process goes on until the learner develops a clear understanding of the Acid-Carbonate Reaction.

6.7.2 Advantages and Disadvantages

Advantages

- In the construction of knowledge, learner utilizes his/her experiences.
- Learners construct knowledge on their own.
- It enhances concept formation/retention.
- It is easy to transfer knowledge and skills through this approach.

**Disadvantages**
- Learning outcomes are not predictable easily.
- Use of this approach requires more time.

**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) Experiential approach is based on objectivism. (True/False)
9) In this approach teacher plays role of a facilitator and guide. (True/False)

---

6.8 CONCEPT MAPPING AS AN APPROACH FOR PLANNING AND TRANSACTION

Concept Mapping approach is based on Ausubel’s theory of meaningful verbal learning and developed into its standard form by Novak & Gowin (1984). In this approach, we hierarchically arrange the concepts in a deductive manner with the super-ordinate concepts at the top of the map and subordinate at the bottom, which are less inclusive than higher ones. The various concepts are linked through lines and these linkages are well defined using words or phrases that show the meaningful relationship between concepts. Through this approach learners learn about the structure of knowledge and the process of knowledge production. Learners, who learn through concept mapping approach, achieve higher and retained more as compared to the learners who learn by rote learning.

6.8.1 How to use this Approach

For using this approach for planning and transaction the following steps could be followed:

a) The topic to be taught will be selected.
b) The key concepts will be identified and listed.
c) The concepts underlying the key concepts will be identified and listed.
d) The various concepts will be hierarchically arranged.
e) The concepts will be mapped out, with the key concepts at the centre or at the top and the concepts hierarchically spread out.
f) The various concepts will be inter-linked by using suitable links.
g) These linking lines will be defined by using suitable words/phrases to elicit meaningful relationships between the concepts.

Let us see the following Example

While planning and transacting through Concept mapping approach, the following procedure can be adopted by teacher to teach Phenol.
**Topic: Phenol**

The teacher started the lesson by probing the previous knowledge of the learners.

**Teacher:** What is the name of this compound?

**Learner:** Benzene.

**Teacher:** The structure of Benzene is also called by some other name, what is it?

**Learner:** Benzene ring or Aromatic ring.

**Teacher:** What is the simplest hydroxy derivative of Benzene?

**Learner:** Phenol

**Teacher:** What is the structure of Phenol?

**Learner:**

![Phenol structure](image)

**Teacher:** Phenol is also known by other name what is it?

**Learner:** Carbolic acid.


**Teacher:** In the structure of Phenol the symbol —OH represents which group?

**Learner:** Hydroxyl group (—OH Group).

**Teacher:** What are the synonyms of make and divide?

**Learner:** Prepared and Classified.

**Teacher:** On the basis of number of hydroxyl group present in the molecule of Phenol, it can be classified into how many types?

**Learner:** ...

**Teacher:** On the basis of number of hydroxyl group present in the molecule of Phenol, it can be classified into four types –

i) Monohydric Phenol

ii) Dihydric Phenol

iii) Trihydric Phenol

iv) Polyhydric Phenol
Teacher: What is the General formula of Alcohol?
Learner: R—OH

Teacher: What is the structural difference between Alcohol and Phenol?
Learner: no answer/ wrong answer

Teacher: Alcohol contains hydroxyl group directly attached to carbon atom of an aliphatic system (CH₃OH) while a phenol contains hydroxyl group directly attached to carbon atom of an aromatic system (C₆H₅OH).

Teacher: Water is found in three states solid, liquid and gas. What does this statement represent about water?
Learner: Properties of water.

Teacher: Which type of properties does a chemical compound possess?
Learner: Chemical reactions and Physical properties.

Teacher: Due to benzene ring Phenol shows which type of chemical reactions?
Learner: no answer/ wrong answer

Teacher: Electrophilic Aromatic Substitution reactions.

Teacher: What happens when Benzene reacts with propene at 523K with Phosphoric acid?
Learner: Cumene is produced.

Teacher: Give the name of these compounds –

a) 

b) 

c) 

Learner: a) Benzene Sulphonic acid  
b) Benzene diazonium chloride  
c) Chlorobenzene

Teacher: Chlorobenzene is alkyl halide or Aryl halide?
Learner: Aryl halide.
The teacher adds ‘Cumene’, ‘Aryl Halide’, ‘Benzene Sulphonic Acid’ and ‘Benzene Diazonium Chloride’, on the black board.

The teacher points at the list of concepts and sub-concepts written on the black board.

**Teacher:** Of the various concepts you have noted down, identify the most inclusive i.e. broader concept.

**Learner:** Phenols.

**Teacher:** Right. Teacher shifts this concept label to the top and asks the learners to identify the next less inclusive concept, which should occupy the hierarchy.

**Learner:** Properties and Prepared.

**Teacher:** Right. Teacher shifts this concept label to the next place on the black board and continues probing the learners till all the concept labels are arranged in the hierarchical order, thus a pyramid is developed on the black board. She asks the learners to copy the list in their note books.
Now the teacher calls one of the learners on the board and asks him/her to connect the various labels using arrowhead lines. The rest of the learners were directed to do so in their notebooks.

After appreciating the learners’ efforts, the teacher guides the learners to define the connecting lines with appropriate words so that the relation between concepts could be highlighted using minimum words. The final structure developed through mutual discussion, which will be displayed on the blackboard, looked like:
The teacher completes the lesson by giving a few questions involving reflective thinking to the pupils to work upon.

The above lesson plan at a glance presents how the concept of Phenol was introduced to the learners through Concept mapping approach. By following the same procedure sub-concepts under the key concept Phenol, could also be taught through Concept mapping approach in an effective manner.

6.8.2 Advantages and Disadvantages

Advantages

• It can be used as a correction and assessment tool.
• In large classrooms, it can be used individually or collaboratively.
• It enhances concept retention.
• It promotes meaningful learning rather than rote learning.
• It allows seeing all your basic information on one page and can also be used as revision tool.

Disadvantages

• It takes more time as both teachers and learners need to be trained for using this approach as they are not familiar with it.
• Individual feedback also takes more time.

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.

Fill in the Blanks

10) Concept Mapping approach is based on ..............................................
11) Concept Mapping approach is developed into its standard form by ..........................................................

6.9 ADOPTING CRITICAL PEDAGOGY IN SCIENCE TEACHING-LEARNING

Teacher and learner engagement is critical in the science classroom because it has the power to define whose knowledge will become a part of school-related knowledge and whose voices will shape it. According to NCF 2005, learners are not just young people for whom adults should devise solutions. They are critical observers of their own conditions and needs, and should be participants in discussions and problem solving related to their education and future opportunities. Hence, children need to be aware that their experiences and perceptions are important.

True participation starts from the experiences of both learners and teachers. Participatory learning and teaching have an important place in the science classroom. Learner participation is a powerful strategy but it loses its pedagogic
edge when it is limited to teacher’s experiences. Critical Pedagogy is a teaching approach which tries to help the learners so that they can ask questions to teacher and challenge the domination of the teacher in their classroom. It tries to help learners to become critically conscious (by thinking, reading, writing and speaking) as the main objective of critical pedagogy- is to liberate learners from oppression.

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.

12) What is the main objective of critical pedagogy?

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6.10 LET US SUM UP

In this unit, we have discussed various approaches of science teaching-learning like Inquiry approach, Experience approach, Problem solving approach, Concept mapping approach, Cooperative learning approach, etc. Every approach has its advantages and disadvantages. As a science teacher we should know how, where and when we should use a particular approach for science teaching-learning.

6.11 UNIT-END EXERCISES

• Describe the problem solving approach? How will you use it in science teaching?

• What are the advantages and disadvantages of inquiry approach?

• How will you use concept mapping approach in your classroom, explain with the help of example?

6.12 REFERENCES AND SUGGESTED READINGS


Teaching-Learning of Science


6.13 ANSWERS TO CHECK YOUR PROGRESS

Ans. 1
1) Observation
2) Formulation of Hypotheses
3) Testing the hypotheses
4) Analysis and Interpretation
5) Driving Conclusion

Ans. 2 The main focus of this approach is to emphasize on “how we come to know” rather than “what we know”

Ans. 3
a) Learner becomes a problem solver rather than teacher’s response follower
b) Learners get the opportunity to learn various concepts on their own

Ans. 4 True

Ans. 5
a) This is a slow and time consuming approach, with the help of which teachers cannot complete their syllabus within given timeframe.
b) All teachers can not follow this approach in their classroom as they are not trained and experienced to use it.

Ans. 6 (a) Positive Interdependence
   (b) Individual Accountability: Each member is accountable for the final outcome

Ans. 7
a) It develops communication skills and social skills
b) It provides an opportunity for intellectual discussion

Ans. 8 False

Ans. 9 True

Ans. 10 Ausubel’s theory of meaningful verbal learning

Ans. 11 Novak & Gowin

Ans. 12 The main objective of critical pedagogy is to liberate learners from oppression.
UNIT 7  METHODS IN SCIENCE TEACHING-LEARNING

Unit Structure
7.1 Introduction
7.2 Objectives
7.3 Teacher Centric Methods
    7.3.1 Demonstration
    7.3.2 Lecture-cum-demonstration
    7.3.3 Laboratory
7.4 Learner Centric Methods
    7.4.1 Investigatory Projects
    7.4.2 Heuristics
    7.4.3 Natural Exploration
7.5 Cooperative Learning Methods
    7.5.1 Jigsaw
    7.5.2 Think Pair Share
    7.5.3 Other Methods
7.6 Inclusion in Science Classroom
    7.6.1 Adaptations in Inclusive Classroom
    7.6.2 Strategies of Teaching Science in Inclusive Classroom
7.7 Adopting Critical Pedagogy
7.8 Let Us Sum up
7.9 Unit End Exercises
7.10 Suggested Readings and References
7.11 Answers to Check Your Progress

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:

• identify 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 planned 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](image)

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:

<table>
<thead>
<tr>
<th>Steps</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>Preparation</td>
<td></td>
</tr>
<tr>
<td>Demonstration</td>
<td></td>
</tr>
<tr>
<td>Recording</td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td></td>
</tr>
</tbody>
</table>

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. Sometimes, 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?
    ...............................................................................................................
    ...............................................................................................................
    ...............................................................................................................
    ...............................................................................................................
    ...............................................................................................................

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.

<table>
<thead>
<tr>
<th>#</th>
<th>Topic</th>
<th>Investigatory Question</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Types of Tissues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Cropping Pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Forms of Energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Methods of separation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 are methods 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](image)

**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.


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.

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

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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 them 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

```
1  2  1  2  1  2  1  2  1  2
3  4  3  4  3  4  3  4
```

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

```
1  1  1  2  2  2  3  3  4  4
1  1  2  2  3  3  4  4
```

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 earthquake, 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.
Methods in Science  
Teaching-Learning

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

<table>
<thead>
<tr>
<th>Difficulty</th>
<th>Benefits from Accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following multiple step instructions</td>
<td>Simplify, repeat or clarify directions; call attention to key words in directions; have student repeat or paraphrase directions</td>
</tr>
<tr>
<td>Understanding concepts</td>
<td>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</td>
</tr>
<tr>
<td>Reading and comprehending material</td>
<td>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.</td>
</tr>
<tr>
<td>Recalling and communicating information learned</td>
<td>Provide mnemonics to aid in prompting memory of concepts taught; provide additional review (in game format to motivate)</td>
</tr>
<tr>
<td>Applying math concepts</td>
<td>Limit math skills required to functional concepts only; allow use of calculator</td>
</tr>
<tr>
<td>Completing tasks on time</td>
<td>Provide additional reminders of due times/dates; help students organize tasks by setting small goals leading to accomplishment of task</td>
</tr>
<tr>
<td>Staying in class and focusing on task</td>
<td>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</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Difficulty in hearing</th>
<th>Allow preferential seating, outlines of information provided in class, and visual cues from teacher to signal key events such as class transitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty with vision</td>
<td>Provide alternative procedures which allow for greater use of the other senses - especially the sense of touch</td>
</tr>
<tr>
<td>Performing gross and fine motor tasks</td>
<td>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.</td>
</tr>
</tbody>
</table>

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:  
1) Write your answers in the space given below. 
2) 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.

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**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 methods 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


- IGNOU (2016). Organizing Teaching-Learning, Unit 10 of Block 3, BES-123: Learning and Teaching, School of Education.


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.
UNIT 8 LEARNING RESOURCES IN SCIENCE

Structure
8.1 Introduction
8.2 Objectives
8.3 Identifying Appropriate Learning Resource
8.4 Various Learning Resources
8.5 Classroom Learning Resources
8.6 ICT as Learning Resource
8.7 Developing Science Resource Centres
8.8 Importance of Various Activities in Science Teaching
8.9 Innovations in Science Laboratories
8.10 Role of Innovation and Research in Science
8.11 Professional Development of Science Teachers
8.12 Unit End Exercises
8.13 Answers to Check Your Progress
8.14 Suggested Readings and References

8.1 INTRODUCTION

At elementary level, the child gains knowledge of scientific concepts by experience and observation but in higher classes they need more knowledge, therefore learning resources play a vital role in the process of learning. We all know that text books were the most widely used learning resource for science teaching for a long time; but in the present era, there has been a vast growth in each and every field and therefore the curriculum of science is reframed and restructured. With the explosion of new knowledge, new concepts and theories have emerged in science. These can be transacted in an effective manner with the help of appropriate learning resources. The child, members of the community and different resources available in immediate environment can be utilized as effective learning resources. Out of all available resources, a competent science teacher is expected to have the ability to identify appropriate learning resource for a specific content. In this unit, we will discuss the role of leaning resources in teaching-learning process of science and the process of developing learning resource center that suits the needs of the school.

8.2 OBJECTIVES

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

- explore learning resources from immediate environment,
- elaborate the concept of classroom learning resources,
- explain the nature and scope of science resource centre,
- describe the importance of various activities, organizing activities like field trips, quizzes, excursions, exhibitions, fair, lectures, etc,
describe the role of Science express, mobile science laboratory, virtual laboratories in science,

explain the role of innovation and Research in Science, and

elaborate the nature and scope of Professional Development of Science Teacher.

**8.3 IDENTIFYING APPROPRIATE LEARNING RESOURCE**

Before discussing the role of learning resource in science, it is relevant to understand the process of appropriate learning resources. Let us discuss this issue in detail.

It is the responsibility of all the teachers to select resources-

a) that will enrich and support the curriculum, taking into consideration the diversity of interests and perspectives and the variety of abilities, learning styles and maturity levels of the learners served;

b) that will stimulate growth in factual knowledge, literary appreciation, aesthetic values, and knowledge of societal standards;

c) that positively and accurately reflect diverse perspectives on controversial issues, ensuring that learners have an opportunity to develop, under guidance, the practice of critical analysis and the ability to make informed choices/judgments in their daily lives;

d) that represent gender, appearance, sexual orientation, ability/disability, belief system, family structure, race and ethnicity, and socio-economic status

According to the **ROLE Psycho-Pedagogical Integration Model** (The ROLE PPIM) any learner centred teaching learning strategy will involve the following four phases:

1) Information of the learner is defined or revised.
2) The learner finds and selects learning resources.
3) The learner works on selected learning resources.
4) The learner reflects and reacts on strategies, achievements and usefulness.

The diagrammatic representation of this model is as follows:

![Fig. 8.1: The ROLE Psycho-Pedagogical Integration Model](image_url)
Now the question that arises is what may be the criteria of selecting a learning resource. In selecting the learning resources, a teacher should evaluate available resources and curriculum needs and consult reputable, professionally prepared selection of tools/aids and other appropriate sources. The actual resource should be examined whenever possible. Selection is an ongoing process which should include the removal of materials no longer appropriate and the replacement of lost and worn materials still of educational value.

**Criteria for Selecting A Resource**

One should take care of following criterion for selecting a resource of learning-

1) Learning Resources should support and be consistent with provincial and local pilot/program curriculum outcomes.

2) Learning Resources should be developed by competent teachers and meet high standards of quality in factual content and presentation.

3) Learning Resources should be appropriate for the subject area and for the age, emotional development, ability level, learning styles, and social development of the learners for whom the materials are selected.

4) Learning Resources should have aesthetic, literary and/or social value.

5) Learning Resources should have a physical format and appearance suitable for their intended use.

6) Learning Resources should be one of a variety of media presentation modes.

Therefore, it is important to understand that learning resources should be activity-based rather than lecture-based because these are tools of interactive learning and involvement of learners in teaching learning is a prerequisite for ensuring optimum level of learning. The objective of using these resources is to encourage learning into group and cooperative learning, as well as to provide an opportunity for individual growth. It helps in applying knowledge of theory into practice and promotes hands-on experiences through various activities and an applied approach to learning. In addition to this, it encourages learners to question, think, react, reflect, and decide ways that develop critical-thinking and decision-making skills and offer choice and flexibility, as appropriate, to meet the needs related to individual aptitudes, abilities, learning styles, multiple intelligences, and interests.

Learning resources should be supportive of continuous learning by the individual and provide both formative and summative assessment and evaluation as appropriate.

**Social Consideration for Selecting the Learning Resources**

Some social considerations are also important while selecting the appropriate learning resources. These are as follows:

1) Learning resources should reflect sensitivity toward gender and sexual orientation, the perspective of aboriginal people, and cultural and ethnic heritage.

2) It should promote equality by enhancing learners’ understanding of a multicultural and diverse society and should be chosen to help learners understand the many important contributions made to our civilization by minority groups and people/groups with a variety of ethnic backgrounds.
Teaching-Learning of Science

3) It should be designed to motivate learners and staff to examine their attitude and behaviour, and to comprehend their duties, responsibilities, rights, and privileges as participating citizens in our society and support/promote learners’ self-esteem and respect.

4) It should recognize the integration of learners with special needs (as part of the class) and reflect good safety practices in texts and visuals (e.g., use of helmets, seatbelts).

5) It should portray positive role models and use language appropriate for the intended audience, and exclude slang, vernaculars, or expletives that detract from meaning.

From the above discussion we can conclude that the following four criterion should be kept in mind while selecting an appropriate learning resource along with academic, psychological and social considerations:

a) **Appropriateness of learning resources**- It is important to select an appropriate learning resource for ensuring optimum learning among the learners.

b) **Availability**- It is always suggested that a teacher should prefer the locally available learning resources rather than resources from external sources. The resource room with all required learning resources should be readily available to the learners and teachers so that they can utilize it as and when required.

c) **Economic**- It is very important to use the learning resources that are cost effective because in a developing country like India where finance is a major issue we should construct low cost learning resources. Classroom learning resources, improvised learning resources and locally available learning resources may be better option.

d) **Safety**- The learning resources should be safe and secure for users (teachers and learners).

**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) What are different social considerations while selecting a learning resource?

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8.4 VARIOUS LEARNING RESOURCES

Before discussing the use of learning resources, it is important to define the learning resource. Various agencies described learning resources in a different manner. Some relevant explanations are as follows:

According to Department of Education, Canada “Learning Resources” refer to any person(s) or any material (whether acquired or locally produced) with instructional content or function that is used for formal or informal teaching-learning purposes. Learning resources may include, but are not limited to, print and non-print materials; audio, visual, electronic, and digital hardware/software resources; and human resources.

This can be interpreted from the discussion above that in a broader perspective learning resources include human resource as well as physical resources. In this section of the unit, we will discuss a child’s ideas, ideas of community members and Resources from immediate environment.

Child’s Ideas as Learning Resources

This is one of the most important components of learning. Ideas of children can be learning resources for a teacher. Children develop abstract ideas from their physical surroundings and they select the idea relevant to them based on their objects/needs.

It is important to understand that learning involves abstract thinking and the children have the ability to develop abstract concepts from their world. They develop this ability by interaction with the environment during games and other activities. They find new ways to represent objects and experiences and generalize those experiences; that’s how children learn to think abstractly. This skill allows the children to build theories about their world.

Community Members as Learning Resource

The role of community is very vital in creating a conducive learning environment. The families begin to create the kinds of connections that address both intellectual and emotional needs of children. The subjects taught in school are related to our daily life and therefore the concepts that a child learns, are not only in the class but outside the class too. A child interacts with his/her siblings, parents, guardians and other members of the community. These interactions are vital learning resources. For example, village children get information about the crops from their elders. They develop the ability to identify different types of crops and crop cycle. It is easy to understand that the ideas and thoughts generated from
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community and its members may be used as important resource of learning to optimize the learning experience of the learners.

**Resources from Immediate Surroundings**

Teaching-learning of scientific concepts is highly correlated with surroundings. The process of learning cannot be far removed from the immediate surroundings of the children. Different resources from immediate surroundings/environment are an essential part of the teaching-learning process. The relevant content available locally should be well utilized by the teachers. This content should be a part of the teaching-learning process ideally, to transact through activities drawn from the local resources. As a teacher, we should accept the importance of community members because most of the time children interact with them and there is a great impact of neighbours, friends and family members on their thought processes. Their daily life experiences help in developing a scientific attitude towards life. Children critically observe and explore the social reality around them while simultaneously enabling them to experience human and scientific values. The ideas given here demonstrate how the learning of science can be enjoyable and exploratory and how the science class can help in raising the awareness of learners about issues related to their environment, encouraging them to be instruments of change.

**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.

3) Explain the role of child’s thoughts in the teaching-learning of science.

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**8.5 CLASSROOM LEARNING RESOURCES**

Classroom is a place where we organize the teaching learning process and it is responsibility of a teacher that s/he should develop educational atmosphere with the help of learning resources available in the classroom. Classroom learning resources are an important tool that can be used by the teacher to present the concept before the learners effectively and learners use these resources for better understanding and to gain hands on experiences for the concept. It can also be used to stimulate learners or relieve anxiety, fear or boredom since many learning resources are like games. Some of the most common learning resources include visual aids like the blackboard, pictures; audio aids like cassette tapes or CDs; and audio visual aids such as video tapes and so on”, even the teachers are a learning resource. In this section of the unit, we will discuss different learning resources available in the classroom. According to Grubb(2008), the school resources can be categorized as follows:
Summary of Grubb (2008) taxonomy of school resources

<table>
<thead>
<tr>
<th>Type of classroom Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>Resources that are physical objects (e.g. textbooks) or classroom factors (e.g. teacher experience and expertise) that can be directly bought, adjusted, and measured</td>
</tr>
<tr>
<td>Compound</td>
<td>Two or more resources that are jointly necessary for success (e.g. class size reduction and adequate teacher preparation)</td>
</tr>
<tr>
<td>Complex</td>
<td>Resources that are not easily bought, measured, or adjusted (e.g. instructional approaches and teaching philosophies)</td>
</tr>
<tr>
<td>Abstract</td>
<td>Resources that are difficult to discern and measure, and often embedded in a web of relationships and practices within a given school (e.g. collegial decision-making practices, internal teacher accountability, and distributed leadership roles)</td>
</tr>
</tbody>
</table>

Now we can understand that different resources may be used as per the demand of the topic and level of the learner. There is no any definite strategy for using these resources but teacher can use these resources as per the requirement to attain the objectives of ensuring optimum learning. This can be better understood by the ecosystem model of classroom resources given by Zhao & Frank (2003) as given below:

![Classroom as Ecosystem Model](drawn from description provided in Zhao & Frank, 2003)

This model indicates that the kind of the resource to be utilized by the teacher is dependent on the teacher, learners and environment. Some of the frequently used classroom resources may be enlisted as follows:

- Teacher’s thoughts
- Children’s thoughts
- Thoughts of community members
- Blackboard and other writing boards
- Books/textbook/worksheets
- Herbarium and other relevant equipments
- Audio resources like radio, tape recorder, mobile phone, etc.
8.6 ICT AS LEARNING RESOURCE

Nowadays, it is being observed that there is a paradigm shift in the teaching-learning process and therefore in the support system that we use for effective teaching and learning. Information and communication technology is going through rapid and continuous change and therefore use of ICT is highly common in the teaching learning process. These changes are reflected by the change in the learning strategy of learners. Different researches proved that new generation of children are using these resources extensively and they share, use, develop and process information and technology for different purposes.

According to Meiers (2009), the teachers are required to possess all the skills that are essential to utilize ICT resources effectively. In this digital age, there is a growing body of evidence that use of ICT in the classroom can enhance learning.

It is essential that the contemporary teacher has good ICT skills and is able to integrate ICT into the teaching and learning processes. It is highly recommended that after a good teacher education Programme, the newly appointed teacher demonstrates current knowledge and proficiency in the use of ICT in the following areas:

- Basic operational skills
- Information-technology skills
- Effective use of the internet
- Software-evaluation skills
- Pedagogical skills for classroom management.

Different ICT resources includes-

1) **ICT based learning objects**- It refers to any digital resource that can be reused to support learning.

2) **Multimedia Learning Resources**- Computer-based multimedia learning environments - consisting of images, text and sound offer a potentially powerful setting for improving learner understanding.

3) **Mobile Learning**- The terms “M-Learning” and “Mobile Learning” are usually used to refer to teaching and learning with mobile technologies. It has following characteristics:
   1) Spontaneous
   2) Personal
   3) Informal
   4) Contextual
   5) Portable
Learning Resources in Science

6) Ubiquitous (available everywhere)

7) Pervasive (so integrated with daily activities that it is hardly noticed)

4) The Internet and Social Networking – Internet is a rich resource for teaching and learning. Web 2.0 refers to a more recent 2nd generation collection of web-based tools, usually involving social networking (sites like Facebook) and amateur publishing (like blogs and YouTube).

5) Interactive whiteboards, slide/PowerPoint presentations – In most of the schools, interactive whiteboards is used to deliver multimedia presentations in a classroom environment. Presentation software, such as Microsoft PowerPoint or Apple’s Keynote, plays an important role in many fields, especially in learning.

8.7 DEVELOPING LEARNING RESOURCE CENTRES

In the changing world in ICT era, it becomes a very big challenge to provide answers to the most educational questions through traditional resources. Learners use internet services and social media for different purposes and they get information flow from a dedicated review of most educational questions, whether from theoretical frames or material facilitations. Libraries and laboratories of the school were treated as most vital educational resource but in the changing scenario, it is important to develop these traditional resources as per the growing demands of the children and it is also important to develop new resources.

It is, also, a fact that there is urgent requirement to develop a centre that can cater to the need of learners and provide information via a wide diversity of technologies and resources. This kind of centre will be helpful for teachers and learners. Most popular term used nowadays for these kinds of centres is ‘Learning Resource Centre’. These centres can be used by institutions for multiple purposes. The prime objective of developing such centre is advancement in the learning experiences of the learner and teaching experiences of teacher.

Any school has many resources such as teachers, learners, community members, library, etc. This kind of centre may be a collection of different kind of information and techniques. Therefore, learning resource centre is essential for the teacher to utilize acquired information. This information is analyzed and evaluated by teacher to build a new knowledge and experience and develop them using several learning methods.

Need of Learning Resource Centre

As we know that any content can only be transacted to the learners only when the concepts are supported with practical knowledge. This will be only possible when different learning resources are readily available to be utilized in an appropriate way. Information provided by the book and printed material should be supported by different other learning experiences for concept clarity and hands on experiences.

Learning resource centers focus on incorporation of resources, information and communication technologies with educational practices inside the class. Learning resource centre’s universal purpose is to guarantee learning educational suitable environment that allows learner to take advantage from any kind of learning resources. It also encourages self-learning among the learners.
Components of Learning Resource Centre

There may be many components of learning resource centre. Some of the important components are as follows-

1) **Self-learning area:** Self-learning auditorium should enable access to all kind of information resources: printed, learning instruments, computerized and ICT resources.

2) **Group-learning area:** It has various equipments and uses, whereas available projectors depend on computer, radio or live presentation through digital camera. There is available, also, flexible furniture which can be reshaped to suit all kind of group and cooperative learning.

The most important elements of a good learning resource centre are different educational resources. In addition to these resources a good learning resource centre will have well defined policy made which will be adapted to satisfy the objectives of the learning resource centre. This policy should ensure the building and development of an integrated collection that can help and enrich educational curricula.

The learning resource as a teacher works with learners and other members of the learning community to analyze learning and information needs, to locate and use resources that will meet those needs, and to understand and communicate the information the resource provides. Learning resource centre is supposed to be successful when it is fully engaged in implementation of modern learning methods. A good learning resource helps in the learning process and evaluation.

There are following two methods of utilizing learning resource centers-

a) **Cooperative Learning:** In this type of learning strategy a teacher has to take at least one class inn learning resource centre.

b) **Self-Learning:** In this type of learning strategy the learner is allowed to learn by themselves. The role of teacher is a facilitator.

Many activities are organized in the learning resource centre. These can be diagrammatically represented as follows:

![Activities in a Learning Resource Centre](image-url)
Through these activities Learning Resource Centers provide the services of Guiding readers, References services, Borrow out along with Copying and scanning and bibliographical services.

These activities and services develop the learning resource centre as a necessary place where teachers arrive to help them to implement their tasks and achieve their educational aims.

8.8 IMPORTANCE OF VARIOUS ACTIVITIES IN SCIENCE TEACHING-LEARNING

Science cannot be taught through books alone. It is always experimented with, observed and experienced through a number of practical activities done inside and outside the school by the learner themselves. For effective science teaching it is needed that co-curricular activities and after various other approaches like organization of field trips along with different activities. Let us discuss different activities that help in learning scientific concepts effectively:

Field Trip or Excursion

Field trips are an important part of the science curriculum because it provides opportunities of hands on experience of science. It is a visit to a place outside the regular classroom which is designed to achieve certain objectives, which cannot be achieved as well by using other means. We can understand by taking example of interdependence of plants and animals. The textbooks provide conceptual knowledge but cannot provide hands-on experience; that may create difficulty in achieving educational objectives. In such a lesson, this strategy is required. Field trips give opportunity for learners to get out of the classroom and experience many new things. The located place for field trip can be zoo, collage, museum, theater, school, science park, botanical garden, etc.

The use of the term ‘field work’ emphasizes some of the formal exercises which are done outside of the classroom, usually in biology and geology at senior high school and tertiary levels. These activities may be considered to be a subset of field trips or excursions.

The benefits of field trips can be summarized as follows:

1) It helps in clarifying subject matter.
2) It creates interest in the subject.
3) It has entertainment value and makes the learning enjoyable.
4) It helps the learners in establishing contact with outer world.
5) It develops scientific attitude and scientific temper among the learners.
6) Filed trips or excursions are very useful in collecting useful material.
7) Excursions help in developing the spirit of cooperation among the learners.
8) It provides opportunity for the selection of the projects.

Concluding our discussion you will get to know that the scientific excursions or trips when organized in a systematic and proper way prove to be quite effective and useful from the point of view of the realization of the aims and objectives of teaching science.
Quiz
Organizing Quiz is a very important activity to make the learning of scientific concepts more enjoyable. Organization of quiz promotes the learning directly in the context of classroom instruction and it reduces the rate of forgetting after the instruction. Quiz helps in learning the learners in two ways:

a) Using “pre-questions” to activate prior knowledge and focus learners’ attention on the material that will be presented in class.

b) Using quizzes to re-expose learners to key course content. Recommendation includes a third way to use quiz for making decisions about allocating study time.

Quiz may be organized as a part of instruction and it can also be used as a co-curricular activity to promote scientific temper among the learners.

Science Fair, Exhibition and Talk on Science
These are one of the most popular ways of making the learning of science enjoyable. Different national and state level organizations like NCERT and state departments of education are working together for the promotion and encouragement of science fairs at the district, regional and state level. They provide required financial assistance and expert guidance to schools for organization of such fairs. These fair provide a forum for interaction among science scholars and learners on the issues of scientific enquiry. Many formal and informal activities related to the teaching and learning of science are organized by coordination among participants and holders. Many other programmes are organized by the host club or some other agency.

Some of the major activities may be undertaken in the science fairs are as follows-
1) Debates, declamation and paper reading contests
2) Essay competition on different events and concepts of science.
3) Group discussions, seminars and workshops
4) Lectures and talks of science teachers or scientist
5) Science quiz contest
6) Completion for developing teaching aids of science.
7) Film shows and plays on scientific concepts.

Science fairs and exhibitions are very useful and it has a social value along with its educational value.

8.9 INNOVATION IN SCIENCE LABORATORIES
Now days, the world is experiencing a lot of development in the field science. For example, a new element becomes the part of periodic table. Many new concepts and many new theories arrive at the doorstep of the learner and laboratory play a vital role in providing hands on experience to the learner. You can easily understand the fact that establishing these laboratories are an essential part of the school infrastructure but at the same time it is very costly and impractical to establish a well-equipped laboratory for each and every school. Therefore, the concept of alternative laboratory arrived to cater to the needs of the learners.
Some of the major innovations in this area are Science Express, Mobile Science Lab and Virtual Laboratories. In this section of the unit we will discuss these laboratories to gain a better understanding of the same.

Science Express
This is a concept coined by the Department of Science and Technology and Ministry of Environment and Forests, Government of India. It is a train with AC coaches and it travels across India with a view to sensitize the people to different issues of science and to develop scientific attitude and temper among learners. For example, ‘Science Express - Biodiversity Special’ (SEBS) is an innovative mobile exhibition mounted on a specially designed 16 coach AC train, travelling across India from 5 June to 22 December 2012. SEBS was the fifth phase of the iconic and path-breaking Science Express.

Mobile Science Lab
It is a well known fact that it is very difficult to establish science labs in each school of India. Mostly in rural areas, most of the schools do not have this kind of laboratory and this has an adverse effect on learning of scientific concepts. This leads to learning of science without performing or even observing a single experiment. Mobile Science Lab (MSL) is one of the best alternatives and initiatives to cater to the needs of the learners. It gives the learners in secondary schools a chance to learn science by performing experiments, thus giving them not only the pleasure of “learning by doing” but also rendering the subject enjoyable and easy to understand.

Mobile Science Lab emphasizes to learners that in general, statements should not be accepted as facts just because they are stated in a book. Instead, they should be verified by observations and rational conclusions drawn from such observations. It is through such an attempt, we hope to inculcate and nurture a scientific attitude among the school children. A good mobile lab possesses all the essential equipment, materials and infrastructure. It should possess all the safety features for conduction of the experiments safety and the materials should be kept safely so that movement of the science lab should not have any adverse effect on the equipment and materials. First aid box and doctor on call facility should also be provided in these kinds of labs.

Following activities may be performed in Mobile Science Laboratory-
- Technology classes
- Science laboratories
- Hands-on workshops
- Video presentations
- Job skills training classes

Virtual Lab
The whole world is growing as virtual world and therefore education now has more virtual components. Virtual labs are an innovative concept where a laboratory experiment is possible without real laboratory with its walls and doors. It allows the learner to link the theoretical and the practical aspects of any scientific concepts, without papers and pens. It is based on a software Programme that can create virtual environment of lab. To understand the concept of virtual lab, we will try to explore the definition of virtual labs.
According to Harry & Edward (2005) virtual lab may be defined as “A virtual studying and learning environment that aims at developing the lab skills of learners. This environment is located on one of the internet pages. Usually, this page has main page & many links, which are related to laboratory activities & its achievements.

From this definition, we can conclude that the virtual lab can be defined as virtual platform for studying and learning science that stimulates the real lab. It provides the learners with tools, materials and lab sets on computer in order to perform experiments subjectively or within a group at anywhere and anytime. These experiments are saved on CDs, Pen drives, Hard disks or on a web page.

Any virtual lab may have following components-

1) **The lab sets & equipments**: These are required because virtual lab is complementary not alternative of real lab

2) **Computer devices**: they are represented in personal computers connected to an intranet and internet connection

3) **Communication network & the related hardware**

4) **The Programs of the Virtual Lab**: These programs are represented in the simulation programs, which are designed by professionals.

5) **Co-operation Programs & Management**

6) **Technical Staff**: It is important to have a technical team to support educators in preparing and assessing scientific materials.

Concluding our discussion, we can state that virtual labs are very useful in enhancing the learning experience of the child. Through virtual labs, experiments can be done quickly and easily and it allows observation and safe measurement where as the experimental process is very slow and / or complex and not compatible with the teaching time available.

---

### 8.10 ROLE OF INNOVATION AND RESEARCH IN SCIENCE

Innovation and research in science education is one of the important prerequisites for the development of sciences. As is known, the researchers conducted in the area of science aims to achieve advancement in economic growth, social development and protection of environment.

The major areas of research are Science curriculum, Pedagogy of science, Misconceptions in Science, Evaluation techniques and many more. In addition to this, as the science scholars conduct researches for innovations and new concepts, theories and inventions are arriving. Therefore, researches and innovations are a boon for the development of Science and science education. These researches may be on two levels – school level and at the level of scientists and institutions working in the area of science.

The curriculum of science should be need based and it should be in tune with national and international demands to fulfill the objectives of scientific era. The innovations and researches in the science should focus on making the concepts more interesting and enjoyable so that the learners gain an understanding of
concepts. This will help them apply the concepts of science to real-life situations therefore the practical component of teaching should be highlighted. Many researches were done in area of teaching science so that learners feel involved and develop an interest in the subject.

8.11 PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS

Professional development refers to informal and formal methods that help develop professional skills of teachers in a formal or informal way. Staff-development and in-service training programmes are widely used for professional development for teachers. Teacher-training and professional development of science teachers is another thrust area and the focus here should be on studying the curricula of both pre-service and in-service science teacher-training programmes. Teachers need to learn to create a suitable environment and employ approaches that boost active questioning and identification of issues and answers by learners. They need to be able to encourage learners, to test the information presented and discuss its personal significance. These abilities cannot be established through traditional programmes of professional development. To cater to the need of teachers for training a carefully designed, sustained, professional development Programme is the need of the hour that actively involves teachers in the learning process of science.

Professional development for teachers should be analogous with professional development for other professionals. Becoming an effective science teacher is a continuous process that stretches from pre-service experiences in undergraduate years to the end of a professional career. Science has a rapidly changing knowledge base and expanding relevance to societal issues, and teachers will need opportunities to build their understanding and ability. Teachers also must have opportunities to develop an understanding of how learners with diverse interests, abilities, and experiences make sense of scientific ideas and what a teacher does to support and guide all learners. And teachers require the opportunity to study and engage in research on science teaching and learning, and to share with colleagues what they have learned.

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) Enlist different types of classroom resources and categorize them.

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### 5) Enlist ICT resources that can be used as learning resource of science.

<table>
<thead>
<tr>
<th>ICT resources</th>
<th>Description</th>
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</tbody>
</table>

### 6) What are different essential components of Learning Resource Centre?

<table>
<thead>
<tr>
<th>Essential components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

### 7) How are science fairs and exhibitions helpful in making the teaching-learning of science enjoyable?

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Description</th>
</tr>
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### 8) Discuss limitations of virtual laboratory in your words?

<table>
<thead>
<tr>
<th>Limitations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

### 8.12 LET US SUM UP

For effective teaching-learning, use of appropriate learning resource is very important. This unit has discussed various criteria which will help you in selecting the appropriate resource. You will agree that an effective teacher can utilize his/her class as resource if s/he is aware of the dynamics of classroom. Physical resources in the classroom as well as learners with diverse experiences both can be used as effective resources. Unit focuses on developing learning resource and resource center at your school as many schools are still not equipped with state-of-the-art laboratories. Apart from this, activities like field trip, science fair, exhibitions, talks on science, etc. can be used effectively as learning resource for facilitating teaching-learning in science. As a science teacher you should be read for your professional development, for which unit sensitizes you.
8.13 UNIT END EXERCISES

1) As a science teacher how will you identify appropriate learning resource for science? Answer with a relevant example.

2) Briefly describe the concept of learning resources.

3) What are different Classroom learning resources? Describe with the help of some examples.

4) Indicate the need and scope of ICT to be used as learning resource. How is it useful for teaching-learning process?

5) Discuss the need of science resource centre. Give a brief overview of a good science resource centre.

6) What is the relevance of co-curricular activities in teaching science? Describe with the example of field trip.

7) Discuss different innovations in science teaching and science laboratories.

8) Briefly describe the concept of professional development with respect to science teachers of secondary level.

8.14 ANSWERS TO CHECK YOUR PROGRESS

1) Your answer should include following points:
   - Learning resources should not cater to the needs of a single category of children.
   - It should have equal effect for all the learners of the class.
   - While selecting a learning resource, a teacher has to ensure that it is not biased to anyone based on gender, race, color or socio-economic background.
   - It should have ethical consideration.

2) Your answer should include following points:
   - Learner’s abilities should be the deciding factors.
   - Learning environment is important aspect of this strategy.
   - Learning resources are an important part of the learner centred teaching strategy.

3) Your answer should include following points:
   - Relevance of learning resource based on the topic to be taught.
   - Low cost teaching aids should be selected.
   - Safety and availability are other considerations.

Check Your Progress 2

1) Your answer should include following points:
   - These are resources that help the learners in understanding different concepts of science.
   - Teachers Thoughts, Child’s Thoughts and all other teaching aids, libraries and laboratories are apart of learning resources.
2) Your answer should include following points:
   • In a learner centred strategy of teaching science the role of learner is important.
   • Children learn from their environment and their experiences may be utilized to develop different scientific concepts.

Check Your Progress 3

1) a

2) According to Grubb, the teaching resources may be categorized in four categories namely simple, compound, complex and abstract.

3) Different ICT resources include ICT based learning objects, Multimedia Learning Resources, Mobile Learning, Internet and Social Networking. In addition to this Interactive whiteboards and Slide Presentations are also used as learning resources in science.

4) Learning Resource Centre should have all kind of information resources: printed, learning instruments, computerized and ICT resources along with projectors depend on computer, radio or live presentation through digital camera.

5) These are one of the most popular ways of making the learning of science enjoyable. These provide forum for interaction among science scholars and learners on the issues of scientific enquiry. Many formal and informal activities related to the teaching and learning of science is organized by coordination among participant and holders.

6) Virtual laboratories are not a replacement of the real labs but they act as support for the tradition experimentation at school level.

8.15 SUGGESTED READINGS AND REFERENCES


UNIT 9 ASSESSMENT IN SCIENCE

9.1 INTRODUCTION

When we talk about assessment, we talk about it with a purpose. As a science teacher, you should be agreeing that purpose of assessment in science is to facilitate the learners in developing scientific attitude and acquiring process skills. A science teacher has to plan and execute the assessment as an integrated part of his/her teaching-learning process. Present unit will help you in planning and designing your assessment strategies so that you can assess various aspects of learners’ progress and facilitate them accordingly. A teacher has to devise various tools and adopt different techniques for assessment depending upon nature of content, type of skills, level of learner, etc. In means, one can not use similar kind of tool for assessing variety of process skill, for different kind of content and activities. The unit will discuss various tools and techniques, which are being used for assessment in science at secondary level. Unit will not only talk about classroom assessment but also give you an idea about various schemes, which are being used to promote the development of scientific temper and attitude among learners. Unit will also help to design your plan for recording and reporting of learners’ progress in science.

9.2 OBJECTIVES

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

- understand the need of different types of assessment strategies in sciences;
• develop assessment indicators for various process skills;
• design various tools for scholastic assessment in science;
• develop a unit-test as a tool for formative assessment in science;
• justify the need and importance of diagnosis and remediation in science; and
• motivate your learners to participate in various schemes for promoting scientific attitude.

9.3 NATURE OF ASSESSMENT IN SCIENCE

Nature of assessment in science is not something entirely different from other subjects but it has certain distinctive characteristics, which have been drawn from the objectives of teaching-learning in science.

Assessment in science promotes scientific enquiry
When a teacher plans assessment activities in science, its key focus is that it should promote scientific enquiry. Assessment in science should not be based on rote memory. Mere memorization of facts, principles or theories will not serve the purpose of science teaching-learning. If as a teacher, you plan and use such tools and techniques, which involve problem solving, investigation, active thinking and reasoning, your assessment will promote scientific enquiry.

Assessment is linked with cognitive levels of learner
In unit 5, we have discussed levels of cognitive learning, which are based on Anderson’s taxonomy i.e. remembering, understanding, applying, analyzing, evaluating and creating. When as a science teacher, you are planning your assessment strategy, you should keep in mind that your assessment tool should be linked with every level of cognitive learning. You have to identify, decide and plan that which content is related to what level and what should be appropriate tool or technique for its assessment.

Assessment in science is comprehensive in nature
Comprehensiveness is the key characteristic of assessment in science. A science teacher never assesses only one dimension, rather it assess many dimensions during one assessment. For example, s/he has to assess the comprehension of the concept, its linkages with examples from immediate environment, applications to solve problems, development of values and role of assessment activity in facilitating development of scientific temper. When you plan an assessment activity, you should keep in mind many dimensions.

Assessment in science facilitates development of process skills
Major role of assessment is not grading or promoting. Its role is facilitating development of scientific process skills. Critical pedagogues also advocate development of process skills among science learners, which is major focal point in present days teaching-learning. Your assessment activities should be in sync with process skills associated with the content.
9.4 ASSESSMENT INDICATORS IN SCIENCE

While teaching science, our focus remains on the development of science process skills. When we plan assessment, we have to identify criteria on which any skill is to be assessed. The criterion, on which development of any skill is being assessed, is known as assessment indicators. In documents like the *Source Book on Assessment in Science* (NCERT, 2102), Formative Assessment Manuals for Teachers (IX-X), (CBSE, 2010, 2016) various learning indicators have been suggested to assess various science process skills. We suggest you to go through these documents to arrive at a deeper understanding of assessment in science. In order to understand various skills to be developed and assessed, let us discuss some learning indicators associated with various skills, which form the basis for assessment in science.

<table>
<thead>
<tr>
<th>Skills</th>
<th>Indicators</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>Children observe critical characteristics of a thing, an event or a phenomenon.</td>
<td>Different shapes of Leaves, Parts of a flower, Shadow of an object, etc.</td>
</tr>
<tr>
<td></td>
<td>Can differentiate between two similar things based on their observation.</td>
<td></td>
</tr>
<tr>
<td>Enquiry</td>
<td>Children ask questions starting with why, when, how and what about various phenomenon, things, etc., which they observe.</td>
<td>Why does the Sun rise in morning? Why are the stars twinkling at night? How do snakes move?</td>
</tr>
<tr>
<td>Experimentation</td>
<td>They are able to perform experiments systematically under guidance. They follow the correct procedure during the experiment. They handle equipment with care.</td>
<td>Test of starch or protein in food, Conduction of water through stem in plants, Measuring length of an object with a scale, Experimenting with electric circuit.</td>
</tr>
<tr>
<td>Classification</td>
<td>Children are able to identify similarities in two objects / phenomenon. They are able to point out the differences. They are able to group certain objects on the basis of any similar characteristic.</td>
<td>Similarities in common salt and sand, Difference when they are being dissolved in water, Enlisting of wild animals into herbivore and carnivore animals.</td>
</tr>
<tr>
<td>Planning</td>
<td>Children are able to list the different steps of an experiment, enquiry or observation. They are able to define their role in a group activity.</td>
<td>Role of different children during the visit to a garden, pond or a zoo.</td>
</tr>
<tr>
<td>Organization</td>
<td>Children can organize group activities on their own. Children cooperate in group performance.</td>
<td>Suggestion of activities related to their life experience, Assigning individual tasks in a group activity on the visit to a zoo.</td>
</tr>
<tr>
<td><strong>Teaching-Learning of Science</strong></td>
<td>They are able to manage the activity in the desired manner.</td>
<td>Collection of pictures of wild animals, edible things, sources of protein, etc. Presentation of collected materials according to classification.</td>
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<tr>
<td>---</td>
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</tr>
<tr>
<td><strong>Collection and Presentation of data</strong></td>
<td>Children are able to collect relevant data with precision.</td>
<td></td>
</tr>
<tr>
<td><strong>Recording of data</strong></td>
<td>They record information in suitable forms, gathered through observation during visits, experimentation, demonstration, etc.</td>
<td>Record of the heights of classmates. Record of the change in temperature. Record of the amount and the time taken by the solvent to dissolve.</td>
</tr>
<tr>
<td><strong>Reporting</strong></td>
<td>Children are able to narrate an event or process orally or through writing. Children are able to convey the information in the desired manner.</td>
<td>Writing the description of a table or a graph on increasing cost of fuels. Explaining the pictures of handicrafts of different States on basis of logic, relevance and importance.</td>
</tr>
<tr>
<td><strong>Communication skills</strong></td>
<td>Children are able to express their views in clear words. Children respond and reflect on others' views after listening to them carefully. Children participate in activities like debates, elocution with comfort and confidence. Children argue with logical facts. Children are eager to respond and participate in discussions frequently.</td>
<td>Giving description of components of food in their afternoon meal. Participation in debates on topics like 'Importance of Nutrients in Food'. Communication of observations during an experiment.</td>
</tr>
<tr>
<td><strong>Explanation skill</strong></td>
<td>Children communicate their life experiences and events happening around them in relation to the content being explained. Children are able to explain any incident or situation in their own words.</td>
<td>Explanation of variety of flowers in their garden. Explanation of possible causes of sudden thunderstorm last night.</td>
</tr>
<tr>
<td><strong>Conclusion/Inferences</strong></td>
<td>Children are able to draw inferences from the observation/experimentation. They use logical arguments to justify their results. They are ready to argue on the results of the experiment using their ideas or in their own words.</td>
<td>Comparison of lengths of objects while measuring through a scale. Reflection of light through mirrors and image formation. Identification of conductors and insulators on the basis of their observation and experimentation.</td>
</tr>
<tr>
<td><strong>Analyzing/applications from daily life</strong></td>
<td>Children are able to correlate their life experiences with the knowledge generated.</td>
<td>Giving examples of hot days and colder nights during discussion on radiation</td>
</tr>
<tr>
<td>experiences</td>
<td>Children give examples from their experiences in everyday lives. They understand the logic/principle/theory behind any incident or event.</td>
<td>Examples of various means of separation of substances. Explaining the causes of sweating and high rate of breathing after long walks or running.</td>
</tr>
<tr>
<td>Values/attitudes/Concerns</td>
<td>Children are able to correlate their scientific knowledge with environmental concerns. They participate in events on pollution, wastage, conservation, etc. Children believe in group tasks and respect and value the contribution of others in the group. They believe in their own and others’ capabilities and are aware of their limitations. They are ready to help others in the group during group tasks to overcome their limitations. They are comfortable in seeking help from the others in the groups.</td>
<td>They cite examples of air pollution due to vehicles and the role of factories in river pollution. Enthusiastically participate in awareness campaigns on various environmental concerns. Generate new slogans and make attractive placards. Take help of group members during any group activity. Help other group members in recording, performing or completing any task.</td>
</tr>
</tbody>
</table>

**ACTIVITY 1**

Select a topic from Science textbook of class IX or X, make a table in following manner:

<table>
<thead>
<tr>
<th>Topic/sub-topic</th>
<th>Process Skill to be developed</th>
<th>Assessment indicators</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Source: BES-019, IGNOU, 2013

**Table 9.1: Science Process Skills and their Assessment indicators**

The discussion in above table clarifies that every skills has a different set of indicators. Without identifying and planning right kind of indicator, it is very difficult for a science teacher to plan the assessment strategy or to identify a tool.
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) Why is it important to identify the assessment indicators in science?

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9.5 TOOLS AND TECHNIQUES FOR ASSESSMENT

With the introduction of Continuous Comprehensive Evaluation (CCE), assessment has changed a lot in schools. There is a fundamental shift from testing to learning as assessment is perceived as an integral part of teaching-learning process. This shift has also brought a shift in traditional ways (tools and techniques) of assessment. Tasks like Role Plays, Crossword Puzzle, Flow Charts, Popular Science, Book Review, Field Trips, Class Work/Home Work Assignments, Group Work, Survey, Project Work, Worksheets, Games, etc. became tools for assessment. Let us discuss some tools and techniques, which can be used by you in your science classroom.

9.5.1 Tools for Scholastic Assessment in Science

Under the domain of scholastics assessment, formative and summative assessments are two dimensions. Formative assessment is used by the teacher in the classroom to monitor the progress of learners and to provide them appropriate support for enhancing their learning. Summative assessment is generally carried out at the end to assess how much learner has learnt. We can say, focus of formative assessment is more on ‘assessment for learning’ whereas focus of summative assessment is more on ‘assessment of learning’.

Following tools and techniques have been suggested for scholastic assessment as secondary level in science.

<table>
<thead>
<tr>
<th>Scholastic Assessment</th>
<th>Formative Assessment (Flexible Timing)</th>
<th>Summative Assessment (Written-End of term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tools</td>
<td>Techniques</td>
<td></td>
</tr>
<tr>
<td>Objective type</td>
<td>Tests</td>
<td>Objective type</td>
</tr>
<tr>
<td>Short Answer</td>
<td>Assignments</td>
<td>Short Answer</td>
</tr>
<tr>
<td>Long Answers</td>
<td>Quizzes and Competitions</td>
<td>Long Answers</td>
</tr>
<tr>
<td>Questions</td>
<td>Projects</td>
<td></td>
</tr>
<tr>
<td>Observation schedule</td>
<td>Debates</td>
<td></td>
</tr>
<tr>
<td>Interview schedule</td>
<td>Elocution</td>
<td></td>
</tr>
</tbody>
</table>
When we talk about scholastic assessment in science, we should keep in mind that nature of content, process skills and objectives are the key determinants of the tool to be used for assessment.

It is being suggested by CBSE (2010), that in Science tools like 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 should be used for assessment. It is also suggested that for science, at least one out of four formative assessments in the year are experiments.

Here we are taking few examples of tools and techniques, which have been suggested in various manuals published by NCERT and CBSE, for assessment in science. These examples will help you understand the comprehensiveness of assessment as well as facilitate to choose and design your assessment strategy accordingly.

A) DEBATE

Debate can be used for scholastic as well as co-scholastic assessment. Debate provides an opportunity to children to communicate their view point about any issue with logical arguments. The objective of debate should not be to highlight the negative aspects only or to criticize, but to provide an opportunity of balanced evaluation by highlighting both dimensions of the issue/topic.

Debates are a useful tool for development of a collaborative and cooperative learning environment as well as for motivating children to search, collect, arrange, share and discuss new information related to any issue being debated. In Science, you can use debate for various topics like balanced diet and deficiency diseases, wastage and conservation of water, industrial growth vs. pollution, effect of deforestation on wildlife, etc.

Debates provide an opportunity for healthy competition among children. Children also learn and sharpen their skills to evaluate the problem/issue with two different sets of opinions. Their higher order thinking skills, communication skills, critical analysis improve through such activities.

Let us explain the steps you can adapt to plan using debate as a learning and assessment tool in your class.

<table>
<thead>
<tr>
<th>Checklist</th>
<th>Group discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating scale</td>
<td>Club activities</td>
</tr>
<tr>
<td>Anecdotal records</td>
<td></td>
</tr>
<tr>
<td>Document Analysis</td>
<td></td>
</tr>
<tr>
<td>Tests and inventories</td>
<td></td>
</tr>
<tr>
<td>Portfolio analysis</td>
<td></td>
</tr>
</tbody>
</table>

**Table 9.2: Tools and Techniques for Scholastic Assessment**
1) **Selection of a Topic:** “Wastewater Management: Role of an Individual”
   - After selection of a topic, give a justification about its need and explain its importance as a topic for debate to children. This will develop readiness among the children.

2) **Specifying the topic for discussion**
   - The selected topic may have many subthemes. You can ask them to identify few sub themes/topics. Some of the topics may be, wastage of water at home, in industries, in construction work, in irrigation, etc. Methods of wastewater management, e.g., household measures, rainwater harvesting, modern irrigation techniques, holding rainwater in big ponds/dams, sewage treatment of contaminated water, etc.

3) **Assigning the role**
   - Ask children to choose a sub-theme or a topic of their interest. This can be done in a group of 2-3 or individually.
   - Assign the roles in management and execution of the debate like, anchoring of the event, collection of score sheets from judges, time management, etc. such practices will help in developing event management skills in children.

4) **Pre-debate preparation**
   At this stage, ask children to go through the relevant material for collecting information and provide them guidance in organizing of their presentation.

5) **Expected Learning Outcomes**
   You are advised to plan some expected learning outcomes, which will be the base for assessment, e.g., Children will be able to
   - Comprehend various causes of wastage of water,
   - Link their day-to-day experiences and observations about wastage of water,
   - Collect relevant information from various sources and compile theme in a s regarding the topological sequence
   - Communicate logically their view point.

6) **Assessment Table**
   You should develop an assessment table for the event to ensure comprehensiveness and objectivity in assessment. One such table is given below as an example.
<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Indicator of Learning</th>
<th>Activity specific Indicator</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| 1     | Planning for the Debate | • Selection of specific roles in organizing the debate by children  
• Choosing the sub-theme  
• Assigning/choosing specific task in a group dealing with a particular sub-theme | Willingness to participate in the organization of the event  
Selection of relevant sub-themes  
Assigning responsibilities to all members of the group with their consent |
| 2     | Organization of facts/ information | • Selection of the source of information  
• Collection of relevant information from various sources  
• Logical arrangement of sub-themes  
• Sequencing of the information to be presented | Knowledge of relevant resources  
Selection and screening of relevant information  
Decision about sequencing of sub-themes  
Linking the previous sub-theme and next subtheme |
| 3     | Presentation of data | • Introduction of the sub-theme  
• Rationale of discussion  
• Issues/aspects raised  
• Logical sequencing in presentation  
• Supportive data/facts to justify the logic | Relevant background of the subtheme  
Linkage of issues with subtheme  
Contextualization of the issue  
New information, which is not commonly known to all |
| 4     | Communication skill | • Expression of views  
• Confidence and clarity of thoughts  
• Acceptance of other's viewpoint  
• Describing important details | Use of vocabulary and command over language  
Confidence and logic  
Considering and countering other's viewpoint during deliberation  
Including all finer details |
| 5     | Linkage with daily life | • Citing examples from their day-to-day lives  
• Giving solutions from their everyday observations routine  
• Giving examples on the basis of their life experiences or observations | Examples from household wastage of water like in kitchen, garden, washing the road, etc.  
Small initiative to taken care at home  
Examples from wastage or conservation at large scale, if they have observed anywhere |
| 6     | Values/attitude | • Respect other view points  
• Cooperating in group dealing with a particular sub-theme  
• Cooperating in organizing the event  
• Showing a responsible attitude towards the tasks chosen  
• Avoiding wastage of material  
• Showing concern for the issue  
• Sensitivity towards the issue being debated. | To what extent have other views been considered  
The degree of cooperation among all children  
Concentration and effectiveness of task chosen by children in organizing of the event  
Cooperating with others in group for providing supportive data and encouragement |
B) ROLE PLAY

(Following Example has been taken from CBSE Formative Assessment Manual, Class IX)

Objectives: To enable the learners to:
- get familiarized with the states of matter,
- compare the properties of the three states of matter at the particle level, and
- visualise the effect of heat and pressure on the states of matter.

Task: Groups of five

Approximate Time: 3-5 minutes to every group

Procedure:
The teacher may:
- Make three groups of five learners (so fifteen learners would be involved in this activity, rest of the learners will observe, do peer assessment and get involved in other role plays during the academic year)
- Assign each team a task to act like the ‘state of matter’ assigned to them. The use of verbal mode, bodily kinesthetic mode and props is on the discretion of the group.
- Guide them as to depict the–
  a) Inter-particle distances
  b) Inter-particle forces of attraction
  c) Kinetic energy possessed by the particles.
  d) Effect of heat and pressure on the state.

Assessment parameters:
One mark for each of the following indicators:
1) Does the child understand the task given?  
   Yes /No
2) Is the child able to work in a team?  
   Yes /No
3) Is the child inquisitive about different phenomena?  
   Yes /No
4) Can the child think logically and rationally?  
   Yes /No
5) Is the child able to apply theoretical knowledge in practical situation?  
   Yes /No
6) Does the child have good understanding of the following concepts?  
   (1 mark for each of the following)
   - Inter-particle distance
   - Inter-particle forces of attraction
   - Kinetic energy possessed by the particles
   - Effect of heat on state of matter
   - Effect of pressure on state of matter

Total marks: 10
Assessment in Science

Suggestive Remediation:
- A few learners may find it difficult to understand the correspondence between observing themselves as particles and the particles of matter. The teacher may explain it to them.
- Since it is an exercise for promotion of self-learning, encouragement may be given to those who take more time to understand and are shy of performing.

C) DEMONSTRATION BASED WORKSHEET

(Following Example has been taken from CBSE Formative Assessment Manual, Class IX)

Chapter-9: Force & Laws of Motion

Objectives: To enable the learners to:
- get into the habit of ‘careful observation’,
- state their observations,
- draw conclusions based on their observations, and
- arrive at a ‘general result’ based on their observations and conclusions.

Procedure:
- Arrange a cardboard/plyboard at some angle to the ground at a place where a long stretch of floor is ‘clear’.
- Make provision for holding the board in its inclined position and for adjusting its angle of inclination.
- Make provision for fixing two different surfaces – One smooth and one rough – on the board.
- Have two different balls – say a smooth rubber ball and a used cricket/tennis ball.
- Let each ball roll down, from each of the two surfaces, for a given angle of inclination.
- Measure the distance (from the lower edge of the inclined surface) the balls travel on the floor before coming to rest.
- Write the results of your observations on the blackboard or notebook.

Assessment parameters:
1 mark for the three correct answers.
1 mark for a ‘tabular presentation’ of the observations.
1 mark for ‘conclusion’ arrived at.

Learner Worksheet

Instructions:
Observe the ‘demonstration’ and the data written on the blackboard carefully and answer the following questions:

1) In each case, is the distance moved by the cricket ball less/more than that moved by the rubber ball?
2) For which of the two surfaces does the rubber ball travel a longer distance?
3) Why do the balls come to rest after travelling different distances?
4) Write the written results of the demonstration in a ‘tabular form’.
5) State your ‘general conclusion’, if any, based on your observations.

Suggestive Remediation:
- Make the learners understand the role of friction in bringing the balls to rest.
- Explain why the force of friction is different for different surfaces in contact.
- Help the learners understand how ‘observations’ and ‘data’ can be used to arrive at some ‘general conclusion.’

D) INDIVIDUAL WORKSHEET (FLOW-CHART BASED)

(Following Example has been taken from CBSE Formative Assessment Manual, Class IX)

Objectives: To enable the learners to:
- learn the common methods of transmission of diseases,
- identify the various modes by which a disease may spread from an infected person to a healthy person, and
- understand how some diseases may be prevented

Task: Individual Work

Approximate Time: 20 Minutes

Feedback and Follow-up:
1) The worksheet with a Flow chart of Common methods of Transmission of Diseases is given to the learners.
2) The learner answers the questions after observing the Flow chart.

Learner Worksheet

Time: 20 minutes

Instructions: Given below is a Flow chart of Common methods of Transmission of Diseases. Six modes of transmission of diseases have been mentioned and numbered. Answer the questions given below after observing the flow chart.

Common methods of Transmission of Diseases
Answer the following questions:

1) Name one disease spread by mode - 1.
2) How can you protect yourself from this disease?
3) How could a person transmit disease causing organisms through air?
4) Name a bacterial disease spread by mode-3.
5) Name a disease that may be spread by a rabid animal.
6) Name a disease that can be spread by animals.
7) Name one disease spread by mode-4.
8) How can mosquitoes spread a disease from an infected person to a healthy person?
9) Name a disease spread by mosquitoes. (other than malaria)
10) Can you protect yourself from diseases that are transmitted through air?

**Criteria for Assessment:** Marks for each correct answer = ½.  
Total Marks: ½ × 10 = 5

**Suggestive Remediation:**
- A few learners may not be able to answer the questions. The teacher may explain the topic again or provide pictures that can be used as hints, for learners.
- If the number of learners who have not answered the questions is more, then the worksheet may be modified by adding more pictures and situations.

**E) ACTIVITIES**

In science, pedagogy is experiential in nature. A number of activities have been suggested in science text books. Many times teachers got confused about teaching learning and they misconceived the textbooks as activity books only. Activities are the tool of learning as well as assessment for scientific process skills. These activities may be individual activities or group activities. Let us discuss one example.

Choose a heavy object like a table or a box, which children can move by pushing hard. Ask them to try to push it all by themselves. Can any of them move it individually? Now ask one another child to help him in pushing it in the same direction [Fig. 9.1]. Is it easier to move it now? Ask them to explain why?

Next ask them to push the same object, but ask one child to push it from the opposite side [Fig. 9.1]. Does the object move? If it does, ask them to note the direction in which it moves. Can they guess which one of them is applying a larger force?

Fig. 9.1: Two friends pushing a heavy load (a) in the same direction, (b) in opposite direction.

*Adopted from NCERT TEXTBOOK of Science, Class VIII*
In the above activity, you have to plan what kind of learning indicators you will use to assess various scientific process skills.

First you have to identify the skills to assessed, activity associated with those skills and check list/or assessment indicator of that particular skill. You have to develop an assessment table for that activity which will help you in assessing the child’s performance and learning electively. Going back to the above example, you can develop a table of the following type.

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Skill</th>
<th>Specific learning Indicator</th>
<th>Assessment of Learner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observation</td>
<td>Observing the size of box Discussion on the possibility of moving it by one learner</td>
<td>Initiatives taken (Yes/No) Hypothesis formation</td>
</tr>
<tr>
<td>2</td>
<td>Planning</td>
<td>Who will move first? Who will be the second child to help? From which direction the force will be applied?</td>
<td>Willingness to participate in activity (Yes/No) Identification of proper direction to apply force (precision and estimation)</td>
</tr>
<tr>
<td>3</td>
<td>Reporting</td>
<td>How will the process be narrated to the whole class? Who will narrate?</td>
<td>Are they communicating in simple language )Yes/ No) Is the narration understandable (Yes/No) All the important facts/ events part of narration (Yes/No)</td>
</tr>
<tr>
<td>4</td>
<td>Communication/ Explanation</td>
<td>Why can a single person not move the box? Why did two children move it? What happens when force was applied from opposite directions?</td>
<td>Is the explanation is satisfactory? (Yes/No) Are they using logic to explain it? (Yes/No)</td>
</tr>
<tr>
<td>5</td>
<td>Conclusion/ Inference</td>
<td>Forces applied on an object in the same direction add to one another. If two forces act in the opposite directions on an object, the net force acting on it is the difference between the two forces. The net force on an object is zero if the two forces acting on it in opposite directions are equal.</td>
<td>Are they able to arrive at a conclusion? (Yes/No) Are their conclusions complete? (Yes/No) Is anyone giving extra explanation? (Yes/No)</td>
</tr>
<tr>
<td>6</td>
<td>Application</td>
<td>a game of tug-of war Fixing a lamp-post on roadside and using ropes to keep it straight Tugging of tent ropes</td>
<td>Examples are given by children (Yes/No) Examples are explained by Children (Yes/No)</td>
</tr>
</tbody>
</table>
On a similar pattern, you can develop an assessment table for any individual or group activity which will help you to assess the children’s learning during the activity and you can use it further for grading in formative assessment too.

These are few examples of tools and techniques, which can be used for assessment. Other tools are also equally important.

You are advised to go through the NCERT Source Book on Assessment for Class VI-VIII Science, and Teachers’ Manual on Formative Assessment, Science Class IX-X, published by CBSE.

9.5.2 Unit Test Development in Science

Unit test

Mr. Mohan, a science teacher, taught a topic “Fun with Magnet” to learners of class VI. During the teaching-learning process, he introduced the concept of magnet with the help of examples of Crain, door of refrigerator etc. He explained magnetite ore and discussed various types of magnet. He performed some activities to differentiate between magnetic and non-magnetic substances. He explained properties of magnet and its use in daily life like finding directions. After completion of his teaching in 3 periods, he planned to assess the understanding of his learners about magnet.

Let us see what he did.

He prepared a question paper comprising of fill in the blanks questions, short answer type questions, true false type questions, one word answer type questions and distributed among the learners of his class without any prior announcement about it. He asked learners to attempt all these questions during his class.

An Example of a Unit Test

<table>
<thead>
<tr>
<th>Class VI</th>
<th>Subject: SCIENCE</th>
<th>Max. Marks: 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUN WITH MAGNETS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Attempt all the questions.

I) Fill in the blanks: (1 × 5 = 5 marks)

1) A freely suspended ________________ always points to the north-south direction.

2) Similar poles of two magnets always ________________ each other.

3) A magnetic ________________ is used for finding geographic direction.

4) A material which attracts pieces of iron or steel is called ____________.

5) ________________ is the world’s first magnet.

II) Write true or false against the statements given below: (1 × 4 = 4 marks)

1) Bar magnet is more powerful than natural magnet.

2) Magnetic attraction is maximum in the middle of a bar magnet.
3) Magnetic Compass is used for finding magnetic directions.
4) A magnet can separate iron nails from a mixture of iron filings and iron nails.

III) Name the following: (1 × 5 = 5 marks)
1) Name the substances from which artificial magnets are made.
2) Name the method to magnetize a piece of iron.
3) Force felt when two unlike poles of magnet are brought closer to each other.
4) Magnet that retains magnetism for short period of time.
5) Name given to U shaped magnet.

IV) Answer the following questions: (2 × 3 = 6 marks)
1) Distinguish between magnetic and non-magnetic substances.
2) What would happen to a pole of magnet if we go on breaking it into pieces?
3) Write any four uses of magnet.

He collected the answer sheets after learners had completed their answers. He evaluated their answer sheets and came to know that most learners had answered his questions but there were a few questions which were answered wrongly by many learners. He realized that he had to re-teach those concepts which were not clear to all learners before moving on to the next topic.

What is this exercise? This is called **Unit test**.

Unit test is the simplest way to assess learners’ progress in subject areas. Teachers generally take an oral test or a written test of 10-20 marks as unit test just after completion of a unit. In most schools, unit test is used to assess the progress made by learners in a particular content. It also plays an important role of diagnostic testing, to some extent.

In CCE, unit testing has become the formal part of total evaluation process, and due credit is given to it in the whole evaluation scheme. This initiative will increase the effectiveness and utility of unit testing in the whole evaluation process. Moreover, learners will also take it seriously.

Unit test should be based on learning objectives formulated for the unit. A teacher can use short answer type questions, one word answer type questions or objective type questions to evaluate the learners’ progress in a unit.

**Activity 2**
Select a unit from Science textbook of Class IX or X. Prepare a unit test of twenty marks based on learning objectives of the unit.
**Check Your Progress**

**Note:**

a) Write your answers in the space given below.

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

2) Why is it important to use variety of assessment tools for scholastics assessment in science?

...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

9.5.3 Tools for Co-scholastic Assessment in Science

In previous section, we have discussed about various tools and techniques which you can use for assessing scholastic aspects of learner’s achievement. There are various tools and techniques, which can be used for assessing co-scholastic aspects.

![Fig.11.10: Tools for Assessing Co-Scholastic Aspects](image)

**Fig.11.10: Tools for Assessing Co-Scholastic Aspects**
Now, we will discuss some tools, which can help you in assessment of co-
 scholastic aspects with objectivity.

**A) OBSERVATION SCHEDULE**

Observation is one of the most frequently used ways to gather information and get a picture of what’s happening in your school or classroom. You can also use it to assess learners’ performance in various co-curricular activities. Systematic classroom observation is a quantitative method of measuring classroom behaviours. Information about a child (his/her behaviour) can be collected in and outside the class through observation. Observation can be used as a tool of assessment in a variety of situations like debates, elocution, group work, practical and laboratory activities, projects, play fields and school prayers, clubs and festivals. Observation can be biased and subjective. However, such errors and risks can be substantially reduced by using an observation schedule.

Observation schedule is used to collect information systematically and with objectivity. Here is one example of using observation schedule for debate competition.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Descriptors</th>
<th>Score out of 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Depth of knowledge of the content</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Strength of the argument to conceive</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Fluency, diction and pronunciation</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Ability to contradict a given point of view</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Respectful to the opponent</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ability to take criticism positively</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Body language while arguing</td>
<td></td>
</tr>
</tbody>
</table>

*Source: CBSE Manual (2010)*

**Activity 3**

Prepare an observation schedule for assessing learners’ performance in group discussion.

**B) RATING SCALE**

Rating scale is a technique, through which an assessor categorizes the objects, events or persons on a scale, represented by a series of continuous numerals or letters. This technique is a subjective method. Rating is basically a term applied to an expression of opinion or judgment regarding some situation, object, character or an attribute. Rating scale refers to a scale with a set of points which describe varying degrees of dimension of an attribute being observed. In a typical numerical scale, a sequence of definite numbers is supplied to the rater or to the observer. The observer assigns, to each stimulus to be rated, an appropriate number corresponding to those definitions or descriptions. In a rating scale, you can use three points, five points, seven points or nine points scale. In a three point scale, you can have rating of 3 for most pleasant; rating of 2 for indifferent and a rating of 1 for most unpleasant.
It is always useful to have an odd number of points in a scale like 3, 5 and 7, so that there could be a middle (neutral) one, a favorable one and an unfavourable one. Numerical rating scales are the easiest to construct and to apply. They are also the simplest in terms of handling the results.

### An Example of a Rating Scale

<table>
<thead>
<tr>
<th>Task Criteria</th>
<th>Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Correctly state the problem and identify the information needed to solve it and the steps needed to arrive at a solution.</td>
<td>Yes</td>
</tr>
<tr>
<td>2) Produce reasonable estimates of data values not identified but needed for the solution.</td>
<td>Yes</td>
</tr>
<tr>
<td>3) Apply concepts and formulas related to motion (velocity, acceleration, average speed).</td>
<td>Yes</td>
</tr>
<tr>
<td>4) Make accurate conversions as needed to solve the problem.</td>
<td>Yes</td>
</tr>
<tr>
<td>5) Communicate conclusions clearly, using examples as needed.</td>
<td>Yes</td>
</tr>
</tbody>
</table>


### C) INVENTORIES

Inventories are used to assess personality of learners. An inventory is constructed in the form of a questionnaire. It consists of a series of questions or statements to which the subjects respond by answering ‘Yes’ or ‘No’, ‘agree’ or ‘disagree’. While preparing an inventory, you have to keep in your mind that the statements are put in the first person i.e. “I think I am more anxious about the examination than others”. That’s why, sometimes, inventories are also termed as self-reporting tools. Inventories are used for measuring personality traits, interests, values, adjustment etc.

Here is an example of an inventory to assess interpersonal skills of learners.

**Table 9.6: An Example of an Inventory**

Read the following statements carefully and mark tick (✓) in appropriate box.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Statement</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I shake hands if other person offers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I can identify relationships that may be hurtful or dangerous.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I can identify my personal strengths and needs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I make arrangements with peers for social activities.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I know who can help me when I am unable to resolve interpersonal conflicts alone.

I can find out the relationship between actions and consequences.

I can develop and carry out a personal plan for achievement of goal without supervision.

I can close a relationship or say “good bye” in a healthy manner.

Activity 3

Prepare an inventory for identifying learners’ areas of interests.

D) ANECDOTAL RECORDS

Anecdotal records are informal observational notes in the form of a story. A teacher records what learners are learning, their academic performance, learning behaviour, their achievements and social interaction.

Though it is an informal note but with its help, you can keep a record of each and every learner of your class in a comprehensive manner. While taking the note, you have to ensure that you only record what you observe and hear without any interpretation. For example, while preparing an anecdotal note on reading habit of your learners, you can consider many issues like:

- Does a learner show a positive attitude towards reading books?
- Does a learner choose his/her favourite books?
- Does a learner read books for pleasure/information?
- Does a learner read them silently?
- Does a learner reflect on his/her reading?
- Does a learner share his/her ideas with others during literature discussions?

Anecdotal records are the **written observations** – word for word, action for action – of exactly what a child is doing and saying. You can use these notes to create a complete developmental picture of young children.

Anecdotal notes should be used to record the day-to-day development of learners, as well as their specific behaviours, especially those that are a cause for concern, speech patterns, language development, social/emotional development, peer interactions, etc.

Here is one sample anecdotal record form.
Table 9.7: An Example of an Anecdotal Record

<table>
<thead>
<tr>
<th>XYZ PUBLIC SCHOOL, NEW DELHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANECDOTAL RECORDING FORM</td>
</tr>
<tr>
<td>Observer: ........................ Observation date: ........................</td>
</tr>
<tr>
<td>Learner name: ........................ Observation time: ........................</td>
</tr>
<tr>
<td>Description of the incident:</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>Description of the location/settings:</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>Recommendations/Action:</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>........................................................................................................................</td>
</tr>
<tr>
<td>Signature</td>
</tr>
</tbody>
</table>

E) PORTFOLIO

It is the collection of evidences of learners’ works over a period of time. It could be day-to-day works or selection of learner’s best piece of work. Painters and commercial artists often use portfolios to demonstrate their skills and quality work before the selection committees. Portfolios encourage teachers and schools to focus on important learner outcomes, provide parents and the community with credible evidence of learner achievement. Portfolio provides a cumulative record of growth and development of a skill or competence in an area over a period of time. It also enables a learner to demonstrate to others, his/her learning and progress. Care should be taken that only selected works having specific purpose need to be put into the portfolio.

Portfolio can include:

- **Photographs:** Provides an insight into child’s emotional, social and psychological development
- **Paintings and other examples of artistic endeavor:** Provides evidences of a learner’s abilities, thoughts and attitudes
- **Audio-Video Recordings:** Important processes and events that can be recorded and analyzed later
- **Self Assessment Sheets:** Provides evidence of learner’s self-evaluation
- **Peer Assessment Sheets:** Excellent for assessing team based activities, social projects and peer related behaviour.
- **Parent Assessment Sheets:** Provides evidences of evaluation carried out by the parents.
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.

3) Why is co-scholastics assessment essential in Science?

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9.6 DIAGNOSTICS ASSESSMENT IN SCIENCE

Diagnostic assessment is a kind of assessment, which helps teachers to determine what learners know and where s/he is lacking behind. Generally, diagnostic assessment is used to know about learners’ strengths, weaknesses, level of their existing knowledge and the skills, they possess. It helps teachers to design and plan their instructions accordingly.

As a science teacher, you can use it before starting your instructions as pre-assessment activity. You can also use it in between to diagnose the difficulties learners are facing in comprehending any particular concept or topic and adopt remedial measures.

A diagnostic test helps teachers to plan their instructions effectively. Because it helps in understanding what the learners know and what they do not know. If a teacher finds that a particular learner or a small group of learners is lacking behind the rest of the class on a particular topic or theme, s/he can organize remedial classes or adopt some other strategies to facilitate learners.

Let us understand with an example:

Ms. Anjuli, a physics teacher in a secondary school of Bhopal, taught the unit of “Light” to her class. She helped learners in comprehending the concept of Mirrors, Lenses, Laws of Reflection and Refraction, drawing the ray diagram to depict image formation, structure and function of Human eye, etc.

She administered a unit test on it. While going through the assessment sheets of learners, she found that few learners have made some common mistakes while drawing the ray diagrams and few are confused between refraction and reflection.

When teachers find themselves in the situation like Ms. Anjuli, they generally re-teach the concept or give some more exercises to learners to practice. Do you think it is a right approach? Let us see what Ms. Anjuli did in this situation.
Assessment in Science

Ms. Anjuli thought and reflected on possible reasons for the mistakes done by learners. She again went through their answer scripts/assessment sheets and identified few common minor errors, due to which learners committed those mistakes.

She prepared a separate test only on the concept of Refraction, Reflection and Drawing of Ray Diagrams. She administered it on those identified learners and found that learners are having difficulty is distinguishing between the use of mirrors or lenses while explaining refraction and reflection. She also identified that learners are confused between focal length, principle axis and optical center.

She came to know the exact reason of mistakes committed by learners. She planned certain activities and exercises to give hands-on practice to learners on identified concept and helped learners to overcome their difficulties.

Hope the above example will help you understand the concept of diagnosis and remediation. It is expected from you as a science teacher that you will facilitate your learners in overcoming their problems and use diagnostic testing as a facilitating tool for learners in your class. You can use many modern assessment tools discussed above as well as concept map also as diagnostic test.

Activity 4
 Identify few topics/concepts with help of a unit test in your science class, where your learners are facing difficulty to comprehend these concepts. Analyze their difficulties with help of a diagnostic assessment tool and provide remediation. Prepare a report on your experiences during this exercise highlighting the benefits you observed.

9.7 SCHEMES FOR PROMOTING SCIENTIFIC ATTITUDE

As a science teacher, you need to be aware of the schemes which are promoting development of scientific attitude among learners upto senior secondary level. Such schemes/initiatives help in attracting young minds towards science. There are many such scheme, few important one have been discussed here in brief.

9.7.1 National Talent Search Examination (NTSE)

National Talent Search Scheme (NTSE) was launched in 1963 as National Science Talent Search Scheme (NSTSS). Initially, this scheme was awarding fellowships to learners of Class XI based on a written examination, a project report and interview. In 1976, this scheme was extended to social sciences too and renamed as National Talent Search Scheme (NTSE). Scheme started separate examination for class X, XI and XII learners. Scheme of examination also changed. The learners have to appear in two objective type written tests namely the Mental Ability Test (MAT) and the Scholastic Aptitude Test (SAT). Based on performance in written test, a selected group of learners was facing a face-to-face interview and scholarship was awarded based on the final awards in both components.
In the year 2000, the number of scholarships was raised up to 1000 with the provision of reservation for SC and ST candidates based on the national norms of 15 per cent and 7½ per cent respectively. From the year 2006 onwards, the NTS examination was held at the end of Class VIII. From the year 2008 examination, a provision of 3 per cent reservation has been made for physically challenged learners.

From the year 2012-13, NTSE is being conducted for Class X learners. Now it consists of Mental Ability Test(MAT) and Scholastic Ability Test(SAT). The amount of scholarship is Rs. 500/- per month for all the learners studying in Class XI onwards(irrespective of class/course) except for Ph.D., wherein it is paid as per UGC norms.

The scholarships are being awarded to learners for pursuing courses in sciences and social sciences up to doctoral level and in professional courses like medicine and engineering up to second-degree level subject.

9.7.2 Kishore Vaigyanik Protsahan Yojna (KVPY)

The Kishore Vaigyanik Protsahan Yojana (KVPY) is a very popular National Program of Fellowship in Basic Sciences, initiated and funded by the Department of Science and Technology, Government of India in the year 1999, to attract exceptionally highly motivated learners for pursuing basic science courses and research career in science.

The objective of the program is to identify learners with talent and aptitude for research; help them realize their academic potential; encourage them to take up research careers in Science, and ensure the growth of the best scientific minds for research and development in the country.

Under this scheme, learners are selected from those studying in XI standard to 1st year of any undergraduate Program in Basic Sciences namely B.Sc./B.S./B.Stat./B.Math./Int. M.Sc./M.S. in Mathematics, Physics, Chemistry and Biology having aptitude for scientific research.

Based on the performance in the aptitude test, short-listed learners are called for an interview which is the final stage of the selection procedure. For receiving a fellowship, both aptitude test and interview marks are considered. The KVPY Fellowships are given to Indian Nationals only to Study in India.

It is being given in three streams.

- **Stream SA:** Learners enrolled in XI Standard (Science Subjects). The fellowship of the learners selected under this stream will be given only if they join an undergraduate course in Basic Sciences.

- **Stream SX:** Learners who are enrolled in XII Standard/ (+2) (Science subjects) and aspiring to join undergraduate programme in Basic Sciences.

- **Stream SB:** Learners enrolled in the 1st year of undergraduate program in Basic Sciences.
9.7.3 Rashtriya Avishkar Abhiyan

In pursuance of the focus on connecting school based knowledge to life outside the school and making learning of Science and Mathematics a joyful and meaningful activity and to bring focus on innovation and use of technology, the Ministry of Human Resource Development has set up the Rashtriya Avishkar Abhiyan (RAA). It is a convergent framework that aims at nurturing a spirit of inquiry and creativity, love for Science and Mathematics and effective use of technology amongst children and encourage those who show an inclination and talent for these subjects to be encouraged and supported to heights of academic excellence and research.

Rashtriya Avishkar Abhiyan is targeting learners in the age group of 6-18 years and in turn the execution of RAA will span across MHRD’s schematic interventions of Sarva Shiksha Abhiyan, Rashtriya Madhyamik Shiksha Abhiyan in the Department of School Education & Literacy and programmes and schemes of Department of Higher Education to encourage Science, Mathematics & Technology.

9.7.4 Science Olympiads

Science Olympiad Foundation (SOF) is a Registered Not-For-Profit Organization popularizing Computer, Science, Mathematics, English, Sports Knowledge and Company Secretaries’ Education among school children.

It is working for over two decades to promote scientific attitude and temperament through innovative activities and use of IT in learning process that involve school learners across the country.

The foundation conducts the following Olympiads:
- National Cyber Olympiad
- National Science Olympiad
- International Mathematics Olympiad
- International English Olympiad
- International Company Secretaries Olympiad
- International Sports Knowledge Olympiad

Learners of classes 1 to 12th are eligible to appear for the 1st level Olympiads. There is no other eligibility criterion like minimum marks. Learners who qualify for the 2nd level exam include:
a) Top 5% of learners’ class wise, who appear for the 1st level exam,
b) State wise top 25 rank holders class wise, and
c) Class toppers from each participating school where at least 10 learners from a class appear in the exam & scores 50% qualifying marks. Learners from classes 1 and 2 are not required to appear for the 2nd level exam and are ranked based on their performance in the first level exam. IEO is a single level exam.

9.8 LET US SUM UP

Assessment is viewed as an integral part of teaching-learning process. Its primary role is not to grade or promote learners to next class but to facilitate learning upto maximum extent. Discussion on nature of assessment in science will help you understand its role more effectively. It is important for you as a science teacher that you are able to identify and design appropriate assessment tool which is facilitating in acquiring desired process skills. Discussion on various assessment tools for scholastic and co-scholastic assessment will help you in it. Diagnosis and remediation is an important part of science teaching-learning; you should use it frequently in your class. Information about various schemes to promote scientific temper among learners will help you to motivate your learners in engaging few of such activities.

9.9 UNIT END EXERCISES

1) Why is identification of assessment indicators important for selecting an assessment tool?
2) What precautions you will keep in mind while designing an assessment tool for scholastic assessment?
3) Why is the co-scholastic assessment necessary in science teaching-learning?
4) Discuss importance of diagnostics testing?

9.10 SUGGESTED READINGS AND REFERENCES

NCERT (2012) Source Book on assessment for Classes VI-VIII Science
CBSE (2010) Formative Assessment Manual for Teachers Class-X (Science)

9.11 ANSWERS TO CHECK YOUR PROGRESS

1) In order to assess the development of process skills in science, you have to identify on what criteria any skill is to be assessed. The criterion, on which development of any skill is being assessed, is known as assessment indicators.
2) During teaching-learning of science, variety of skills is to be developed along with development of scientific temper and attitude and inculcation of values. Everyone cannot be assessed with one or two kind of tools; hence it is necessary to use variety of tools for assessment.
3) Write on the basis of your understanding.