B.Ed., II YEAR

PEDAGOGY OF PHYSICAL SCIENCE – PART 2

(Course – 18)

STUDY MATERIAL FOR

PONDICHERRY UNIVERSITY

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UNIT - 1

PEDAGOGICAL SHIFT IN PHYSICAL SCIENCE

Syllabus: Pedagogical shift from science as fixed body of knowledge to the process of constructing knowledge – Critical pedagogy, democratising science learning and role of teachers – Pedagogical shift: planning teaching learning experiences.

Pedagogical shift: Introduction

Science is an enterprise that has been changing continuously over the years. There is a shift from understanding Science as mere collection of facts and principles to the constructivist and inquiry-oriented learning experiences taking learner at the centre stage. The role of classroom discussion in promoting critical, creative and reflective thinking of learners and thus collaborative participation in the classroom have been identified as being centre to the construction of their knowledge. Moreover in the present age of globalisation, information and communication technology has directly or indirectly affected our education system.

Today's pedagogy gives value to the voice of learners and their questions, their abilities of making argumentation and justification, synthesizing and analyzing knowledge and their involvement in the process of inquiring science in a collaborative set-up rather than their ability of rote memorization. There is also a shift in our understanding of process of learning and about learners in the classrooms.

There is a need to understand the epistemic and epistemological dimensions of learning. Pedagogy includes both teaching as well as learning process of learners. Hence, there is a need to understand the nature of learning and nature of teaching with reference to physical science.

Pedagogical shift from 'science as fixed body of knowledge to the process of constructing knowledge

Earlier, nature of knowledge in general and nature of knowing in particular was considered as a fixed entity. However, in the contemporary understanding of nature of knowledge and nature of knowing, these are dynamic entities. The pedagogy which we use to construct knowledge through diverse learning strategies includes previous experiences of the learner, their socio-cultural and economic background along with the content knowledge rather than over whelming emphasis on the psychological characteristics to the individual learner.

The fundamental difference between the acquisition and the construction of scientific knowledge is passive receipt of the knowledge, and active involvement and critical examination based on critical thinking on the part of the learners.

Shift in pedagogy of science from affixed body of knowledge to the process of constructing knowledge has many dimensions. It includes a shift in our understanding of,

- Nature of science
- Knowledge
- Learners, learning and teachers
- Assessment
- Science curriculum
- Scientific method and scientific inquiry
- Importance of critical pedagogy
- Approaches to planning
- Various aspects of inclusive education etc.

In order to understand pedagogical shift in physical science, it is important to have a brief overview of all these aspects related with teaching–learning in science.

1. Pedagogical shift: Nature of science

The knowledge in science is subject to change. It is tentative in nature. This tentative nature of scientific knowledge interestingly does not make it un reliable. We now realize that there is always an element of subjectivity in the development of scientific knowledge, even if we consider that science always strives for objectivity.

Socio-cultural factors also have impact on nature of science. Role of creativity, observation, inference, etc. have been understood to be important in the development of science.

In simple terms, we can say that scientists collect relevant data and use evidences to explain ideas under consideration. They use their own perspective to guide themselves about problems. Scientists can change their ideas on the basis of contemporary development in their fields and create new ideas. In order to understand science, we must know the manner in which knowledge is constructed over time as well as the method used to validate that knowledge and the place of science in society.

2. Pedagogical shift: Knowledge

Science is an enterprise that has evolved over many thousands of years and continues to evolve. Our understanding of knowledge has shifted from a 'static entity' to a 'dynamic entity. We understand that knowledge is actively constructed by learner and cannot be passively received. Scientific knowledge is always subject to change and its modification is not an end product in scientific inquiry. Teaching– learning of science should go beyond presenting the facts and principles and result of investigations. Although knowledge is something personal and individual, the learners construct their knowledge through their interactions and with the physical world, collaboratively in sociocultural settings and linguistics environments. Learners should be facilitated to make observations, collect and interpret data, use the acquired information in critical way to construct their knowledge.

3. Pedagogical shift: Learners, learning and teachers

A more integrated understanding of learners and process of learning and we see them in inseparable form. Learners come to the learning situations in physical science with their existing ideas about phenomena, not just around them but across the real physical realm within their reach. Learners have now taken the central stage. Their view points are sought and valued. Learners get motivated to learn when they discover their own ideas, asking their own questions and trying to find out answers for themselves. Negotiation and mediation by learners, plays a prominent role in learning that takes place in a social setup.

Learners enter into dialogue and argumentation in learning science to construct their knowledge. Thus, for an effective pedagogical design, a teacher has to take care of the existing ideas of the learners and the difference in nature of their ideas with the scientific explanation of those ideas. She should develop the habit of listening to learners, giving value to their ideas and motivating them to bring their own ideas about their observation and interpretation of phenomena in their own context.

The learning of science must help them nurture their curiosity, rather than their ability to reproduce textual knowledge. This shift is necessary to make learning atmosphere conducive and learning more meaningful.

Teacher is no longer considered as custodian and manager of all teaching learning processes. There is a major shift in the teacher's role from where she assumes apposition of centre stage as a source of knowledge as to being a facilitator of transforming knowledge and as a supporter in enhancing learning through multiple exposures, encouraging the learners to continuously achieve their educational goals.

4. Pedagogical shift: Assessment

In addition to learner's achievement in various subject areas that can be tested easily, assessment needs to encompass attitudes to learning, interest and the ability to learn independently. Furthermore, to test all the learners through a written test of the same type in all subjects is unfair to those who several proficiency is superior to their writing skills or those who work more slowly but with deeper insight.

NCF-2005 recommends a shift in modes of assessment by making it more flexible. It emphasizes various modes of assessment including all meaningful aspects of performance, e.g. activities, experiments, journals, illustrations, oral presentations, peer evaluation, self evaluation, group work assessment, models, portfolios, and other art if acts of learning. Learners may be involved in selecting learning indicators and evaluation criteria to provide a sense of ownership in learning.

There is shift in emphasis from testing rote memorization to understanding and application to the knowledge and from examination-centered classroom processes to learning-centered classroom processes. The focus of question should move from mere plug-in type problems to genuine application type problems and questions demanding organization of thoughts in to arguments to demonstrate interpretative skills and critical thinking.

5. Pedagogical shift: Science curriculum and scientific inquiry

Earlier scientific method was as summed that scientific inquiry is related with the development of process skills such as observing, inferring, classifying, predicting, measuring, questioning, interpreting and analyzing data. After a pedagogical shift, It was about engaging learners in scientific investigations to find answers of self indentified questions.

The scientific inquiry varies widely within scientific disciplines and also across various disciplines. Inquiry as a teaching-learning approach will thus mean placing learners in situations that are very similar to something that scientists experience during the daily journey of scientific endeavour. In terms of science curricula, we need to emphasize the importance of merging classroom experiences of a learner in science with the experiential construction of scientific knowledge by the learner outside the classroom boundaries. Instead of strict adherence to curriculum, pursuit of learners' questions needs to be emphasized.

Pedagogical shifts recommended in NCF-2005

- Teacher centered and fixed designs →to → Learner centered, flexible process

- Teacher's direction and decisions →to → Learner's autonomy
- Teacher's guidance and monitoring of learning → to → Teacher's facilitation, support and encouragement for learning
- Passive reception in learning→ to→ Active participation in learning
- Learning within the four walls→ to→ Learning in the wider context of the classrooms
- Knowledge as 'given' and 'fixed' →to → Knowledge as it evolves and is created Disciplinary, Multidisciplinary and educational focus
- Linear exposure →to → Multiple and divergent exposure
- Short and few Assessment→ to→ Multifarious and Continuous Assessment

6. Pedagogical shift: scientific method to science as inquiry

Science is both the study of knowledge and the process of acquiring and refining knowledge. Learners of science should be exposed to scientific method which helps them to develop the power of reasoning, critical thinking, creativity, collaborative learning and application of scientific knowledge.

Scientific methods are ways of thinking and inquiring that allows investigating and explaining natural phenomenon and solving problems scientifically. A scientific method does not prescribe series of steps to be followed rigidly; rather it is a series of dynamic and flexible steps by which reliable evidence can be gathered.

National Curriculum Frame work for Teacher Education (NCFTE-2009) also recommends adoption of process-based teacher education. The student-teacher should also be provided with ample opportunities for self-learning, reflection and assimilation.

In addition and more importantly, there should be scope for articulation of new ideas, ability to enhance thinking and work efficiently in groups. One understands the intricacies of nature of science by the process of observation and experimentation. To inculcate scientific temper to the learner, the science teacher has to facilitate the learners to think like a scientist and get actively involved in the inquiry through learning process.

The learners should be encouraged to question and learn to observe carefully, interpret their observations to understand the situation. This motivates the learners to learn more and more themselves and to explore the world around them.

Democratising Science Learning – Critical Pedagogy

Critical Pedagogy is child-centered pedagogy. It facilitates collective decision making through open-mindedness and by encouraging and recognizing multiple views of the learners. It emphasizes to move beyond authoritative role of the teacher by promoting sharing of power with the learners by encouraging critical thinking and commitment to democratic form of interaction.

It is a pedagogy that takes into accounts the experiences and perception of learners and helps them to learn in a fear free and independent form.

In the context of critical pedagogy, NCF-2005 recommends following guidelines:

- Participatory learning and teaching, emotion and experiences need to have a definite and valued place in the classroom.
- Children need to be made aware that their experiences and perceptions are important.
- Children should be encouraged to develop the mental skills needed to think and reason independently.
- It is important to value what learners learn out of school-their capacities, learning abilities and knowledge.
- More importance for the children of under privileged class
- Children are critical observers of their own conditions and needs.
- Children should actively participate in discussions and problem solving related to their education and future opportunities.
- Teacher's engagement with children is critical in the classroom, because it has the power to define whose knowledge will become part of the school-related knowledge and whose voice will shape it.
- When children and teachers share and reflect on their individual and collective experiences without fear of judgment
- If children's social experiences are to be brought into the classroom, it is inevitable that issues of conflict will need to be addressed. Conflict is an in escapable part of children's lives.
- To use conflict as a pedagogic strategy is to enable children to deal with conflict and facilitate awareness of its nature and its role in their lives.
- A pedagogy that is sensitive to gender, class, castes and global inequalities is one that does not merely affirm different individuals and

- Collective experiences but also locates them within larger structures of power and raises questions
- Other literary sources in their own environments can be facilitated by encouraging learners to compare, think and communicate about elements that exist in their own environment.
- Repository of knowledge exist in different mediums, hence all these forms, whether television programmes, advertisements, songs, paintings, etc. need to be brought to create a dynamic interaction among learners themselves.
- Critical pedagogy provides an opportunity to reflect critically on issues in terms of their political, social, economical and moral aspects. It entails the acceptance of multiple views on social issues and a commitment to democratic form of interaction.
- This is important in view of the multiple contexts in which our school functions.

Thus, we observe that critical pedagogy provides an opportunity to reflect critically on issues in terms of their political, social, economical and moral aspects. It entails the acceptance of multiple views on social issues and a commitment to democratic form of interaction. This is important in view of the multiple contexts in which our school functions.

Role of teachers in critical pedagogy

- The role of teachers is to provide a safe space for children to express themselves, and simultaneously to build in certain form of interactions.
- Teachers need to step out of the role of 'moral authority' and learn to listen with empathy and without judgment
- Teacher should enable children to listen to each other.
- While consolidating and constructively stretching the limits of children's understanding, they need to be conscious of how differences are expressed.
- A safe space of an atmosphere of trust would be made by teacher in the classroom
- Chances for children can share experiences and where conflict can be acknowledged and constructively questioned, and provided solutions, however tentative can be mutually worked out.
- In particular, for girls and children from under privileged social groups will be given priority
- Schools and classrooms should be spacious for discussing processes of decision-making, for questioning the basis of their decision, and for making informed choices.

- Teachers need to cultivate an understanding of the cultural and socio-economic diversity that learners bring with them to school.

Pedagogical shift – planning teaching learning experiences

There are so many aspects that should be considered for planning effective teaching-learning environments. It is important to listen to learners and encourage them to engage in assessing and evaluating their own ideas. There is an urgent need to build up activities and strategies that are effective not just for arrange of science content areas but also productive for exploring and challenging learners' conceptions.

Also the importance of the socio cultural perspective that focuses on the way learners' differentiation and cultural back grounds shaping their learning experience cannot be undermined. For the learning environments to be effective, learners' willingness to engage with learning, the effect of assessment, nature of school environment, learners' perception about relevance of science in their lives should be planned.

It is important to reflect upon the shift in planning that can be visage in the light of the learner's need and society expectation. Centralized plans to be followed by all the teachers in different schools of the state/region, so that there is uniformity in what is going on in the classrooms across the state or region. If that sort of plan could not be followed for any reason, actions were taken against the teachers. This sort of centralized action on the teachers' role in the classroom still prevailing at some places, however, is to be done away in the interest of learners.

Teachers need to develop the ability to plan 'units' of four or five lessons for each topic. They need to understand how to develop lesson design, so that learners are challenged to think and try out what they are learning and not simply repeating what is told to them.

In fact teachers could also consider involving learners in planning the class work. Such variety can bring tremendous richness to the classroom processes. The paradigm shifts have however encouraged the teacher to shift the focus from traditional to the constructivist approach.

Planning teaching-learning: Before shift

- What will be teaching?
- How much do I know the syllabus?
- How do I prepare the students for the upcoming exams?
- What serialization of theconceptsshouldIconsider?

- What objectives are to be used for measuring performance of the students?
- When and how to plan the measurement of the learning integrating with teaching experiences with respect to my lesson plans?
- How do I control the students?
- How can the knowledge I have to transmit be the best?
- Who are the students who have succeeded?

Planning teaching-learning: After shift

Following are the respective changes in the questions that need to be answered in order to plan teaching-learning process in physical science:

- What are the learning needs and previous experiences of my learners?
- How much I am acquainted with the learning needs of my learners?
- How do I facilitate each learner's learning?
- How do I incorporate the differential learning pace of my learners?
- What is the progress of the learner as compared to her previous learning experiences?
- How do I analyse the present learning evidences to plan further learning experiences for the learners?
- How do I facilitate and support each learner in learning?
- How best can knowledge be constructed by all learners?
- What next?

The shift to the new frameworks also means that the teacher obviously has a lot of liberty in choosing the planning approaches and strategies. This liberty of planning provides flexibility to the teacher to consider students' learning needs; their existing concepts; the context of their learning; local and national needs; nature of curriculum; etc. in designing teaching-learning experiences

PEDAGOGICAL SHIFT- INCLUSION

A policy of inclusion needs to be implemented in all aspects of teaching learning of science. A pedagogical shift is required to identify diverse capabilities and talent of all learners. For an inclusive educational setup, the following will be taken in to an account as pedagogical shift.

Science curriculum

Equal opportunities and full participation to all learners including learners with special needs, and learners learning with different paces should be provided in the theoretical and practical activities

conducted in science classes. Through adaptation of the curriculum (what learners learn) and modification of the approaches of teaching learning (how learners learn), access to science curriculum can be made possible for all these learners.

Changes may be made at teaching-learning level, in the content, or in the performance criteria. Such changes are made to provide a learner with meaningful and productive learning experiences, environments, and assessments that are based on her needs and abilities acquired proficiency.

Diversity in class

Inclusion is centrally a pedagogical issue, since it creates the most significant barrier to learning and exclusion for many learners. These barriers to learning arise from various interlocking parts of the curriculum and pedagogy, such as the content of learning programmes; the language and medium of teaching and learning; the management and organization of classrooms; learning style and pace; time frames for completion of curricula; the materials and equipments, that have been available for conduct of theoretical and practical sessions; and assessment tools and techniques.

Pedagogical principle that teacher should use a variety of approaches and strategies that promote meaningful learning, active participation of all learners, recognition of their knowledge and previous personal experiences, autonomy in their learning process and self control and collaboration among learners.

A number of assistive and adaptive devices such as Braille equipments, adapted science kits, hearing aids, communication aids, mobility aids, for transaction of curriculum contents as per the needs of the students. The pedagogical shift in science education should be based on giving respect and value to individual differences and providing opportunities for scientific exploration, manipulation, experimentation and discovery of scientific phenomena which ultimately enhance the personal development of every learner.

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UNIT- 2

EXPLORING LEARNERS

Syllabus : Uniqueness in learner – Motivating learners to bring their previous knowledge into Classroom- Involving Learners in teaching-learning Process – Encouraging learners to raise and ask questions, collect materials from local resources.

Introduction:

We have come to an understanding that well-developed learning objectives should be flexible according to teaching-learning situation and the need of the learner. You will appreciate that each learner is different from the other in terms of intellectual, emotional and social needs. Their motivational levels of learning physical science are also different. They are not same with respect to their knowledge, experiences, interests and the abilities. These differences can be seen even in one individual over a period of time. All these variations contribute in the way they learn and the knowledge they acquire.

Furthermore, we observe that learners construct their knowledge of science by interacting with the learning materials available in their environment in their own way. Knowing and creating the learning environment through various activities and investigations helps you in the process of teaching and learning. It helps the learners to relate their learning with their everyday life experiences. In order to maximize their learning and facilitate them to utilize their wide range of potentials in a variety of teaching-learning situations, it is necessary to explore your learners.

Dictionary meaning of exploration is to investigate systematically. In the context of teaching-learning situations and processes, exploring the learners implies knowing your learners and their learning situations. The questions arise - Why should you know your learners? What should you know about them? How can you know about them? Let us first look at the answers of these questions through a broad framework.

Firstly, you should know your learners because each learner is unique. Secondly, you should know about their previous and naive ideas of scientific concepts, their learning needs and the variety of ways they learn physical science. You have to find how they are constructing their knowledge and the extent of their learning. All these help you to plan your teaching- learning experiences and processes. Thirdly, you can know about the learners by creating conducive learning situations.

Learners should be involved actively in the teaching-learning process by motivating them to bring their previous and naive ideas of the concepts in physical science, appreciating dialogue among peer group, getting them engaged in discussion and arguments, and facilitating them to mediate and negotiate learning.

You should encourage them to collect learning materials from local resources for various activities, experiments and projects. For all these purposes, you need to provide them opportunity to raise and ask questions and express wonders on science and you have to cultivate the habit of listening to the learners. In this chapter we shall discuss about them in detail.

UNIQUENESS IN LEARNER

We have discussed above that every learner is different from the other. Hence the teacher should ask,

"Why should I know?

- Individual differences among the learners when I have to teach the 'same content' to all of them in my class?"
- We can get the answer by recalling our own experiences. Recall some of the teaching-learning situations of school days, where the teacher had taught the 'entire class' the 'same content' in the 'same way'.
- What was the result? Did all the learners learn the 'same thing' at the 'same level'?
- Did they get the 'same marks or grades' when examined by the teacher? If not, then, why?
- Did you ever feel like sharing your experiences with the teacher and classmates during teaching-learning process?

You will find learners in your class with a wide range of educational experiences that you should consider in planning teaching-learning experiences. Some have read a number of books; some have worked on many projects at the previous stages of learning, while some have travelled to various places.

Different learners interact with different people and they observe and interpret their environment differently. All these factors contribute to the difference in their experiences. They construct their knowledge differently by relating it to their previous experiences.

Therefore taking into account the heterogeneity of the class as well as uniqueness of the learner and paying attention to the existing ideas of the learners brings enrichment in teaching-learning

experiences. At the same time, this makes the learners feel valued and motivates them to get actively involved in the learning process.

MOTIVATING LEARNERS TO BRING THEIR PREVIOUS KNOWLEDGE INTO CLASS ROOM

- Learners' experiences and observations of real-life situations and their previous knowledge should be used in teaching-learning of science.
- They should be motivated to participate actively in the teaching-learning process for construction of their knowledge.
- Emphasis should be given on their involvement by facilitating them to experiment, form hypothesis, modify, discuss, infer, justify, defend, argue, analyse, solve, put question, relate, organise, use, apply, critically examine, explain, and interpretate.
- Teacher should nurture a learning environment where learners can get motivated to share their previous experiences and knowledge without fear and take initiative to participate.
- You would find classroom with such an environment a very lively place in the pursuit of quality learning that helps learners to develop a sense of inquiry and scientific attitude.

Providing situations of observations can arouse curiosity among learners and generate questions in their minds. For example, you can start the lesson on *Combustion* or *Flame* by burning a candle and a spirit lamp (taking necessary precautions) and ask the learners to observe the two flames and give their observations.

Student's attention can be drawn towards:

- size of the flame;
- brightness of the flame; and
- colour of the flame, etc.

To relate the concept of combustion with the experiences of the learners in the classroom you can also help them to compare other flames they might have seen, such as the following:

- Flame of the burner in the kitchen.
- Flame of the burner used by the blacksmith.
- Flame of burning wood/paper/cow dung cakes, etc.
- Flame of things burnt at bonfire.

Here you are bringing the experiences and the previous knowledge of the learners about the flame in the classroom. When the learners are able to relate the classroom learning experiences to their

observations and experiences outside the world, it works as a motivating factor for them to participate in the learning process.

Before starting the lesson you should ensure that the learners are ready to learn. You need to know that learning takes place in a variety of ways- through reading, asking, listening, writing, making and doing things, experimenting, discussing, thinking and reflecting, and expressing oneself through speech. They may perform these activities individually or with others. You can motivate the learners to share their existing knowledge and ideas by providing such opportunities to them.

Encourage learners to share their experiences, clear their doubts and share their existing ideas with the class. There is a lot of science in their experiences. Those experiences and ideas can be used as a stepping stone to learning scientific concepts.

When learners are encouraged to share and seek out knowledge from sources other than the textbook, in their own experiences, in the experiences of their peers, homes and surroundings, outside the school, in the laboratory and library, they realise that knowledge can be sought out, authenticated and constructed.

We have discussed above that learners in a classroom have different experiential background. Based on their experiences of natural world they form some ideas/notions/beliefs of a concept or process. These ideas are alternative framework (alternative conceptions) that may be right or wrong. If wrong, they should be removed from cognitive framework of the learners. These are *misconceptions*. If learners' previous ideas do not match with the scientific explanations and are partially correct, these are *naive concepts*.

Recognising the evolving nature of cognitive development of the learners, they should be facilitated to construct new ideas over their naive ideas. When we talk of naive ideas we recognize that knowledge is always being constructed. We need to view the learners as constructing knowledge all the time. This is true not only regarding science or any discipline, but equally regarding values, skills and attitudes.

Learners' mental representation of ideas are continually adopted, reformed and revisited in the process of construction of their knowledge. Teaching-learning of science helps them to develop their ideas in particular ways.

Active involvement of learners in intellectual stimulation with new and other's ideas, in social interactions with teachers and peers and their physical interaction with phenomena and materials, can

bring conceptual changes in them. Let us now discuss how naive ideas of the earners can help you to explore them.

INVOLVING LEARNERS IN TEACHING-LEARNING PROCESS

Involving learners in teaching-learning process provides a feeling of ownership in their learning. Traditionally, it has been the responsibility of the teacher to do all the planning for teaching learning but presently, it is considered as a shared activity between the teacher and the learners about content, activities, approaches and assessment.

Keeping themes in mind, you can interact with learners to decide what they would like to know about a particular theme. With their help you can identify the 'content' for the lesson. You can add and supplement to the 'content' selected by them.

The approach of transaction can also be negotiated with learners. Learners can suggest, discuss, share information and experiences, perform experiments, go for excursion or do other activities for learning and developing deeper understanding about the concept to be learned. You can use a variety of activities, strategies and approaches to involve the learners at various junctures of learning.

Appreciating dialogue among peers

You should appreciate dialogue among peers in the teaching-learning process. Dialogue involves one to one interactions in the classroom among the learners. Dialogue provides space to learners to reflect on their own ideas on scientific concept. It may lead to a discussion intended to produce an argumentation. Dialogue may be structured or unstructured.

Structured Dialogue: It may be used by the teacher and the learners as a means of orienting the dialoguing discourse towards understanding the problems under consideration.

Unstructured dialogue: It may also be used as a form of discussion which may not have a desired end.

Dialogue is an important classroom tool which can be used to focus on a problem and has the potential to inculcate interest among learners and encourage them to open up for discussion and argumentation. It helps to reinforce learning by helping learners to construct collectively deeper understanding of concept and to know how the same learning experiences are perceived differently by different learners.

Encouraging dialogue among peers also develops bonding among them that provides a foundation to collaborative learning, negotiating ideas and other life skills. When students are engaged in conversation about their observation, hypothesis, ideas and thinking on a particular activity, experiment, project or scientific concepts, they get an opportunity to know one another's perspectives on the concerned issue make connections with their prior learning and get the key points. They co-construct the meaning and learn how to express their opinions.

However, guidance of the teacher is necessary to help them remain focused on the issue. In the process of dialogue the teacher empowers the learners through conversation and questions to build their own understanding and to learn to think analytically.

Teacher can ask her own question in response of student's questions rather than simply providing readymade answers to them to keep the dialogue rolling on. It can encourage learners to get an insight for interconnectivity of various concepts.

Learners can examine and analyse the concepts from multiple points of view from the social interactions in the classroom. The teacher should facilitate the learner to listen to her classmates attentively without interruption and to use sensitivity to take her turn to express her ideas.

Obviously, knowledge is being constructed by learners through social interactions in the class and this knowledge is shared among the learners. It is important that teacher should remain vigilant, so that dialogue does not lead to wrong conclusion. She should intervene at critical juncture to guide the conversation, so that it leads to scientifically consistent explanations.

Lev Vygotsky (1896–1934) believed that, "Children undergo quite profound changes in their understanding by engaging in joint activity and conversation with other people." He emphasised that learning is a complex activity. Learners learn a lot when they interact with their environment. Environment refers not only to school and physical and social surroundings, but also to their peers, the teachers and parents.

Therefore, meaning is constructed not only through processes operating on 'individuals', such as the stimulation of senses or the mediation of prior knowledge, but also through processes of social communication. Learners should be encouraged to learn from each other, be it dialogues, small group activities, cooperative or collaborative learning.

This is essential for holistic development of the learner. The process of dialogue can be followed by generating discussion in the class by emphasising on argumentation in science,

highlighting the importance of learning from social interaction in the classroom and the role of learners in negotiating and mediating learning in physical science.

Generating discussion

Discussion is an important process of learning and understanding our environment. It is a way of putting our point of view and supporting it through convincing information, arguments and evidences. Discussion is required to acquire scientific and technological knowledge and to understand the physical and social environment around us. Therefore, teaching-learning of science should encourage the learners to generate discussions and question about the world around them.

Many a times the term discussion is used for any type of oral interaction. For example, when a teacher says, "let us discuss on the *conservation of momentum"* and asks a few questions to the class about the content without providing the learners the space for raising and asking questions, performing activities, doing investigations, solving problems, interacting with peers and surroundings- it is not discussion and has little learning value.

Generating and conducting discussion for active participation of the learner require the following:

- Selecting suitable concept or topic which interests learners. Learners maybe involved in this.
- Creating situations like activity, experiment, project, video clip, learners' report, field trip, etc. It can provide a common platform to the learners for class discussion.
- Ensuring participation of all learners. When you plan discussion based on the activity or experiment, arrangement of materials and apparatus should be such that each learner may obtain, perform and return the materials herself with a minimum disturbance to the classmates.
- Encouraging the learners to put their questions as well as to response to other's questions or viewpoints with suitable reasoning and argument. Probing questions asked by the teacher seeking explanations and reasoning can foster critical and creative thinking in learners.
- Acknowledging and praising learners for their responses, adding and supporting their ideas, identifying knowledge gaps without criticising them can help them to sustain their interest and keep the discussion rolling on.
- Summarising, reviewing and evaluating the ideas with the help of learners at the end of the discussion.

Such situations can encourage learners to consider multiple views, reflect on their own and other's views using their thinking and existing ideas. Though it is not possible to anticipate all

questions of the learners in the class, framing few questions or identifying some points on the concerned concept or topic beforehand helps the teacher to remain focused on the issue during discussion. You can initiate a discussion by giving a 'statement' or 'posing a problem' or putting a question in situation where you expect varied experiences and understanding to exist among the learners.

Generating discussion is one of the powerful ways to lead the learners into inquiry and learning to learn. Discussion may be generated in order to predict, explain and interpret the result of activities and experiments, solve problems and plan future teaching-learning activities. A good discussion allows free exchange of ideas amongst all learners and the teacher in the class.

Learners get opportunities to listen, support criticise, argument and evaluate other's ideas. Learners put forward their point of views and experiences. These help in the development of open-mindedness and ability to suspend judgment until convinced by arguments presented by others. Let us now see how learners can be involved in argumentation in teaching-learning of science.

Argumentation in science

Argumentation is the process of doing argument. Argument is a form of discussion that needs to be planned through suitable learning experiences. It plays a vital role in science education. It helps building of explanations, models and theories in science and promotes learning.

Argumentation in science provides the learners an opportunity to generate, collect and use evidences to make sense of the concepts being studied. Learners critically evaluate each other's claim and evidences.

- It provides opportunity to the teachers to explore ideas of the learner in a social set up by engaging her in justifying, defending, collecting evidences, doing experiments and activities, critically evaluating evidences.
- It develops communication skills of learner. Learner learns to use scientific vocabulary and scientific concepts to support her arguments.
- It discourages learner to accept science as a mere collection of facts and accepting passively the provided explanation of natural world as right or wrong.
- It helps the teacher to know about thinking and learning process of the learner.

Generally, the most frequent type of questions that is used by teachers in science classroom demanding fixed responses, do not encourage students to share their ideas or enter into interactive

discourse. It is observed that there is a direct relation between open-ended questions and increased involvement of learners in argumentation.

When learners are given opportunities to voice reasoning to their knowledge claims and throwing them to be evaluated by the peers and the teacher, they learn about constructing as well as evaluating arguments and making sense of their own knowledge. Learners then view themselves as the constructor of knowledge and teacher as a *facilitator of learning* rather than a *knowledge dispenser*.

Role of teacher in promoting argumentation

Just giving learners scientific or controversial scientific issues to discuss will not ensure argumentation and valid learning. Following considerations can be made in teaching-learning of science:

- Provide an open-ended situation to the learners to initiate argument.
- Use arguing prompts to motivate learners to participate in the argument. Some of the arguing prompts can be:

  – How can you explain the observation?

  – Why do you think that way?

  – What do you think about the reason for your answer?

  – Can you think of another argument for/against your view?

  – How do you know what you know?

  – What is the evidence of your knowledge?
- Ensure homogenous participation of learners in argumentation.
- Intervene in the argumentation when the objectives of learning are not being achieved directly or indirectly or the argument becomes unharmonious or unhealthy.
- Provide positive feedback to the learners.
- Help the learners to summarise the major ideas evolved in argumentation at the end.
- Suggest further follow-up activities to ponder over the argument further.

This is a sample of argument that makes students participate in interactive learning. You can see how students are giving reasoning and justifications. Teacher can initiate and sustain argumentation for learning science by discussing on common observations. Space should be given for reasoning,

evidences, justification, open ended questions, experiments and investigations, analysis and interpretation of data.

Thus, argumentation includes coordination of evidence and theory to support or refute a task related with knowledge. Argumentation in science can be supported by the observations based on activities and experiments, discussion based on mathematical formulations and using sentences with scientific vocabulary clearly and logically.

Introducing argumentation in the classroom requires a shift in the role of teacher from authoritative to a dialogue approach associated with extended contributions of learners. Argumentation in classroom helps to construct knowledge, clarify concepts, remove naive concepts and make learners active partners and become self aware of their learning.

NEGOTIATING AND MEDIATING LEARNING IN PHYSICAL SCIENCE

The mediation of students helps the teacher to design relevant activities according to the need of the learners. The learners develop a sense of involvement and participation in the teaching-learning process.

Learners negotiate what they will learn, how they will learn within the given framework of the curriculum. Following are the positive points of learners' negotiation and mediation in learning process:

- Learners become active partners in learning. It generates interest in learning science.
- It raises self-esteem, critical thinking and listening skills of the learners.
- They design activities with the help of the teacher. Thus they learn by doing themselves.
- They feel responsible for their learning. The whole learning process imparts a sense of achievement and satisfaction.
- They work in collaboration with other learners and teachers, and develop various social skills.

Teacher should create a learning environment in the class that is conducive for mediating and negotiating learning in the pursuit of learners' questions rather than strict adherence to the curriculum. Learners can mediate and negotiate in a collaborative set-up that can influence their actions.

Learners can compare and contrast their ideas, attempt to integrate information from two or more sources such as observations of two similar experiments to mediate and negotiate learning and construct their knowledge.

In the context of physical science, there is little scope for compromise as indicated by the words *negotiate* and *mediate* in isolation. Learning tasks in physical science may be performed differently, argumentations may be given differently, and however, meaning can be obtained by mediating and negotiating with peers and the teacher.

Opportunities of observations, discussion, argumentations and presentations can be given to the class as a whole. Negotiation is reached when a learner believes that her construction of knowledge and its scientific explanation are not different from her peer's even though they are likely to be different. The role of the teacher is to act as a facilitator of learning, encouraging interventions and promoting learner's autonomy.

You may argue that involving learners actively in the teaching learning provides little time for the teacher to cover the contents of the syllabus. However, this gives learners time for critical thinking. This places more responsibility of learning on the learners and they come prepared in the class. It also brings readiness for learning in them.

Active engagement of the learner needs proper planning and patience on the part of the teacher in the beginning. It saves your time and effort in the long run as it leads to deeper understanding, setting the learner on the path of meaningful learning. You would not observe more misconceptions and naive concepts in learners.

ENCOURAGING LEARNERS TO RAISE AND ASK QUESTIONS

If you take a round of the corridors of traditional schools running the classes, most of the time you will hear the voice of the teacher. Even if students are speaking, they are answering the questions that the teacher asked. Opportunities are seldom provided to students to raise and ask questions.

NCF-2005 recommends that teachers need to nurture an enabling learning environment in the class where children feel secure; there is absence of fear, and which is governed by relationship of equality and equity. Often this does not require any special effort on the part of the teacher, except to practice equality.

The classroom space should have a favourable climate where children can ask questions freely, engage in dialogue with the teacher as well as with their peers during an ongoing lesson. Unless they can share their concept-related experiences, clarify their doubts and ask questions, they will not engage with learning.

If instead of ignoring children's comments or sealing their tongues with strict rules and restricting on the language to be used, teacher encourages them to talk, they would find that the classroom is a more lively place and that teaching is not predictable and boring. It then becomes an adventure of interacting minds. Such an environment will facilitate the self-confidence and self-esteem of learners of all ages.

It will also go a long way in improving the quality of learning itself. Science involves observation, investigation and inquiry. **Asking questions is one of the most valuable skills a learner can have for learning science.** Learning process should lead to a situation where the learner gets involved in cognitive conflict.

Studies show that students find the class boring if only teacher asks questions and they are not allowed to express their ideas. In the class learners ask mostly those questions that relate what they are learning in the school with the things outside the school. In this process many questions may come up to their mind.

Strategies to encourage learners to ask questions

• Welcome and value each and every question. No question should be stamped as simple or silly question.

• Even if the question is simple or silly, it should not be tagged as such. Instead, learner should be guided to search the answer by asking some probing questions based on her previous experiences.

• Acknowledge their questions as *very good; interesting; intelligent questions; good statement; your question shows, 'you are thinking;' 'you are creative;' 'you have read a lot*;' or with similar feel.

• Only a few students should not be allowed to dominate the class. Provide equal opportunities of interaction to all. Students and teachers together may set a rule with respect to interaction. It may be *each learner of the class has to raise at least one question during teaching-learning process of one chapter/unit.*

• Familiarise them with the fact that asking a good question requires thinking and knowledge. Not only their answers, but also the quality of their questions will be assessed in the class. This would motivate them to concentrate on learning and thinking.

• In spite of having a good social and emotional climate of classroom, you may find that a few students are hesitant in asking questions. You may need to be empathetic with them.

You may say, *I understand. Even today I sometimes find difficult to ask question in meetings, but I have observed that once I start getting involved in conversation, things become normal and easy.*

• When you set up a difficult problem and do not get any response from the class, you may provide hint or draw their attention to the difficult part of the problem to encourage them to think and raise questions.

You may speak in lighter tone, *perhaps I explained it very quickly; I will discuss it again;* or, *this type of problem we have not done in the class earlier; do not give strain to your brain; take your own time; we shall discuss it tomorrow; etc.* Learners should be made to realise that learning science is not difficult, if they understand the underlying concepts.

• Instead of providing readymade answers to learners' question, the teacher should provide situation or experience so that they can get the answers themselves. You can pass on the question to different groups of learners. Let them enter into a dialogue with one another and then facilitate them to arrive at the answer.

• When you observe that the same question is raised by many learners of a class or one learner asks the same question many times, you need to reconsider the strategies of your teaching-learning. You may say, *sometimes I move from one concept to another concept very fast.*

These types of statements will help the learner to save her face and she will not feel hesitant in asking questions in future. Statements like *listen carefully to what I say; you are not attentive; I have explained it several times,* should be avoided.

Teachers should not insist that all learners in her class must give identical answers to her questions. Instead she should encourage students to ask as many questions as they can, related to the activities going on in the classroom, and also search for the answers on the basis of their own observations and experiences and information including the one they get through the media.

They should be encouraged to express themselves in their own words from their own experiences. Learners may ask questions not only during transaction of a concept but also when involved in any teaching-learning experience.

Creating the habit of listening to learners

Asking and listening are closely tied together in teaching-learning process. You can listen to students by asking questions or presenting an open-ended question or problem or conflicting situation

or asking a battery of questions. Listening to students is one of the most powerful tools of teachers in order to

• know what students think about certain scientific phenomena;

• understand why students think that way;

• find if their thinking is consistent with the scientific explanation;

• gauge how logically they think;

• find how they apply their understanding of concepts in explaining a scientific phenomenon or a new situation;

• find if there is a learning gap between their thinking and existing concepts of science; and

• know how do they organise their thoughts about scientific concepts and express themselves.

While listening to your learners, be focused on what the learners say, do not agree or disagree or be judgmental. Let the ideas first flow. You may respond non-verbally occasionally. Your body language should encourage the learners and convey that you are listening.

Creating opportunity of listening to learners

• **Acknowledge the fact that each learner is unique with varied levels of interest and abilities.** Learners come from a diverse social and educational background. Each of the learners may respond differently to the same learning situation. Also each learner is capable of learning, but you need to be aware of her existing ideas to motivate her in learning.

• Take the time to observe and assess the ideas of all learners including those seemingly invisible students who seldom participate in teaching-learning process. Listen to their explanation of scientific concepts. You will be aware of the complex way of thinking that might give you an insight into choosing an appropriate approach to teaching-learning.

Children are curious by nature; observing any novel situation or thing they become impulsive to ask questions. Pin drop silence in the class is not conducive to learning. Science classroom environment should be conducive for generating curiosity and thinking, so that learners get motivated to talk over the issue, ask questions and enter into discussion and argumentation. Every question of each child should be respected.

There is no hard and fast rule by which you can generate situations for listening. If you ask formal questions, answers to which may be given by ‘yes’ or ‘no’ only, you will not get much

opportunity to listen to your students. You need to pose open-ended and thought provoking questions that may help learners in interpretating information, predicting consequences, making inferences and thinking critically.

Activities that teacher can provide situations where learners can collect materials, learn and enjoy learning.

- Developing a science corner in the school.
- Opening science club in the school.
- Organising field trips.
- Arranging for bulletin board or wall magazine.
- Maintaining a scrap book.
- Taking up a project.
- Making static and working models.

Encouraging learners to collect materials from local resources

We know that children learn or construct their knowledge on the basis of the experiences they gain through observation and activities they are engaged in outside and inside the school and home. It is reiterated that with proper planning of activities involving learners, a teacher can awaken their interest in learning science. Learners get opportunities to establish link with their previous experiences and for context-based learning by getting involved actively.

You can provide many situations where learners can collect materials, learn and enjoy learning. Some of the activities are as follows.

• Developing a science corner in the school.

• Opening science club in the school.

• Organising field trips.

• Arranging for bulletin board or wall magazine.

• Maintaining a scrapbook.

• Taking up a project.

• Making static and working models.

For developing a science corner in the school, you can encourage learners to collect materials such as coloured stones, metallic wrappers, sheets and wires, spring balance, torch cells, small tumblers and bottles, droppers, syringes without needles, small bulbs used in torches, thread, balloons, sieves, beads and thread, sticks or sipper of cold drinks, ice-cream cups and spoons, straws of different radii and many other things that can be used in making models, doing an experiment or just to study.

Learners may collect different samples of soil, water, rocks, fibre, fabric, toys and materials made using magnets, stamps with pictures of scientists, etc. An exhibition of the materials collected along with proper write-ups can be organised in the school to motivate them.

Learners can also collect some materials when they go out for excursions, field trips or visits to some places. They can use the collected materials in performing activities in science club. To develop the habit of reading, learners can be encouraged to identify and collect information regarding current issues and award winners in science from various sources such as newspapers, magazines, and internet. A sense of wonder and curiosity can be generated when students see pictures given in newspapers and magazines and read about them. This can enhance their learning.

They can express their own ideas and prepare write-ups for maintaining wall magazines and bulletin boards in the school. Some learners may design cartoons or write poems, jokes and skits based on scientific concepts.

The wall magazines or bulletin boards can display theme-based information collected and displayed by learners. The themes could be from history of science, inventions, discoveries, phenomena, current issues such as global warming, floods and droughts, disaster management, volcanoes, deforestation and afforestation and many more depending on the stage and capabilities of the learners.

Learners may also search and collect learning materials for virtual experiments and activities from internet. Emphasis should be given on primary sources of data and use of manipulative materials in teaching–learning of science. Learning situations emerging from some events and their observations may also be used in teaching–learning of science as it happened in the following case.

All the above mentioned activities can generate interest in the learners, motivate them for learning and give them a chance to move out from the school boundaries and collect relevant materials and information from their surroundings.

SUMMARY

In teaching-learning of science, it is important for learners not only to be able to make sense of meanings and data to construct their knowledge, but they also need to be able to consider and critique others ideas.

Therefore, conversation, discussion, argumentation, negotiation, mediation and listening and asking play key roles in exploring the learners. Creating learning environment through various suitably designed activities, giving value to each learner and their ideas, and understanding how they are constructing their knowledge also help the teacher to explore the learners.

Eliciting learners' existing knowledge and understanding, uncovering the ideas coming to their mind and linking those ideas with suitably designed teaching-learning experiences are essential to explore learners. Active involvement of learners in all these processes are necessary to move towards achieving the aims and objectives of learning physical science.

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Unit - 3

Curriculum in Physical Science

Syllabus : Meaning – curriculum and syllabus – Principles and approaches of curriculum construction – selection of content –Recommendations of various commission since Kothari commission to NCF on science curriculum–Physical science syllabi and textbooks at upper primary, secondary stage.

CURRICULUM -Meaning

The term "curriculum" is derived from the Latin word" currere", which means “run". Thus curriculum means a course to be run for reaching a certain goal or "destination" here education is imagined as a race, with its aim as the goal and curriculum as the course leading to that goal. So the term "curriculum" came to signify a group of subjects or courses of study, arranged in particular sequence, for instructional purpose in school. A curriculum is more than just a syllabus or a statement of content. A curriculum is about what should happen in a teaching programme – about the intention of teachers and the way they make this happen.

According to the modern concept curriculum-does not mean only the academic subjects, traditionally taught in schools but it includes the sum total of experiences that pupil receives through the manifold activities that go on in the school, in the classroom, library, laboratory, workshop, play-grounds and in the numerous informal contacts between teachers and pupils. Curriculum touches the life of the students at all points and help in the evolution of a balanced personality.

Curriculum perhaps best thought of as sum total of all deliberately planned set of activities which facilitate learning and which are designed to implement specific educational aims. It is a plan to explain what concepts are to be transacted and what knowledge, skills and attitudes are to be deliberately fostered. It includes statements of criteria for selection of content, and choice of methods for transaction of content as well as evaluation. It is concerned with

- The general objectives of education at a particular stage or class; subject-wise learning objectives and content;
- course of studies and time allocation;
- teaching-learning experiences;
- teaching-learning aids and materials; and
- Evaluation of learning and feedback to learners.

Curriculum is a plan to develop capabilities that are likely to help achieve the chosen aims. The curriculum should provide experiences that build the knowledge and provide capabilities of thinking rationally, to understand the world through various disciplines, fosters aesthetic appreciation and sensitivity towards others to work and to participate in economic process.

It provides the vision of capabilities and values that every individual must have. It also gives a socio-political and cultural vision for society. In other words, curriculum is a complete plan for implementation of educational aims. Curriculum should respond to the new developments and the concern of the country.

Curriculum - Definition

Curriculum is a formal plan of educational experiences and activities offered to a learner under the guidance of an educational institution. It is more structured in schools and more flexible in higher education.

A curriculum is a systematic arrangement of the sum total of selected experiences planned by a school for a defined group of students to attain the aims of particular educational programmes

Syllabus

It is a document that gives details of the content of subjects to be transacted and the skills, knowledge and the attitude which are to be deliberately fostered together with the stage-specific objectives.

In India, NCERT develops exemplar syllabus for all stages of school education. States can adopt/adapt NCERT syllabus or can develop their own syllabus on the basis of NCF.

It will be interesting to know how the content to be transacted is chosen. To choose the content to be transacted, the requirements and challenges being faced by the country are considered. The challenge before our country is that of quality education. It demands that the education available to all children in different regions and sections of society be of comparable quality.

Therefore, selection of knowledge to be included in each subject requires careful examination in terms of socio-economic and cultural conditions and educational goals. Quality in education includes a concern for quality of life and all its dimensions viz. concern for peace, protection of environment and positive attitude towards required social change, universal human rights and changes in pedagogy. Education must provide the means and opportunities to enhance the child's creative expression and capacity for aesthetic appreciation.

The criteria used for the development of syllabi by NCERT in 2005, evolved from NCF-2005 are listed below:

- Appropriateness of topics and themes for the relevant stages of children's development from a psychological point of view.
- Pervasive resonance of the values enshrined in the Constitution of India in the organisation of knowledge in all subjects.
- Continuity from one level to the next.
- Interdisciplinary and thematic linkages between topics listed for different school subjects which fall under discrete disciplinary areas.
- Linkages between school knowledge in different subjects and children's everyday experiences and knowledge derived from them.
- Infusion of environment-related knowledge and concern in all subjects and at all levels, treating 'environment' as a holistic expression, covering nature, all forms of life, human values and socio-economic and cultural meanings of environment.
- Sensitivity to gender parity, peace, health and the children with special needs.
- Integration of work-related attitudes and values in every subject and at all levels.
- Need to nurture aesthetic sensibility and values by integrating the arts and India's heritage of crafts in every aspect of the curriculum.
- Linkage between school and college syllabi avoiding overlapping.
- Using the potential of educational technology which includes the new information technology in all subjects.
- Encouraging flexibility and creativity in all areas of knowledge and its construction by children.

Principles of curriculum construction

Principle of Suitability

What is to be given to the children in the form of learning experiences at a particular age and grade level should suit their age and mental development. The capacity for understanding, how children grow with age. The content of the study in any subject should be formed to suit their mental ability.

Principle of specific interests of students

Children will be able to learn better in fields where they have special tastes and inclination of the mind. It is also found that at different stages of age groups, children have different interest patterns. Interests of children also change according to circumstances and situations. Therefore learning experiences should be designed to suit the interests and tastes of the age group of students.

Principle of environmentally centered

The content of the learning experiences for children should be linked with the needs of the environment in which they live. Children from rural areas can understand and grasp easily the information which is directly concerned with their experiences in their own rural environment. The same thing applies to children in a various environments like urban areas, hilly areas, etc.

Principle of the comprehensive curriculum

The curriculum must have the necessary details. List of topics to be covered does not solve the purpose. Both teachers and students should know clearly what is expected of them, what is the beginning and what is the end of the topic for the particular class. Material, aids, activities, life situations etc. should be listed in the curriculum.

Principle of co-relation

The curriculum should be such that all the subjects are correlated with each other. While designing the curriculum, it must be kept in mind that the subject matter of various subjects has some relation to each other so that they help the child eventually.

Principle of practical work

Curriculum should be designed in such a way that it provides maximum opportunity to the child for practical work with the help of concrete things.

Principle of flexibility

Instead of being rigid curriculum should show the sign of flexibility. The organization of the curriculum should be on the basis of individual differences as every child is different from the other. Apart from these conditions of society goon changing, therefore, the curriculum must be flexible enough to address the needs as aspirations of the society.

Principle of forward-looking

This principle asks for the inclusion of those topics, content and learning experiences that may prove helpful to the students in leading their future life in a proper way.

Principle of consultation with teachers

Teachers play a key role in the implementation of the school curriculum of any grade or stage. It is therefore quite essential to seek the proper involvement of the teachers in the construction and development of the school curriculum.

Principle of the joint venture

It is necessarily a joint venture where various experts are involved like educational psychologists, educational technologists, curriculum specialists, evaluation specialists, teachers, subject matter experts etc.

Principle of availability of time and resources

While developing curriculum experts should be aware of the conditions of the schools and possible availability of time and resources available.

Approaches of Curriculum Construction

Curriculum Approach-It is a way of dealing with curriculum, a way of doing, creating, designing and thinking about the curriculum.

Subject-centred approach

In this approach, only subject knowledge (content) has been stated. This syllabus is based on 'subject-centred curriculum.' The basic assumption in 'subject-centred curriculum' is that knowledge, which is objective and universal can be transmitted directly from those who have acquired the knowledge to those who have not.

The teacher transmits subject knowledge to students through classroom instructions. Lecture is most commonly used method to communicate subject knowledge to students. Students generally memorise the subject content provided by the teacher/textbook. The teacher is considered to have all the right knowledge. Examinations test the content knowledge of students. While designing syllabus under subject-centred curriculum, experts select the content which is most important or worth teaching in schools.

The debate still continues as to which knowledge is relevant and useful for students. The curriculum developers and teachers who view learning solely as acquisition of subject matter, may have difficulty in planning student's learning beyond recall or comprehension level. Mere recall of skills does not by itself directly change a student's understanding and analytical ability.

Behavioural Approach

Behaviourist psychologists view learning as change in behaviour and learning objectives are defined in terms of behavioural change. Knowledge is the capability for action, identified as the 'successful performance of tasks.' For example, within the behavioural context student's ability to define dispersion of light falls as her knowledge. The only way to determine whether or not students 'know' or 'do not know,' something is to see how they behave in certain situations.

The behaviourist approaches to learning are based on following assumptions:

- Learning requires a change in the learner's behaviour which can only be gauged by what the learner does.
- Real competence comes only with extensive practice. The stimulus-response connection is strengthened with practice.
- The learning is strongly influenced by the feedback that tells the system when responses are correct and when they are wrong.
- Skilled performance requires that responses to stimulus be conditioned in such a way that a particular stimulus automatically generates the specific response.
- The total learning of a student with respect to a complex task is summative accumulation of specific expected learning outcome associated with that task.
- Most complex skills are hierarchical in structure and can be broken down into simpler tasks.

In behaviourist curriculum, teachers are instrumental to implement curriculum developed by curriculum developers. Teachers do not question 'ends or means of curriculum.' The behaviourist curriculum does not take into consideration the learner's experiences, context and cognitive predispositions. Learners are treated as passive receivers of knowledge and teacher as transmitter of knowledge.

Chalk and talk is the common method of teaching. Learners memorise, recite or study their lessons silently without questioning. Childhood is viewed as preparation for adulthood within society. The education aims at developing such knowledge and skills which will be helpful for students to serve society in their adult life.

Learner-centred approach

- The aim of learner-centred curriculum is to stimulate and nurture growth of learners.
- The learner-centred educators stress that aim of education is growth and development of the learner and the orientation of the entire school should be towards the learner.
- Learners create meaning and thus, construct knowledge by engaging in stimulating experiences when they interact with their environment.
- Learners are innately curious and predisposed toward exploration.
- The role of teacher is to provide learning environment and stimulating experiences to learners.
- From the learner-centred viewpoint, teachers must trust in the innate abilities of learners; in their capacity to direct their own exploration and learning.
- Learner-centred curriculum views learning from a constructivist perspective.
- Learning takes place when learners engage with stimulating environment, get involved in inquiry and make meaning for themselves out of interactions with environment.
- Learner-centred educators are interested in knowing, 'what is happening within' the learner between stimulus and response.
- The learner-centered educators are interested in parameters such as the state of learner's cognitive structures, her meaning-making abilities, and her creative spirit.

Managerial Approach

In this approach, the principal is the curriculum leader and at the same time instructional leader who is supposed to be the general manager. Curriculum managers look at curriculum changes and innovations as they administer the resources and restructure the schools.

System Approach

The whole system is approached by system theory. The whole approach represents line-staff relationship of personnel and represents the way, how the decisions are made? It gives the equal importance to all levels: 1. Administration 2. Counseling, 3. Curriculum, 4. Instruction 5. Evaluation.

Humanistic Approach

It is rooted in the progressive philosophy and follows the child centred movements. It considers the formal or planned curriculum and the informal or hidden curriculum. It considers the whole child and believes that in curriculum the total development of the individual is the prime consideration.

Integrated Approach

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

Curriculum integration can be described as an approach to teaching and learning that is based on both philosophy and practicality. Curriculum integration occurs when components of the curriculum are connected and related in meaningful ways by both the students and teachers.

Interdisciplinary Approach

An interdisciplinary curriculum combines several school subjects into one active projector is organized to cut across subject-matter lines, bringing together various aspects of the curriculum into meaningful association. It focuses on broad areas of study since that is how children encounter subjects in the real world—combined in one activity

Concentric and Spiral Approaches

The whole curriculum is spread over a number of years. A general treatment of almost all the topics are attempted at the beginning and it is developed in successive years according to the mental development of the pupils

Taylor's Model(A Classical Model)

It is often termed as Taylor's Model and Objective Model. It emphasis on consistency among objectives, learning experiences and outcomes. Curriculum objectives indicate both behavior to be developed and are content to be applied.

Hilda Taba's Model (Grass root Approach)

Here teachers are involved in the development of curriculum. Here the goal is to provide students with cognitive support. Taba's model include Diagnosis of Students' needs, Formulation of objectives, Selection of Content, Organisational Chart, Selection of learning experiences, Organisation of learning activities, and Evaluation procedures.

Selection of content for curriculum construction

The selection of subject matter for curriculum employs the following criteria for the macro curriculum, the subjects needed for the curricular program or course.

Criteria of Self-sufficiency

To help learners attain maximum self-sufficiency in the most economical manner is the main guiding principle of subject matter or content selection. Although the economy of learning implies less teaching effort and less use of educational resources, students gain more results. They can cope up with the learning outcomes effectively.

This criterion means that students should be given a chance to experiment, observe, and do field study. This system allows them to learn independently.

Criteria of Significance

The subject matter or content is significant if it is selected and organized for the development of learning activities, skills, processes, and attitude. It also develops the three domains of learning namely the cognitive, affective and psychomotor skills and considers the cultural aspects of the learners. Particularly, if students come from different cultural backgrounds and races, the subject matter must be culture-sensitive.

In short, select content or subject matter that can achieve the overall aim of the curriculum.

Criteria of validity

Validity refers to the authenticity of the subject matter or content you selected. Make sure that the topics are not obsolete. Thus, there is a need to check regularly the subject matter or contents of the curriculum, and replace it if necessary. Do not wait for another 5 years to change it. Modern curriculum experts are after current trends, relevance and authenticity of the curriculum; otherwise, the school or the country becomes obsolete.

Criteria of Interest

This criterion is true to the learner-cantered curriculum. Students learn best if the subject matter is meaningful to them. It becomes meaningful if they are interested in it. However, if the curriculum is subject-centered, teachers have no choice but to finish the pacing schedule religiously and only teach what is in the book. This approach explains why many fail in the subject.

Criteria of Utility

The usefulness of the content or subject matter. Students think that a subject matter or some subjects are not important to them. They view it useless. As a result, they do not study. Students only value the subject matter or content if it is useful to them.

Criteria of learn ability

The subject matter or content must be within the schema of the learners. It should be within their experiences. Teachers should apply theories in the psychology of learning to know how subjects are presented, sequenced, and organized to maximize the learning capacity of the students.

Criteria of feasibility

Feasibility means full implementation of the subject matter. It should consider the real situation of the school, the government, and the society, in general. Students must learn within the allowable time and the use of resources available. Do not give them a topic that is impossible to finish.

Recommendations of various commissions since Kothari commission to NCF on science curriculum

The NCF of 1975 recommended 10+2 system of school education with general education of 10 years. The NCF of 1975 also recommends that general science should be a core compulsory subject up to Class X. The framework suggests activity-based integrated science up to Class X.

The National Curriculum for Elementary and Secondary Education (NCESE) (1998) :

- A Framework recommends learner-centred science curriculum.
- It also recommends that general science should be a compulsory subject up to class X.
- It also suggests that science education should aim at developing well-defined abilities in cognitive, affective and psychomotor domains such as spirit of inquiry, creativity, objectivity, the courage to question and aesthetic sensibility

At the primary stage during the first two years (Classes I and II), study of science should form an integral part of environmental studies. In Classes III, IV, V, it should be one of the two parts of environmental studies – one devoted to science and the other to social studies.

At upper primary stage (Classes VI to VIII), learner is expected to consolidate and strengthen the abilities acquired at the primary stage. Science education at this stage should help the learner to develop skills of manipulation, handling simple science equipment and designing of simple experiments to seek explanations of natural phenomena.

At the secondary stage (Classes IX and X), the aim of teaching science would be primarily directed towards problem solving and decision making through the learning of key concepts which cut across all disciplines of science.

The National Curriculum Framework for School Education (NCFSE)-2000 recommends

At the primary stage, science should form an integral part of environment studies. In Classes VI to X as a single discipline. It was felt that technology is increasingly influencing our lives and therefore, needs to be included in the science course. At the senior secondary stage, teaching-learning of science takes a disciplinary approach as physics, chemistry and biology.

The National Curriculum Framework-2005 recommends

- Hands-on, inquiry-based science curriculum. NCF-2005 also addresses the issue of curriculum load, rote memorisation and rigid examination system.
- NCF-2005 suggests flexible examination system and time schedule, reducing curriculum load and integration of theory and practical work in teaching-learning of science.
- NCF-2005 recognises learner as constructor of knowledge and suggests that learners be provided with learning-experiences which enable them to inquire, solve problems and develop their own concepts.

At the primary stage, the child should be engaged in joyfully exploring the world around and harmonizing with it. The main objectives at this stage are to arouse curiosity about the world (natural environment, artifacts and people) and to engage the child in exploratory and hands on activities.

At the upper primary stage science education should provide a gradual transition from environmental studies of the primary stage to elements of science and technology. Science content at the upper primary stage should not be governed by disciplinary approach. At this stage the child should be engaged in learning the principles of science through familiar experiences, working with hands to simple technological models.

At the secondary stage, students should be engaged in learning science as a composite discipline, in working with hands and tools to design more advanced technological models than at the upper primary stage.

At the higher secondary stage, science should be introduced as a separate discipline, with emphasis on experiments/technology and problem solving.

The analysis of physical science syllabi

- There is a shift in approach to syllabus development.
- There is a shift from information loaded content to ‘activity-based’ integrated science syllabus to ‘learner-centred’ syllabus.

- The 1988 syllabus has been spirally developed, detailing the competencies, concepts and activities appropriate for the stage of schooling and graded in terms of difficulty level and depth.
- The real-life issues related to problems of *Food and Nutrition, Health, Population, Agriculture and Environmental Protection,* form the essential components of science learning.
- 1988 science syllabus for Class VI is presented as a list of topics. The approach was to rapidly acquaint children with the content of science without giving due importance to the process of science. Many topics like *Force, Friction, Galaxy*, etc. have been included in Class VI syllabus.
- The list of topics to be transacted at times is over specified or underspecified.
- Syllabus is under specified because list of topics fails to define the intended breadth and depth of the content.
- It is over specified in that it attempts to enumerate items of content knowledge which could easily have been left open.
- The focus is to acquaint children with the content of science and its application in technology.
- A thematic approach was adopted to organise the syllabus. The themes selected were *Universe, Our Environment, Matter, Measurement, the Living World, Energy, Nutrition and Health and Agriculture*
- Most of these themes continue throughout the upper primary stage and continue even up to the secondary stage.
- An attempt was made to arrange the concepts in hierarchical order from Classes VI to X. These themes have been further divided into chapters that contain suitable content and also indicate extent of coverage.
- NCF-2005 recommends that emphasis should be laid on the active participation of the learner in the construction of their knowledge.
- While developing science curriculum in 2005, it was decided not to combine technology with science.
- The information load in syllabus was reduced and only age appropriate concepts were included.
- The syllabus was prepared in the light of NCF-2005 and recommendations of the report '*Learning without Burden'* were also considered.
- A thematic approach was adopted to organise the content and the syllabus was framed along cross disciplinary line.

- The themes included in the syllabus were Food, Materials, The World of the Living, How Things Work, Moving Things, People and Ideas, Natural Phenomenon and Natural Resources.
- These themes run from upper primary to the secondary stage and there is consolidation of themes at the secondary stage. The 2005 syllabus has been presented in four columns titled as questions, key concepts, suggested resource and suggested activities.

The syallabus starts with questions. These are key questions which are meant to provide points of entry for the child to start the process of thinking. The activity column lists experiment as well as other classroom processes in which children may be actively engaged, including discussion. Although the items are suggestive in nature, they are meant to give an idea of the unfolding of the content. If you read activity column together with the questions and key concepts; they give the intended depth and breadth of the content coverage.

The syllabus provides clues for teaching-learning strategies and choosing content for textbook writing. It also has space for learners to perform activities/experiment. The local context also finds place in this syllabus. NCF-2005 recommends plurality of textbooks and relating science to everyday experiences of students.

For teaching-learning of science, NCF-2005 recommends a pedagogy that is hands-on and inquiry based. While this is widely accepted at the idea level, practice in India still tends to be dominated by chalk and talk methods. To make any progress in the desired direction engaging learners in inquiry and involving them actively in teaching-learning process is important. In 'hands-on' way of learning science, we start with things that are directly related to the learner's experiences and can be taken as concrete examples. In subject-centred approach, concepts are arranged in a hierarchical order, but in learner-centred approach, concrete situations come first followed by abstract concepts.

An example is the concept of electric current. If we think that the concept is abstract and needs the knowledge of movement of charge, then it should be treated at later stage only when the child is comfortable with the concept of charge. Charge is an abstract concept and is understood at a higher stage. However, we see that children can easily make simple electrical circuits and understand the concept of current. Therefore, concepts of *Electricity and Circuits*, *Electric Current and Its Effects* have been included at upper primary stage.

The Analysis of Physical science textbook

The textbook as a part of teaching-learning materials, is a tool to engage the learner. The teacher in classroom practices can use a variety of activities, concrete learning materials along with

textbooks. When we come to decisions regarding approaches of teaching-learning, learning materials and concrete examples to be used, we have to consider learning needs of the learners.

These concrete decisions can be made only for specific classrooms and children as the actual learning happens only in the child's mind and depends totally on what has been learnt earlier. Therefore, the reinterpretation of the content, approaches, and materials are completely within the sphere of practical decisions to be made by the teacher.

A textbook may not necessarily cover the entire syllabus of one class/ stage and it may not necessarily be for the whole year. Any good textbook should lead the child to interact with the environment; peers and other people rather than be self-contained.

A textbook should function as a guide to construct understanding through active engagement with text, ideas, things, environment, and people rather than transferring knowledge as a finished product.

The recent attempt by NCERT to prepare syllabus based on NCF-2005 aims at making the syllabus an enabling document for the creation of textbooks that are interesting and challenging without being loaded with factual information.

Overall, science has to be presented as a growing body of knowledge rather than a finished product. In the light of this argument, what is needed is not a single textbook, but a package of learning materials that could be used to engage the learner in active learning and inquiry.

At the primary stage environmental science textbook is provided and which includes cleanliness, good habits, healthy foods etc.,

At the secondary stage a science textbook which includes physics-basic science concepts like measurement, force, motion, magnetism etc., matter around us, chemical equations, separation etc. in chemistry

At senior secondary stage science textbook has been designed separately for physics and chemistry within-depth wider elaborated manner of each topics.

- NCF-2005 recommends plurality of textbooks and relating science to everyday experiences of students.
- Concepts of Electricity and Circuits, Electric Current and Its Effects have been included at upper primary stage.
- The textbook as a part of teaching-learning materials, is a tool to engage the learner.

- The teacher in classroom practices can use a variety of activities, concrete learning materials along with textbooks.
- When we come to decisions regarding approaches of teaching-learning, learning materials and concrete examples to be used, we have to consider learning needs of the learners.
- The reinterpretation of the content, approaches, and materials are completely within the sphere of practical decisions to be made by the teacher.
- A textbook may not necessarily cover the entire syllabus of one class or stage and it may not necessarily be for the whole year.
- Any good text book should lead the child to interact with the environment; peers and other people rather than be self-contained.
- A textbook should function as a guide to construct understanding through active engagement with text, ideas, things, environment, and people rather than transferring knowledge as a finished product.

Evaluation of good textbook

The following criteria will have to be kept in mind while evaluating the science textbook

Lesson Purpose

Lesson objectives should relate to the curriculum indicators and also enhances students to understand the content that they are going to learn.

Content

For each lesson, prerequisite knowledge is well defined. All of contents, questions and situations in the lesson are appropriate for students' abilities and should also encourage students to express their level of understanding.

Phenomenon and Learning Experience

Phenomena and situations included in the textbooks should be related to the lesson content. In addition, learning activities provide students to learn by working in real or simulated situations. Either direct or indirect phenomena and situations, should be used to encourage students to connect scientific concepts, make reasonable conclusions, and construct their own knowledge.

Communication

Explanation and scientific / technical terms used in the textbook should easy to understand and communicate scientific concepts. These terms also show the relationship among those concepts.

Learning Activity

Learning activities, problems and questions should encourage students to practice scientific processes. Especially, end-of-lesson questions should be given to students to check their understanding after doing activities and help them to apply knowledge in everyday life.

Assessment

Questions, problems and exercises should be aligned with the curriculum indicators and also emphasize on higher-order thinking levels and the application of scientific concepts in everyday life.

Use of Textbook

A textbook is a book used for the study of a subject. People use a textbook to learn facts and methods about a certain subject. Textbooks sometimes have questions to test the knowledge and understanding of the learner.

1. There are many reasons why textbooks have been proven to be a more helpful for students

2. Students will not get as distracted, the information is understood more clearly, and textbooks are more reliable

3. Textbooks are a great source of information and are easy for teachers and students to use.

4. “Good textbooks are excellent teaching aids. They’re a resource for both teachers and students.”

5. A textbook series provides you with a balanced, chronological presentation of information

6. Textbooks are a detailed sequence of teaching procedures that tell what to do and when to do it.

7. Textbooks provide administrators and teachers with a complete program. The series is typically based on the latest research and teaching

8. Good textbooks are excellent teaching aids. They're a resource for both teacher and students.

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Unit - 4

ICT RESOURCES IN LEARNING PHYSICAL-SCIENCE

*Syllabus : Dale's Cone of Experience (modified) – Teaching Physical–science with**:** audio broadcast, educational television, multimedia: audio, slideshow, animated video, simulation, games, and e–picture/poster. – Blended learning**:** eBooks, web, wikis, Moodle, social networking. – ICT tool used in classroom – advantages of using ICT in learning–teaching processes.*

Introduction

Information and Communication Technology (ICT) has changed the way people interact and communicate with one another. The school systemcannot remain aloof from this development. Gradually ICT has enteredinto schools and has started influencing teacher-learner interaction.The teacher of twenty-first century must be proficient enough in usingICT for her teaching-learning in the classroom. In today's world, moderntechnology offers very exciting possibilities for this purpose. In thischapter we shall discuss on various forms of print and ICT resources.

Dale's cone of experience

Edger Dale's cone of experience is a model that includes several theoriesrelated to teaching-learning design and processes. During the 1960s,Edgar Dale theorised that learners retain more information by whatthey 'do' as opposed to what is 'heard', 'read' or 'observed'. His research led to the development of the 'Cone of Experience'. Today, this 'learningby doing' has become known as 'action learning.' Modified diagram ofthis cone is depicted in Fig. This diagram is self-explanatory.

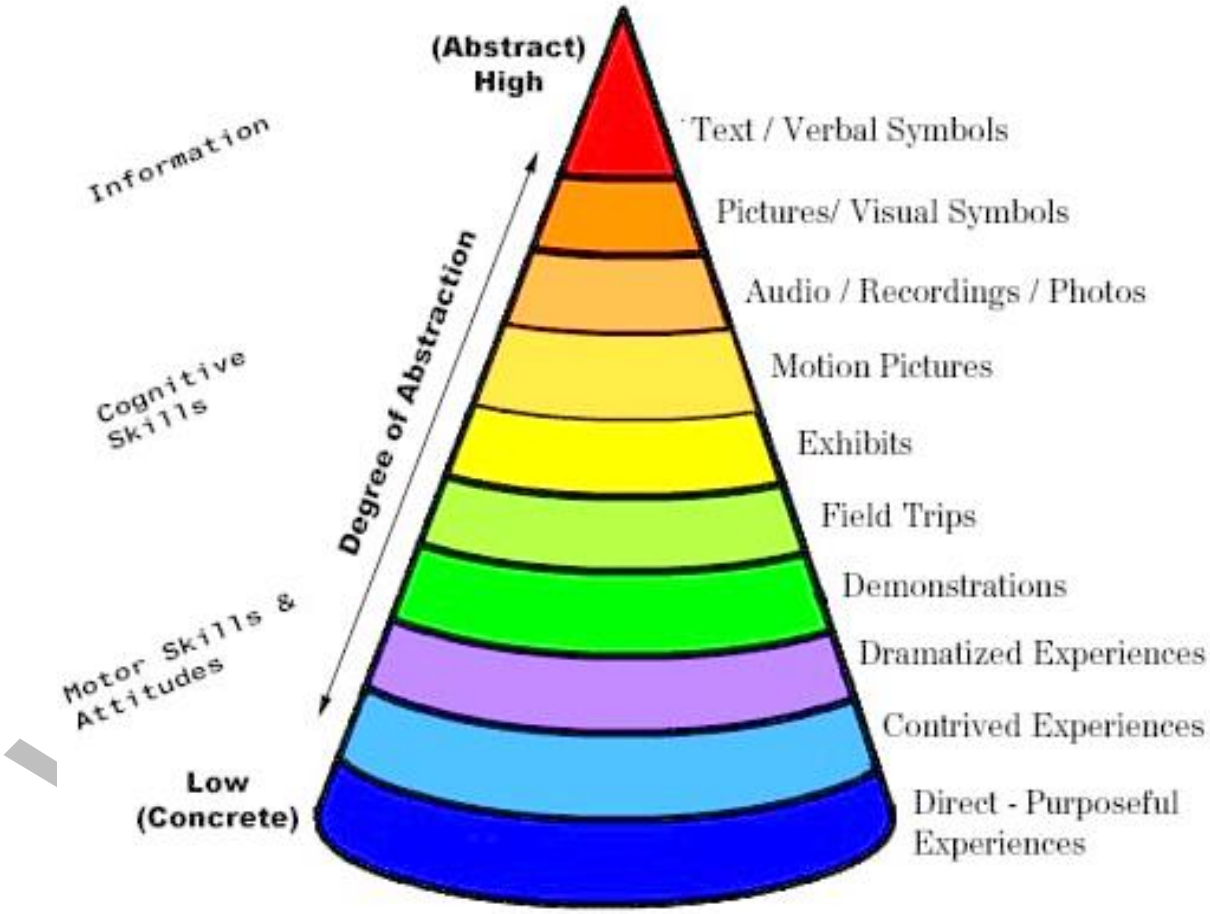
Using the Cone of Experience

The least effective method at the top involves learning from informationpresented through verbal symbols, i.e. listening to spoken words oraudio aids. The most effective strategies at the bottom involve direct,purposeful learning experiences, such as hands-on or field experience.A direct purposeful experience represents reality or everyday life.

The Cone indicates the average learning for various strategiesof teaching-learning. As we progress down the Cone, the greater thelearning and deeper the understanding. It also suggests that involvinglearners in the processof selecting a teaching-learningresource isimportant. It facilitatesto strengthen theirknowledge.

Dales' Cone ofExperience is a toolto help teachers makedecisions about teaching-learningresources andactivities. The teacherscan think on the line offollowing questions formaking a decision.

- Where will this teaching-learning resource fit with the learner'sexperience on the Cone?
- How far it is related to their real life?
- What kind of learning experiences can be provided in the classroom?
- How does this teaching-learning resource augment the informationsupplied by the textbook?
- What and how many senses can learners use to learn this teaching-learningmaterial?
- Does the teaching-learning material enhance learning?



Edger Dale'sCone of Experience (modified)

All the experiences that human beings derive are mainly from three sources namely

i) Direct sensory contact which involves "doing"

ii) Pictures or some other forms of representation of objects which involve "Observing"

and

iii) Oral or printed words which involve “symbolizing”

Of these three possibilities, the third is perhaps of least value from the point of view of teaching the young learner. All the learning experiences which can be utilized for classroom teaching are shown by Edger Dale in a pictorial device – pinnacle from which he called the ‘cone of experience’.

The base of cone represents the concrete, direct, first hand experiences. In the absence of direct experiences teachers use models and mock ups. Such teaching aids provide contrived experiences. A contrived experience is a simplified experience through a model. For example, it will be a difficult thing to bring in an electronic microscope or an atomic reactor in the classroom. But a working model of them will provide contrived experience.

The next stage is the dramatized experiences which provide a situation for participation in a reconstructed situation, though it is not a real experience. Dramatization can also be used in the classroom.

Demonstrations, field studies, exhibits etc. are helpful in visual explanation of the phenomena. If students are involved in these activities, they can get a feel of creative participation.

The highest abstraction is through symbolic or verbal experience. A science teacher uses chalkboard, charts and maps to give abstract, situations and students are far away from the real things.Verbal communication gives simple representation of a thing and fails to evoke participation.

1. Teaching Physical-Science with Audio

(a) Broadcast talks

Radio broadcast and audio recordings are the sources of audio learning experiences for the children. In order to provide learning experiencebeyond the school syllabus and to relate it to the real life outside theclassroom, school broadcast programmes could be one of the bestmedium. It may not always be possible for a science teacher to inviteeminent persons of science for the lecture or talk. In such cases thelectures or speeches can be pre-recorded and can be played in theclassrooms. There are various types of programmes, such as discussionforums, question-answers, debates, quizzes, speeches, dramas, whichcan be either played live or can be pre-recorded, to be used in teaching-learningof science.

The All India Radio has regular programmes for school children.Programmes generally include talks on educational, scientific, currenttopics, etc. The topic, date and time of broadcast of such talks are givenin advance. The schools can take advantage of such talks. Sometimes, it is also possible to synchronise the broadcast on a topic with the actualteaching-learning time of that topic in the class. To get the maximumbenefit from such talks, the following points should be kept in mind:

- ❖ To keep students' interest alive, they are facilitated to get familiarwith the background of the talk beforehand. A discussion could bearranged after the talk.
- ❖ Preferably short duration talks are arranged.
- ❖ The students having hearing problems are seated near the source.

(b) Audio tapes

The major advantage of a magnetic audio tape over a disc is that onecan record programmes easily and economically. When the materialbecomes outdated, or is no longer useful, it could be erased and thetape can be reused. Tapes are not as easily damaged as discs, andthey can be easily stored. Records of talks on interesting topics byeminent scholars can be easily reproduced in the classroom. Thesetalks provide an inspiration to the students. Such a recording couldbe used to introduce a topic or to develop it. These devices are seldomused these days.

Advantages

- Audio media are inexpensive. Once the audio tapes andequipments have been purchased, there is no additional cost,because the tapes can be reused.
- Audio materials are readily available and very simple to use.They can be used for a group or an individual.
- Audio cassette recorders are portable and can be used outsidethe classroom because they can be run on battery.
- Cassette recorders are ideal for home study as students canafford to have their own cassette players. Audio tapes can beeasily duplicated in required quantities.
- They can be used in all phases of teaching-learning fromintroduction of a topic to assessing students' learning. The audiomedia could be very well used for the purpose of self-pacedlearning. If required, learner can go back and repeat desired segments of teaching learning as often as necessary because therecorder/playback machine can serve as a very patient tutor. Onthe other hand, learners can skip ahead or increase the pace oftheir learning as and when desired.

- Pre-recorded audio media can be used as ‘talking books’ for thevisually impaired students. Audio tapes can easily be preparedby teachers for students with special educational needs.

2.) Educational television

The television in the present day society can be used as one of theimportant teaching-learning aids. It combines the advantages of aradio (broadcast) and of a film, and could be used for mass education.Topics of discussion can be announced in advance and teacher caneasily carry on teaching-learning process around the telecast time toincorporate them in the on-going lesson so that students can watchand discuss the concepts in the class. Such teaching-learning helpsstudents to develop their interest in the subject. UGC programmes aretelecast on Doordarshan. NCERT telecasts its educational programmeon GyanDarshan channel.

Thereis a tremendous potential to increase television basededucation as we have a dedicated satellite in the geostationary orbitnamed EDUSAT. A large number of educational television programmescan be made and telecast. EDUSAT also offers a facility for two-wayinteraction where the viewers can raise their doubts and make commentsalso.

NCERT also uses video-conferencing mode to interact and train teachers all over India. A large number of scientific programmes on scientific issues are telecast on various channels of television. Teacher herself needs to be aware of such programmes to guide her students. National Geographic, Discovery, Discovery Science are informative channels made available through television. These channels enable us to see many programmes on scientific issues with High Definition (HD) transmission and give better, more vivid watching experiences which are of educational value.

Multimedia

The Multimedia concept involves using multiple media for transactionof a concept. It involves integrating different media into a structured and systematic presentation. Each medium in a multimedia system isdesigned to complement the other, so that ideally the whole multimedia system becomes greater than the sum of its parts. Multimedia systemsare multi-sensory and stimulate learning. The multimedia kit mayinclude films, videos and audio tapes, records, still pictures, overheadtransparencies, maps, worksheets, charts, graphs, booklets, real objectsand models.

Commercially multimedia kits are available for various subjects.Multimedia kits can even be prepared by teachers. It is importantthat the components of the kit be integrated, that is, each componentcontributes to the attainment of the lesson objective. Multimediaactivities should also be correlated with other relevant learningactivities in the classroom. Multimedia kits should be designed

totransact particular topics and develop various skills. The teachersshould involve students in handling and manipulating the materialsin order to maximise their learning potential.Since they cater to many senses, multimedia kits make learningenjoyable. They are versatile in their content, range of media, and varietyof applications, and thus contribute to learning for a wide variety oflearners in many subject areas. In addition, multimedia kits providescope for individualised attention to students.

Multimedia is content that uses a combination of different content forms such astext, audio, images, animations, video and interactive content. Multimedia contrasts with media thatuse only rudimentary computer displays such as text-only or traditional forms of printed or handproducedmaterial. Multimedia can be recorded and played, displayed, interacted with or accessedby information content processing devices, such as computerized and electronic devices, but can alsobe part of a live performance. Multimedia devices are electronic media devices used to store andexperience multimedia content. Multimedia is distinguished from mixed media in fine art; byincluding audio, for example, it has a broader scope. The term "rich media" is synonymous for multimedia. Hypermedia scales up the amount of media content in multimedia application.

i) Audio

An audio tape recorder, tape deck or tape machine is an analog audiostorage device that records and plays back sounds, including articulated voices, usuallyusing magnetic tape, either wound on a reel or in a cassette, for storage. In its present-day form, itrecords a fluctuating signal by moving the tape across a tape head that polarizes the magnetic in thetape in proportion to the audio signal. Tape-recording devices include reel-to-reel tape deck and the cassette deck.

Talk radio is a radio format containing discussion about topical issues. Most showsare regularly hosted by a single individual, and often feature interviews with a number of differentguests. A talk show or chat show is a television programming or radio programming genre in whichone person discusses various topics put forth by a talk show host.

ii) Slideshow

A slideshow isa presentation ofaseriesofstillimagesonaprojectionscreenor Electronic displaydevice,typicallyinapre-arrangedsequence. Awell-designed slideshow servesasavisualaidandhelpskeepanaudience'sattention.

- Theslideshowisagreatwaytobreakdowninformationinsimpleways.Teachercan use the slideshow to make their point in seminars and workshops.
- It’sagreattooltokeepalltheinformationinoneplace

- Allpointsofatopiccanbeneatlyorganizedinasingleplace,usingdifferentslides,and Keepingtrackofinformationiseasy.
- Duringschoolhasan exhibition oraneventsday,graduationoraparent-teachermeet,Theslideshowisanexcellentwaytogiveoutcapsulesofinformation
- Thisisanenvironmentallysafewaytocarryeducationfrom onegenerationtothenext.Makingdigitalslideswithmaximum impactareMicrosoftPowerPoint,Prezi,GoogleSlides,Xtensio,KeynoteandPlaceit

iii) Animated videos

Animations produced for the specific purpose of fostering learning. The popularity of using animations to help learners understand and remember information has greatly increased since the advent of powerful graphics-oriented computers. This technology allows animations to be produced much more easily and cheaply than in former years. Previously, traditional animation required specialisedlabour-intensive techniques that were both time-consuming and expensive. In contrast, software is now available that makes it possible for individual educators to author their own animations without the need for specialist expertise. Teachers are no longer limited to relying on static graphics but can readily convert them into educational animations.

Uses of animated videos

- ❖ Emphasizes development of students' skills and understanding of creating and responding.
- ❖ Enables students to apply Imagination & Rational Thinking.
- ❖ Enables students to invent and explore multiple solutions to a problem.
- ❖ Enables students to understand the value of reflection and critical judgment in creative work.
- ❖ Facilitates positive peer interaction, including receiving and using feedback.
- ❖ Encourages self-motivation to create and problem solve.
- ❖ Uses artistic literacy as a natural enhancement to learning in other content areas.
- ❖ Fosters positive attitudes toward Art & Animation.
- ❖ Introduces career possibilities.

iv)Simulation

A simulation is a simplified version of reality in which essentialphysical or social elements are represented without hazards, costor time constraint normally associated with them. The purposeof simulations is to enable us to understand and function in realsituation. Simulations are representation of real situations with theelement of safety, because some real equipment cannot be used in the class as

they may be too costly or too delicate or may be lengthof time involved in a real exercise would be too great. Simulation andgames can give students practice in decision-making and allow themto test a hypothesis in abstract situations.

One familiar example isthe prediction of effect of increase in temperature on the pressure ofa system. The variables can be manipulated on computers and it ispossible for students to test out various hypotheses. One of the markedadvantages of effective simulation is increase in students' motivationand participation. Students respond with unusual enthusiasm andinterest to simulation/ gaming, because of its relevance to how thingsget done in real life.

v) Games

Games are a ubiquitous part of life in our culture, and experts suggest they will become even more deeply embedded in the coming years. Games help people develop a disposition toward collaboration, problem-solving, communication, experimentation, and exploration of identities, all attributes that promote success in a rapidly-changing, information-based culture.

vi) E- Poster

An electronic poster (E-Poster) is a poster in PowerPoint format, allowing the inclusion of movies, and other multi-media formats, and presenters are encouraged to take advantage of the versatility of this medium. All multi-media E-Posters will be presented at numbered monitors in the Exhibition Hall. The time allotted for E-poster presentations is 60 minutes, and authors are requested to be at their assigned computers for the period of time specified in the acceptance message. During this time you will be available for discussion of your E-Poster. A formal presentation is not necessary.

Uses

- Preparation of the poster by using a pre-defined model and the preferred edition software
- Enhanced presentations with the possibility of including videos online submission in an easy, quick and secure way.
- No need for printing, carrying and posting the poster on conventional boards More attractive, interesting and interactive presentations
- Higher work visibility, thanks to the searching options that make it easily accessible

Blended learning

Blended learning is a formal education program that involves combiningInternet and digital media with traditional classroom methods that require the physical presence ofboth a teacher and students, with some element of student control over time, place, path, or pace.

Blended learning is a term increasingly used to describe the way e-learning is being combined withtraditional classroom methods and independent study to create a new, hybrid teaching methodology.

It represents a much greater change in basic technique than simply adding computers to classrooms;it represents, in many cases, a fundamental change in the way teachers and students approach thelearning experience.

Blended learning is a combination of offline (face-to-face, traditional learning)and online learning in a way that the one compliments the other. It provides individuals with theopportunity to enjoy the best of both worlds. For example, a student might attend classes in a real worldclassroom setting, and then supplement the lesson plan by completing online multimediacoursework. As such, the student would only have to physically attend class once a week and wouldbe free to go at their own pace

E-learning

E-learning is electronic learning, and typically this means using a computer todeliver part, or all of a course whether it's in a school, part of your mandatory business training or afull distance learning course. In the early days it received a bad press, as many people thoughtbringing computers into the classroom would remove that human element that some learners need,but as time has progressed technology has developed, and now we embrace smart phones and tabletsin the classroom and office, as well as using a wealth of interactive designs that makes distancelearning not only engaging for the users, but valuable as a lesson delivery medium. Buildingpartnerships with quality training providers, and combining this with a dedicated experiencedtechnical team and support staff, Virtual College provides the perfect blended learning environment,

a) E - Book

An **electronic book**, also known as an **e-book** or **eBook**, is a book publication made available in digital form, consisting of text, images, or both, readable on the flat-panel display of computers or other electronic devices. Although sometimes defined as "an electronic version of a printed book", some e-books exist without a printed equivalent. E-books can be read on dedicated e- reader devices,

but also on any computer device that features a controllable viewing screen, including desktop computers, laptops, tablets and smart phones.

Applications of e-books

- **Informational Texts:** There is a much greater emphasis on students reading nonfiction content than ever before. E-books give teachers access to a large volume and wide array of titles to match what they need.
- **Student Choice:** E-book series offer flexibility in the classroom. For example, in the Britannica Guides Series, there are 10 different titles, all set up in the same structure. Teachers can use the series to teach text features, vocabulary, and research skills; while each student can read the title that they find the most interesting.
- **Search by MARC Records**: E-books provide free linked MARC records, enabling search, discovery, and access to collections from your library catalog. E-books also make citing easy, providing APA and MLA citations.
- **In-class Teaching Tools:** E-books are great to explore with the whole class. Teachers and students can insert questions and notes, highlight key sections, bookmark passages, and save it all for review. In addition, e-books are easy to share across platforms like Pinterest, Facebook, Twitter, LinkedIn, and email.
- **Partner Subscriptions:** Thousands of Britannica's nonfiction e-books for every age, reading level, and subject can also be used on any one of a number of popular platforms, including: EBSCO, Follett, GALE, MACKIN, Overdrive, and ProQuest.
- **Funding Resources:** Britannica Digital learning and DonorsChoose.org have partnered to connect educators with a thriving community of donors that are eager to fund all of your e-book needs.
- **Student-Tailored Options:** Teachers can select e-books by GRL, Lexile level, and grade level to find books on the same subject at multiple reading levels. In addition, visually impaired readers can change the font size for more ease while reading.
- **They're Great for Everyone:** E-books are environmentally friendly, they are more affordable than paper-based books, and they take some of the weight off… literally! Books are so heavy!

b) Web

It is a major tool for gathering, accessing, analysing, sharing anddisseminating information. With the help of networking your computer is connected with remote computers for accessing the

information. Thisweb of computers has certain specific locations called websites whichstore information on specified subjects. This information can be accessedby any internet user through the website's address. Alternately, one canalso upload one's own information on the web to make it available toany user. The user depending on her/his requirement then navigatesthrough the web to access desired information.

So versatile is the computer with internet that it is now an essentialpart for all stages of education, from the lowest to the highest, andfrom sciences to social sciences, fine arts, languages and whateverelse one can think of. It is an excellent resource for teaching-learning.Newer applications of computer are being discovered everyday inthe field of education.

The teachers can use computer and the internet to design theirlessons using huge reservoir of information and knowledge availableonline. The information includes film/video/audio clips, animations,drawings of complicated pieces of apparatus and a host of data of allkinds. One of the advantages of using computer and the internet isthat one can explore quickly the information available online and use itjudiciously to make lessons more relevant and interesting. In additionto designing lessons and teaching strategies, teachers can write theirreports, prepare question papers for assessment and evaluation ofstudents. Electronic portfolio of all students of a class can also bemaintained on the computer.

The teachers can form networking groups where they can exchangeideas, innovative experiences, joys and excitements of teaching-learningprocesses with their peers. They can get help from them and give help tothem. They can use computers and internet as a tool for lifelong learningto enhance their professional and social stature.

The teachers can alsodirect their students to educational sites already reviewed by them, sothat students can improve on their understanding of various conceptsof science by themselves and encourage them to become independentlearners. It would take off some tasks from the teachers, giving themmuch needed time for their other duties. In addition, teachers can setvarious tasks to students, such as writing reports, term papers, etc.,which students can do using the computer.

Wikis

A wiki can be thought of as a combination of a website and a worddocument. At its simplest, it can be read just like any other website,but its real power lies in the fact that groups can collaboratively (andprivately, when necessary) work on the content of the site using just
a standard web browser.

The second important element of a wiki is its ability to keep trackof the history of a document as it is revised. Since people come to oneplace to edit, the need to keep track of word files is eliminated. Eachtime a person makes changes to a wiki page, that revision of the contentbecomes the current version, and an older version is stored. Versionsof the document can be compared side-by-side, and edits can be 'rolledback' if necessary.

A wiki makes it easy for students to write, revise and submit aassignment, since students can develop, write and revise. Studentscan be given a wiki page to develop an assignment, and might start bytracking their background research. This allows the teacher, and peers,to see what they're using, help them if they are off the track, suggestother resources, or even get ideas based on what others find useful.

Next, the student can draft the paper in the wiki, taking advantageof the wiki's automatic revision history that saves a version of thedocument each time she makes changes. This allows the teacher andpeers to see the evolution of the paper over time, and continually comment on it, rather than offering comments only on the final draft. Ithelps in making assessment continuous. When the student completesthe final draft, the teacher and peers can read it on the wiki, and offerfeedback. You may visit the website www.wikispaces.com to get anidea about it.

Moodle

Moodle is a free and open-source learning management system (LMS) written in PHP and distributed under the GNU General Public License. Developed on pedagogical principles, Moodle is used for blended learning, distance education, flipped classroom and other e-learning projects in schools, universities, workplaces and other sectors.With customizable management features, it is used to create private websites with online courses for educators and trainers to achieve learning goals. Moodle allows for extending and tailoring learning environments using community-sourced plugins.

Moodle was originally developed by Martin Dougiamas to help educators create online courses with a focus on interaction and collaborative construction of content, and it is in continual evolution. The first version of Moodle was released on 20 August 2002.Nowadays the Moodle Project is led and coordinated by Moodle HQ, an Australian company of 50 developers which is financially supported by a network of eighty-four Moodle Partner service companies worldwide. Moodle's development has also been assisted by the work of open-source programmers.

Moodle is a learning platform used to augment and move existing learning environments online.As an E-learning tool, Moodle developed a number of featuresnow considered standard for learning management systems, including a calendar and a Gradebook. Moodle is a leading virtual learning environment and can be used in many types of environments such as education, training and developmentand in business settings.

Social networking

A social networking site can be a good way to make connections withpeople having similar interests and goals. These sites can be a way toconnect with or 'meet' people that a student may not get otherwise.One can stay connected to the learning communities as a wholethrough these sites. These websites offer tremendous educationalpotential for students and teacher-educators for advanced teachinglearningprocess. Teacher can share link of educational website withher students. Some of the social websites are discussed below. It is tobe noted that these websites are not prescriptive.

i) Face book (www.facebook.com)

One of the most popular social networking sites is face book. One canadjust privacy settings and make group so as to control who has accessto one's personal information. Students' social networking accounts canhelp teacher to discuss on the doubts and questions on any concept.She can also know about their interests and hobbies and this may helpher for better understanding of her students.

ii) Twitter (www.twitter.com)

There is a value in networking and real time interaction that wecan get using twitter. Manyeducators and academiciansfind this to be an effectivestrategy for dealing with theisolation that can come fromworking in the classroom oroffice. Imagine encountering technical difficulties duringour lesson and having a meansof receiving assistance withinminutes. Twitter is an effectivecommunication tool for concisemessages and news items, orlinks to longer messages andnews items.

Twitter is fun to use and may, therefore, be effective in engaging students in discussionswho do not need to write longer essays. Consider the ability to receiveassistance from others during a teaching-learning situation where wedon't know the answer to a student's query. We can share events atwork and this helps us to know our friends a bit more and adds anadditional layer of community within our online network. One cancustomise and use it to meet ones' specific needs and interests.

iii) Orkut (www.orkut.com)

Orkut communities can be used productively by teachers for effectiveteaching-learning. One can get enormous benefits through Orkut,provided that we use it in a productive way. Discussion or scientificissues can be generated and idea can be exchanged on this site. Through
Orkut communities, like-minded people can come together for betterunderstanding of their subjects of interest.

We can create communitieson Orkut in the name of our school to share our memories and stayin touch with our childhood friends. Orkut can be used to get newsupdates, find a suitable job, get good career ideas, and know aboutinstitutions and certification, and so on.

iv) YouTube

YouTube can be used for viewing, sharing and uploading video files.Teacher can make videos of experiments and activities and upload themon the YouTube and interact with students. A large number of videos onany experiment and activities already available on the YouTube can bereviewed and used for teaching-learning of physical science. Studentscan upload video file of any innovative experiment and project on theYouTube.

v) Podcast

A podcast is an audio or video file created and placed on the webfor individuals to download and view or listen on their computers ordigital media players. Podcasting is a means of one-to-many audiodistribution via the Internet. The term was coined from ‘iPod’ and orvideo ‘broadcast’.

A podcasting is a useful educational tool for two verydifferent activities— receiving content from experts, and as a means ofstudent media production. Podcasting is the generally accepted termfor both audio and video files, but video file distribution is sometimesreferred to as ‘podcasting,’ this provides a convenient, subscriptionbasedmodel for distributing educational materials. A list of educationalpodcasts to get an idea of what is available and how do they work, youcan visit the site– www.enpweb.org. This site also describes simplesteps on how to create a podcast by clicking on ‘cast’.

vi) Flicker

Flicker is an online photo management and sharing application. Thebasic service is free, which allows you an access of about 300MB permonth. You can upload your pictures from your desktop or your cameraphone. Then you can organise your photos by categorising them. Thesephotographs

related to activities, experiments, projects, model; chart,poster, etc. can be later used in teaching-learning process.

Flicker allows you to share your photos online, create groups that arepublic or entirely private. So, if you are participating in a collaborativeactivity with another class somewhere in the world, you can share yourphotos instantly. And if you want only your students to see the photos,you can maintain autonomy by creating a privacy setting.This aspect is so significant for education that every group canhave its own discussion board. The class can ask questions about thephotos and have meaningful discussions regarding the photos, andwork with international students to generate discussions with them.Visit the website www.flickr.com to have an idea about it.

vii) Blogs

Blogs allow you to post homework and other discussion prompts. Itkeeps record of threaded discussions and arranges items by date.Attachments can be added to blogs too. Students can interact with theteacher online. A blog is a type of website or part of a website. Blogs areusually maintained by an individual with regular entries of commentary,descriptions of events, or other materials, such as graphics or video.

A blog is similar to an empty book. This book can be in the form of asketchbook, a diary, a dictionary or portfolio— it depends on the contentthat we put into the book.The commenting feature of blogs allows for immediate feedbackon a posting and active participation. The content that can be postedto a blog can be text, images, files, hyperlinks, audio and video.

Blogscan be classified on the basis of their purpose as Educational Blogs,Personal Blogs, Group Blogs, Press Blogs, Project Management Blogs,Library Blogs, Institutional Blogs,etc.Edublogs can be written by the teachers for improving classroomteaching-learning process, by the students to post their assessmenttasks and by the policy makers who need to comment on education.Edublogs allow all students to participate in discussion on any topic.

Teacher acts as a facilitator in blog-based teaching and learning whomoderates the discussion process to keep it on the right track. She caninvite absent students, provide necessary teaching-learning materialsand communicate with parents, link her class with another classsomewhere else in the world, write comments, opinions, or questionson daily news items or issues of interests and showcase students’best writing pieces.

Teacher can also post teaching-learning notes forstudents, resources, and important links. In many countries studentsuse mostly blogs instead of paper journals for writing assignments.Services like http://www.blogger.com; www.learnerblogs.org andhttp://epnweb.org/blogmeister/are free blogging services that studentscan join. Some are open to the public, others are password protected.

ICT Tool used in classroom

Student-teachers need to be empowered to use emerging ICT to explorethe huge reservoir of knowledge, information and vast amount of dataavailable anywhere in the world and to communicate with the learningcommunities of physical science for enriching their teaching-learningexperiences. Student-teachers should be helped in acquiring a criticaland constructive outlook to use technology for their project work,assessment of students' assignments, and designing teaching-learningexperiences for learners.

Communication technology encompasses all forms of electroniccommunication in both digital and analogue form. The digital electronicdevices include computers, CD, optical disc and its players, storage devices, the Internet, cellular telephony and satellite broadcasting whileanalogue devices are largely limited to conventional radio broadcastsand audio tapes and tape recorders. Due to increase in bandwidth andthe availability of various types of connectivity, the various technologiesare converging into the broad field of Information and CommunicationTechnology (ICT).

Inclusive education is the need of the day. We have to ensure thateveryone in the classroom is able to understand the concept beingtransacted. A teacher usually faces situations where the learners needadditional inputs to facilitate acquisition of concepts. Teacher alsocomes across students with special educational needs. She has toensure their learning of science by making special efforts. In all thesecases, ICT comes very handy.

This is an area that takes care of learners who need specialattention like visually and hearing impaired, or learners learning withdifferent paces and styles. Use of computers by visually impaired isnow a common thing as most of the commands can be given throughauditory mode. In addition to inputs, outputs can also be given in theaudio mode for the sake of visually impaired students. Students withhearing impairment and others also can get help from digital resources.Appropriate digital package should be selected for them.

ICT in Classroom Instruction

The systematic use of ICT tools in classroom instructionmakes the teaching learning process more effective and highly interactive. It has shifted theteaching –learning process from teacher –

centered learning to student centered learning. Researchhas shown that high level of student and instructor satisfaction can be produced in ICT enabledlearning process.

But the effective and efficient use of ICT depends on technically competent educators /teachers.They should be able to appreciate the potentiality of ICT and have positive attitude towards ICT.

The effective and efficient use of ICT in classroom instruction depends on:

a) ICT literacy of Teachers

b) Effective use of ICT hardware and software for teaching –learning activities

c) ICT – based pedagogy, online support, networking and management.

d) Adopting best innovative practices in the use of ICT.

Various ICT tools used in Classroom Instruction

The following are some of thetechnological tools used in teaching –learning process. These are, Computer-Aided Instruction(CAI), Computer –Assisted Learning (CAL), LCD projector, PowerPoint Presentation, Smartboard, E-mail, Discussion forum, Wikis, Blogs Social Media, YouTube, CCTV, Videoconferencing , Teleconferencing , Google earth, Google Maps , School tube, Teacher Tube, Flicker,Classroom 2.0 Ning etc.

Role of ICT in Education

Information Technology can provide a medium for teaching andlearning and contribute flexibility to course provision.

The valid uses of information Communication Technologies are:

- Distance learning via electronic networks.
- Open learning through students controlled learning pathways.
- The process of changing teaching and learning styles by using a narrow range of InformationTechnology based facilities.

ICT make education system more productive, interesting, give more powerful instruction andalso able to extent the educational opportunities to masses and creating information –rich learningenvironment.

ICT has made the class-room transaction more interesting. It has extended the teaching learningprocess beyond the boundaries of classroom. Students are now able to use laptop computers andwireless networks anywhere in campus.

A computer allows high speed information exchanges tooccur with individuals within the institution as well as around the world. ICT brings the outsideworld in to the classroom teaching learning process, makes the things more realistic and thus helpsthe learners to understand the abstract thought very clearly.

ICT can improve the quality of higher education by promoting experimentations, researches andinnovations, adopting the new strategies in the teaching –learning process and integrating the newinformation with the best practices.

ICT has also played a vital role in providing distance education very effectively. IT providesonline delivery of courses, online assessment and online design courses to large no. of students at atime. The IC –based system like digital libraries; online courses, audio and video conferencingcontribute significantly to the area of E- Learning and have opened a new era in the area of ELearning.

Benefits of ICT application in Education:

The benefits of ICT application in education can be summarized as bellow:

- ICT increases the access to education.
- It improves the quality of education by developing new ways of interaction and also makesteaching –learning process more interesting.
- It provides equal opportunities to the large number of learners to obtain education andinformation.
- It provides specialized tools for learners with visual, hearing or mental impairment, so thatthey learn and acquire knowledge at their own pace.
- It provides support to each and every school in sharing educational / learning experienceswith the different schools throughout the country.
- It enables the distance education system to be more effective.
- It helps in promoting technology literacy to every citizen and especially to young stars.
- It provides opportunities for lifelong educations.
- It enhances the teacher's quality both in terms of teaching and research.

Benefits of ICT in Teaching Learning process:

- ICT can make the teaching learning process more interactive and effective.
- It helps in motivating the students towards their lesson.
- Learners can learn and work at their own pace just with little guidance from the teachers.
- ICT enables the learners to interact with the teachers, peers and experts on various issuesoutside the classroom.

- Learners can get various information very quickly.
- ICT also helps the teachers to evaluate the learner's progress and proficiency in certain skills.
- It can also remove the monotonousness of traditional classroom system.
- Encourages contact between students and faculty through social networking tools, blogs,wikis, text message etc, especially those students who are shy and unable to speak out inface-to- face classroom settings.

Thus, proper use of information and communication technology canshift the role of a teacher from providing information passivelyto creating and generating learning environment for individual studentas per her requirement and learning style. This can help a studentto construct her own knowledge. Students can conceptualise thesituation and arrive at the solution of a problem. However, learning isdefinitely affected by the learning environment and context, attitudeand self motivation of the learner. Therefore, it is important that the teacher provides learning experiences through developed materials,reviewed sites, reviewed web pages, and facilitate interaction with herpeer groups.

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Unit - 5

Organizing Science Related Activities

Syllabus : Science libraries, science Museum, science club, science hobbies, field trips / excursions, science Fairs/exhibitions, Science corner.

Science Library

A library is the heart of schools' academic activities. The quality, growth, manners, human values, culture are greatly influenced by libraries. The teaching and learning process will certainly be lacking luster without a good library. It is indispensable for student centered teaching and learning process.

Science library is the primary requisite of every school it is an integral part of teaching and learning process It is the place where students sit and do the independent work and where the students go in for further study in the subject. It serves as an instrument for developing skills and aptitudes among the pupils.

Science library develop scientific attitudes among students. It develops the teachers to extend their scientific knowledge and in putting progressive method of teaching science.

Values and uses of science library

1. ScienceLibraries are important indicators of growth and development.

2. They provide scientific services, fulfill social needs, and help individuals flourish.

3. Provides access to more sources of print and digital materials to support reading and inquiry learning.

4. It facilitates the work of classroom teacher and helps each student to make them understand and gives a lot of opportunities to access the resource of desired information.

5. Create and develop motivating, flexible, physical and digital learning spaces.

6. It equips students with the skills which is necessary to succeed in a frequently changing science and technological, social and economic environment.

7. It provides and promotes quality fictions to develop the students' habits and enjoyment in reading and enrich their intellectual, aesthetic, cultural and emotional growth.

8. The libraries support the teachers in access to relevant curriculum, to make a cooperative plan, implement and evaluate various kind of learning programme.

9. It develops an interest in the subject and wider the horizon of students.

10. Library provides requisite supplementary material and extra reading to the students to understand the subject and get the required information.

11. It also helps in developing students' vocabulary; enhance comprehensions, developing the habit of silent reading and problem-solving attitude of the students.

Science museum

A science museum is a museum devoted primarily to science. It is intended to concentrate on static displays of objects related to natural history, paleontology, geology, industry and industrial machinery, Science museums teach critical thinking, empathy, and other generally important skills and dispositions. It expands the general world knowledge of students.

Many science museums offer arrange of professional development courses and works hops designed to strengthen teacher expertise and integrate hands-on science activities into the classroom.

Science museums often collaborate to develop education materials and public outreach for their visitors. These materials are often available with the goal of increasing science literacy across the full spectrum of education, both in the classroom and in daily life, Many museums offer materials which provide a focused course of exploration during your museum fieldtrip.

The mission of museums today is to stimulate curiosity, creativity and learning through fun, interactive exhibits and programs for children, families and school groups.

Popular science museum in India

1. Birla Industrial &Technological Museum, Kolkata
2. Birla Science Museum, Hyderabad
3. Gujarat Science City, Ahmedabad
4. Birla Planetarium, Chennai
5. Hakim Karam Hussain Museum on History of Medicine and Sciences
6. Kerala Science and Technology Museum, Thiruvananthapuram
7. National Council of Science Museums (NCSM)

8. National Science Centre, Delhi

9. Nehru Museum of Science and Technology, Kharagpur

10.Nehru Science Centre, Mumbai

11. Regional Science Centre,Bhopal

12. Science City Kolkata, Kolkata

13. Science Park, Jaipur

14. Sri Krishna Science Centre, Patna

15. Visvesvaraya Industrial and Technological Museum, Bangalore

Science Club

Science club as an organization, which helps in the development of scientific attitude, and develops genuine interest in science and scientific activities.

The Science Club aims to promote science interest and engagement through challenging and mind-stretching tasks. Members will be exposed to a variety of problem solving tasks that involved forensic science.

Science Club bridge in-school and out-of-school learning and foster the development of skills, such as experimentation, critical thinking, and problem solving. By giving a supportive environment to explore science, we are also building more confident learners and educators.

Aims and Objectives of a Science club

- To provide proper incentive and inspiration for the pursuit of scientific knowledge in rigorous way by broadening their scientific outlook.
- To make the students understand the values of time and to help them in the proper utilization to their hours.
- To provide opportunities for bringing school close to the society and to acquaint the people with the services and contribution of the science in their life.
- To develop among the student the spirit and attitude of healthy competition for the individual and social cause.
- To help the students in imbibing the habit of self-reliance, self-dependence and love for manual work.

- To inculcate scientific attitude.
- To provide opportunity for the development of the constructive, explorative and inventive faculties of the students.
- To develop training in scientific method of problem solving
- To develop students, inters and participation in the practical application of the knowledge related to different branches of science.
- To grate interest in scientific facts and events related to one's surroundings.
- To develop interest in scientific hobbies.
- To encourage individual and group activities.
- To stimulate active participation and initiative among students in the learning process.
- To develop the creativity and encourage the habit of exploration.
- To widen the outlook of students, apply the knowledge in life situations.
- To provide opportunity for the development of the constructive, explorative and inventive faculties of the students.
- To create interest in latest inventions and discoveries of science in various fields and to get acquainted with the life history and contributions of great scientists.
- To develop students, interest and participation in the practical application of the knowledge related to different branches of sciences.

Organization of Science Club

A properly organized science club will be a valuable aid to teaching science and also a means of motivating the children for learning science. The successful working of the club depends on the persons who organize it and also on the interest and enthusiasm of students. Though science club is run by the students for the students, the science teacher is the pivot of all activities.

To begin with, the science teacher can explain the importance and benefits of organizing science club and can arouse enthusiasm among students. Every science club should have its own constitution. They should be a general body and an executive body.

Suggested Science Club Activities

- ❖ Publishing school science magazine.
- ❖ Preparing science albums, Preparing still and Working models on science topics.
- ❖ Maintaining a bulletin board for displaying science news.

- Conducting essay competition on scientific problems.
- Arranging science discussions, debate, essay writing, Conducting workshops Conducting science quiz competitions, etc.
- Arranging the science excursions and field visits.
- Arranging science exhibitions, Film shows and science fairs.
- Organizing lectures, debates, seminars, symposia etc.
- Organising much bigger projects such as regional science expo's and other interesting inter-school events.
- Organizing and prizing students for solving science problems
- Offering Incentives to facilitate and encourage learners to research topics that they find interesting.
- Conducting visual programmes of scientific interest
- Improvising and preparing hand-made apparatus.
- Preparation of soaps, ink, candle, matches, toys, bleaching powder, nail polish, chalk etc.
- Helping the community by way of demonstration on health and hygiene, improvement of agriculture, eradication of superstitious belief etc.
- Celebrating science days. Celebrating birthdays of eminent scientist

Scientific Hobbies

Scientific hobbies represent those activities that suit the basic interests and aptitudes of the students. Students never take them as a work but enjoy them like play.

Merits of Scientific Hobbies

1. Financially useful

Scientific hobbies although initially adopted as a source of self-enjoyment and means for the utilization of leisure hours may prove quite advantageous from the financial point of view. Students may get opportunity to earn while getting the school education.

Many useful hobbies like gardening, repair of scientific articles, etc. may also prove a money saving device in one's domestic life. In this way, scientific hobbies may be seen to possess very rich financial potentiality.

2. An aid for joyful learning

Scientific hobbies make the study to science a joyful event besides providing opportunity to learn the facts and principles of science in a quite natural and applied way. Similarly, the preparation of charts models and improvised apparatus may help the students of learn about all the related facts, principles and concept of science.

3. Meeting the psychological needs

Scientific hobbies prove a good media and source for the satisfaction of the students.

4. Good use of leisure time

Students should not waste their time in useless pursuits but engage themselves in constructive and educational and at the same time entertaining pursuits. These hobbies provide a good means for the utilization of their leisure hours not only during the school or college life but throughout one's life.

Suggested scientific hobbies for Schools

- Maintaining aquarium, vivarium and science museum.
- Participating in science fair and exhibitions.
- Repair and maintenance of common house hold articles and gadgets involving scientific knowledge and skills.
- Listening to Radiobroadcast and watching programme on T.V. and Video related to scientific interests.
- Photography, printing and developing of the negatives.
- Providing first aid to the injured and getting acquainted with ordinary medicines of everyday use.
- Preparing articles of daily use such as soaps, toothpowder, inks, polish, varnish etc.
- Preparation of charts, pictures and models related to scientific knowledge.
- Assembling and devising scientific toy.
- Sketching, painting and making diagrams of objects and places of scientific important Field Trip

When organised from the point of view of enrichment of teaching-learning experiences, it is a field visit. This makes learning realistic, concrete and interesting. Learners get opportunity to discover the concept and their connection with their environment. They can use this opportunity to learn various skills in interacting with the physical world, materials, technology and other people. It helps students to

create knowledge by figuring out the components of objects, events, people, and concept. Let us now see the various advantages of field visits in teaching-learning of science.

Advantages of the field visits

The field visit:

- Helps in providing first-hand experience to the students which is not possible within the four walls of the classroom;
- enriches general knowledge of students. It supplements the classroom learning;
- helps in broadening the outlook, deepens insight and widens vision of students; gives the students new ideas and vision for taking up projects;
- helps to deepen understanding of the concepts and brings clarity in the subject. It also helps in concretising the abstract ideas;
- helps the students develop an inquiry attitude towards the environment;
- develops skills in science processes like observation, collection, classification and analysis of data;
- brings the awareness that science is all around us and not just in books;
- relates the community to the learners, teachers and school and encourages sharing of responsibility of child's learning with the community;
- Acknowledges the authenticity of community knowledge, etc.

Organisation of the field visits

Planning: The entire planning can be done by students under the guidance of a teacher.

First a guide sheet can be prepared. It should have learning details, physical details and administrative details.

Learning details*:* Consist of sites to be visited, data to be collected, list of questions to be asked to the persons working at the site and any process which is to be studied, etc.

Physical details*:* Route to be taken, time schedule, personal equipments, provisions for refreshments, meals, first aid box, materials to be carried such as umbrella, camera, etc.

Administrative details*:* Teacher needs to give details, purpose and outcome of the trip for getting permission from the administration of the school for the field trip.

The checklist of a planned field trip can be

- objective of the field trip;
- date of the field trip;
- time of departure;
- date and time of return;
- name of the supervisors accompanying students;
- rules of conduct for students;
- materials students need to bring for the trip, such as water bottle, umbrella, field diary, etc;
- cost for the trip; and
- Permission from parents.

Transport facility should be also planned in advance. Prior to students field visit, the place to be visited should be seen by the teacher and a student representative. They should find out, whether learning objectives would be achieved or not. The main aim of the visit should be providing learning experiences; pleasure should be the secondary aim. The objective of the visit should be clear to all learners in order to optimise learning.

Teacher should plan follow-up activities in order to make learning experience, a fruitful one. After coming back from the field visit students can discuss their observations and experiences, ask questions and share photographs. Teacher needs to encourage students to submit the report and mention explicitly what they learned from the visit. Evaluation of the field visit can be done in the light of the planned objectives.

Science Fair/Exihibition

A science fair is a competitive event, hosted by schools worldwide. Students present their science project results in the form of a report, display board and models that they have created. Science fairs allow students in elementary, middle and high schools to complete in science and technology activities.

Merits of Science Fairs / Exhibitions.

Learning tool- A science exhibition is a wonderful tool that engages students in learning new facts and inventions with a zeal of interest.

Platform of togetherness- An exhibition is a platform for the students to work together In groups.

Learn to respect- This gives the opportunity for the students to develop social and moral skills. Students apart from the scientific knowledge learn to respect each other's views and thoughts, sharing

experiences, cooperating with each other, managerial skills, skills of leadership, helping and caring about the feelings of fellow members.

Learn to speak- When the presentation is ready, during the exhibition the students learn publics peaking and it helps the students remove the fear of speaking in public.

Boost confidence – This kind of science exhibition boosts the confidence of the students and develops their interest and curiosity even further.

Reveals reality – Science always reveals a new truth, a new discovery, an unknown reality.

Explore creativity – Science exhibitions explore the creative talent of the students and force them to think outside of the box.

Develops curiosity – Science exhibitions develop a scientific spirit and curiosity in a student which in turn forces them to think and creatively find solutions to the challenges.

Joyful learning – Students enjoy learning through such exhibitions and feel a sense of belongingness as they make the models with their own hands.

Develops scientific attitude – Student develops a scientific attitude towards his problems and challenges of life. The student develops an inquisitive nature and learns to ask questions.

Life learning – The student does not feel scared and fearful of any challenge of life and treats it with patience, knowledge and learning from these science exhibitions at school.

Practical learning – The students apply their classroom and bookish knowledge in these exhibitions and develop taste for learning by doing. Students avail the opportunity of practical learning and experiencing everything first hand during these exhibitions.

Enables independent research – Science fair is an opportunity for students to apply the scientific method to conduct in dependent research. The results of each student's research studies are awarded prizes and are advanced to compete in regional, state, national and international science fairs.

Science Corner

The development of science corner becomes even more important in schools situated in areas of resource crunch where setting up of full science laboratories is difficult. For this, one or two tables can be arranged in the classroom. Children should be encouraged to bring materials they think are relevant for discussions and display. These materials can be used to provide them hands-on experience.

Also these materials should be continuously updated and changed as per the learning needs, interest and curiosity of children.

Benefits of science corner

1. Providing a special interest area or science learning corner in schools program can offer many hands- on opportunities and activities that will fascinate and teach curious children.

2. School children are like little scientists and they are curious about the world around them

3. Science corner delve deep into the scientific method or theory and present an interesting exposure of the scientific world to beginners seeing it all for the first time.

4. Students just playing around with the amazing concepts that around in our natural world, Concepts like colour, nature, weather, water, magnets etc.

5. Students build the foundation for a deeper understanding of science in the world as they grow and mature.

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Unit - 6
Laboratory as a Learning Resource

Syllabus: Objectives of laboratory work – Planning laboratory work – Approaches to laboratory work – Working plan for group of students (Batch) in the laboratory –Motivating students to maintain the regular record of laboratory work – Safety in laboratories and precautionary measures.

Science Laboratory

Laboratory work can be used as a powerful learning resource of science. **Laboratory work is based on the principle of learning by doing and it is an integral part of science education.** It helps in better understanding of various concepts of science and construction of knowledge. The first-hand experience obtained through experimental work imprints a permanent impression on the mind of the learners. It provides opportunity to the teacher to inculcate various process skills of science, viz. observation, classification, analysis of data, recording, inferring, generalising and communicating. Process skills so acquired help in developing interests, values, and spirit of inquiry that constitute scientific attitude. Students learn while handling, manipulating and innovating different types of equipments.

It provides an environment to learners for exhibiting their qualities such as resourcefulness, initiativeness, orderliness, cooperation, and team spirit. Students enjoy working together with their peers with some freedom of action, having a feel of the excitement of the unknown and achieving a sense of discovery. Of course, learners cannot rediscover all of science; however, encouraging them to observe, investigate and think critically on a laboratory activity can facilitate them to construct some abstract concepts and principles of science, to awaken curiosity about the world around them and to gain a feel and appreciation of science.

Objectives of Laboratory work

- To help the students in better understanding of various concepts of science and construction of knowledge.
- To provide first-hand experience through experimental work imprints a permanent impression on the mind of the learners.
- To provide opportunity to the teacher to inculcate various process skills of science, viz. observation, classification, analysis of data, recording, inferring, generalizing and communicating.

- Students to acquire process skills to help in developing interests, values, and spirit of inquiry that constitute scientific attitude.
- Encouraging students to learn while handling, manipulating and innovating different types of equipments.
- Providing an environment to learners for exhibiting their qualities such as resourcefulness, imitativeness, orderliness, cooperation, and team spirit. Students to enjoy working together with their peers with some freedom of action, having a feel of the excitement of the unknown and achieving a sense of discovery.
- Encouraging students to observe, investigate and think critically on a laboratory activity can facilitate them to construct some abstract concepts and principles of science
- To awaken curiosity about the world around them and to gain a feel and appreciation of science.
- Thus, laboratory work facilitates development of cognitive abilities, process skills of science, scientific attitude; and understanding nature of science.
- Opportunities to raise question, involving the learners in critical discussion, investigating their own questions and being flexible in the work should be facilitated in the laboratory.

Thus, laboratory work facilitates development of (i) cognitive abilities, i.e. principles and laws discussed in the classroom may precede or follow the laboratory work or it may be carried out during discussion; (ii) process skills of science; (iii) scientific attitude; and (iv) understanding nature of science. Use of laboratory must be focused towards achieving these objectives.

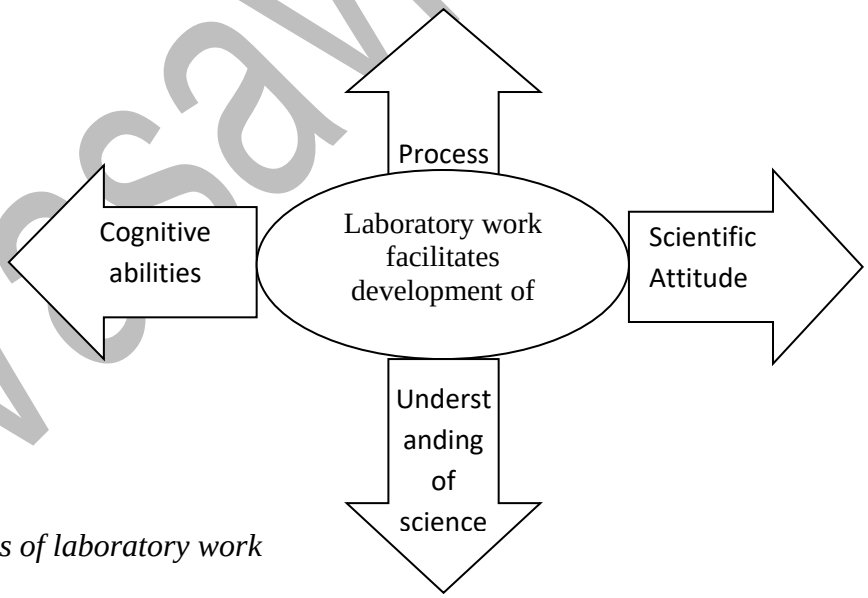

Fig. *Objectives of laboratory work*

Kind of experience that is provided by the laboratory cannot be replaced by any other exercise. **Well-planned laboratory experiences have great potential to attract our young generation into science courses.**

Performing experiments in prescribed fashion and just involving students in hands-on activities do not result in development of inquiry skills in science. Development of inquiry skills cannot be taken for granted as the by-product of the process skills of science. Opportunities to raise question, involving the learners in critical discussion, investigating their own questions and being flexible in the work should be facilitated in the laboratory. Inquiry can be broadly planned considering limited availability of time and crowded classrooms. It is to be kept in mind that emphasis should be given to the first five letters of **LABORATORY** rather than the last seven letters.

Merits of Laboratory

- The student performs the experiment and on the basis of experiment, he attains practical knowledge from theoretical knowledge.
- The students develop self discipline and self confidence.
- The students learn from his experiences. He develops the power of thinking, observation and decision making.
- The students understand the topic clearly and easily
- Favourable atmosphere is created for science teaching
- Working collectively, they develop the spirit of sociability.
- In the laboratory all apparatus and material is available for the experiment, thus the time is not wasted in doing the practical and the breakage of apparatus is minimum.

Planning and organising laboratory work

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

- Is the objective of activity/experiment/project work clear to the students? How will I facilitate them to perform the experiment?
- Are materials/apparatus available in the laboratory?
- How will I involve learners in setting up the experiments?

- Have I performed the experiment myself to check the functionality of all apparatus?
- Is the procedure simple and can be performed within the allotted time period?
- How will applications of their findings enhance their learning?
- How will I integrate the laboratory experiments with classroom teaching-learning experiences?

The learning experiences in the laboratory should provide some challenge to the students to learn. They get interested if they understand the purpose of the experiment and are made to realise the application of it to their everyday life.

Students can be involved in planning and organising various works of laboratory. Following guidelines for planning and organizing experiments in physical science may be considered.

- It should be ensured that students have a sound theoretical knowledge required for handling the apparatus and performing the experimental work. For this, theory and practical teaching learning Situations should be properly integrated and coordinated.
- Students should come prepared for the laboratory work. They should be encouraged to refer laboratory manual and other supplementary materials. They should be facilitated to find answers to their own questions.
- Enough apparatus should be set up to provide opportunity to all learners on hands-on activities. It should be checked that the apparatus are in proper working condition.
- **During the laboratory work, extensive and critical discussion on the theoretical aspects of the experiments with the students and continuous assessment of their performance are of utmost importance.** This helps the teacher to know their misconceptions and naive concepts and she can then facilitate them in the construction and reconstruction of their knowledge.
- A notice board to display safety rules of the laboratory, time- table, list of experiments, group patterns, etc. can be maintained and kept up to date.
- Good discipline is necessary for smooth functioning of the laboratory work.
- Maintaining all possible standards of safety in the laboratory and inculcating safety conscious attitude in students are important.
- Safety kits such as fire extinguishers, sand bucket, rubber gloves, separate dustbins for dry and wet waste materials, etc. should be kept handy.
- First-aid box must be kept ready and timely replenishment of medicines must be ensured.

- **Remember that safety of the students and teachers is more important than the safety of the apparatus.**

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

Approaches to laboratory work

Deductive approach: It is perhaps the most common approach and used for the verification of concepts, laws and principles of science. The theoretical aspect of the concept is first discussed (e.g. Ohm's law, Archimedes principle) and it is followed by firsthand experience. Students can get time to organise their abstract ideas (using mathematics, wherever required) and can acquire meaning of the concepts and find relevance of the laboratory work with their previous understanding.

Inductive approach: Students are provided opportunity to develop concepts, principles and laws through first-hand experience before these ideas are discussed in the class. Students search for patterns, relationship between different quantities and applications of the concepts while engaged in the laboratory work. Their ideas are reinforced during discussion after the laboratory work. This work is immediately followed by discussion for strengthening of their understanding.

Problem solving approach: Learners can be provided opportunities to do open-ended activities and experiments of exploratory nature where they have freedom to explore their ideas. By the time students reach higher secondary stage, they acquire basic technical and inquiry skills. They should be encouraged to identify their own problem, develop hypothesis, design investigation and experiment to solve the problem, collect and organise the data and report their findings. It gives them opportunity to become independent learners, organise their own learning and develop self-confidence. For example, a group of students are interested in knowing, *do oils of higher density have larger value of refractive index?* or *what factors may be responsible for variation of the result in Ohm's law experiments and to what extent?* They should be encouraged to work on their problem. **It is important to mention here that it is not central to reach a concluding result, getting students engaged in the process of inquiry is more important.**

Working plan for group of students (Batch) in the Laboratory

Students can be grouped into different ways depending upon the equipments available in the laboratory.

Working Plan for a batch with single group

All the students may work on the same equipment at the same time the arrangement is convenient for the teacher, as general guidelines to the entire class can be given at a time, but it is feasible only if strength of the class is less.

Working Plan for a batch with four groups

If the number of students is more, the teacher may facilitate the class to form 4 to 6 groups. Each group may be allotted different experiment in a cyclic manner.

Students in each group may perform the experiment either individually or in pairs ,i.e. two or more pairs of students may work on the same experiments separately.

After performing experiment number 1, group I shifts to experiment 2, group II shifts to experiment number 3 and soon. In this type of arrangement, teacher as to give different types of guidelines to each group separately. Supervision of the various experiments being carried out in the laboratory needs to be done simultaneously.

Teacher can maintain a record of date of allotment of experiment to each student and date of its completion for her reference and follow up action.

Motivating students to maintain the regular record of laboratory work

- Students should be instructed to maintain and bring the following in the laboratory:

(i) Auxiliary record book in which preliminary work for the experiments such as drawing ray diagram/circuit diagram, observation table, writing chemical reaction, etc. is done. Observation of the experiment performed should be recorded in it. Students should be encouraged to record observations and interpretation of the result in their own way/words.

(ii) Laboratory notebook for keeping the systematic and methodical records of the experiments.

- Students should keep in mind that proper plan for recording the observation should be made. Whenever possible, observations should be represented with the help of diagrams and graphs.
- Teacher should ensure that observations are recorded in the auxiliary notebook in the laboratory itself.
- Students should be encouraged to learn to distinguish inferences from their observations. Also, they should have understanding of the relevant concepts, principle and theory to interpret the result.

- ❖ After getting checked the observations, calculation and result in the auxiliary notebook by their science teacher, students should make a final record in the laboratory notebook of the experiment performed. Index table should be duly filled up. Regularity in the submission of laboratory record book should be ensured.
- ❖ A few words of appreciation can encourage students to maintain regularity.
- ❖ Learning Indicators (LI) for various experiments can be identified involving the students and the tasks specific to the experiment should be assessed during each experiment. Oral test should also be conducted during each experiment, and grade can be given.

Safety in laboratories

One of the important duties of science teacher is to develop safety conscious attitudes and safe personal habits in students.

- Students need to learn about safety in the laboratory by being instructed about the hazards rather than by experiencing them.
- They should be given explanation of the laboratory safety rules with reasoning.
- They should be warned of any specific hazard when it is likely to arise.
- The layout of the laboratory should be such that teacher is able to oversee the activities of all the students in the class.
- The location of water, gas, electricity main control, and firefighting equipment should be at the proper and convenient place.
- She should have rapid access to the site if any incident occurs. Above all, teacher should avoid getting stuck at a place.
- She should move around the classroom to offer suggestions to those who are confused as how to use an equipment.
- All reasonable precautions in the performance of laboratory work should be taken.
- Lesson should be planned in such a way that all the hazards are minimised. Some common potential hazards in physics and chemistry laboratories are discussed below:

(i) Mechanical and glassware hazards

All equipments with moving parts constitute a hazard if they are misused or fail to operate properly. Wherever possible, moving part of the apparatus should be guarded properly.

Some precautionary measures

- Students should be instructed to stay away from the heavy slotted weights hanging from the apparatus, such as sonometer.
- Large glass containers must be handled by the neck. Proper care should be taken in storing the apparatus.
- Reagents likely to react vigorously with each other should be kept as far apart as possible. Liquids placed in spherical containers can act as a lens, focusing enough sunlight to cause a fire. They should be kept in dark.
- Broken glass pieces can be cleaned with the aid of some plasticine.
- Glass tubing should be cut with a file or glass knife, the hands being protected by a cloth. It should be carried vertically.
- Wherever possible, glass materials may be replaced by a less hazardous alternative, e.g. plastic bowls and measuring cylinders.
- Glass stoppers which have become jammed should be loosened by tapping gently with a wooden block wrapped in a soft cloth or if the bottle contents are appropriate, by running warm water over the neck of the bottle.
- Experiments involving the heating of solutions should be done in pyrex glassware, not in ordinary glassware.

(ii) Electrical hazards

The obvious danger in using electrical equipment is that of electric shock and fire hazards. The electrical resistance of the body varies enormously from one individual to another and within the same person under different conditions. The resistance is very low if the skin is moist. A current of 100 mA through the body can be fatal. A higher current can also produce burning.

Some precautionary measures

- The electric power supply or the electrical outlet in the physics laboratory should be sufficient in number, properly insulated, in excellent working order, properly grounded, and inspected routinely by qualified electricians.
- Wherever electrical outlets are not available, extension cords that are as short as possible and insulated properly for that particular voltage and current should be used.
- Equipment should carry a distinctive on/off light.
- The range of the measuring instruments should be properly marked and the students should understand the meaning of the range properly.

- Wearing metal rings, necklaces, using metallic prongs, pencils, rulers, etc. should be avoided while working with switched-on electrical equipment and apparatus.
- Service of electrical appliances, devices and apparatus should always be done by qualified experts.
- Hands and bench should be kept dried and long trailing leads and makeshift connections should be avoided in the experiments.

(iii) Toxical hazards

It would be better to treat all chemicals as though they were poisonous, as range of toxic substances is greater than those declared officially.

Some precautionary measures

- ❖ All the chemicals should be adequately labeled.
- ❖ Careful supervision is required in the use of caustic and corrosive substances.
- ❖ Ingestion of chemicals is most likely to arise from pipetting by mouth. Vigil should be kept on the students.
- ❖ Gases, vapours, fine spray and fumes of toxic materials may enter in the body by inhalation. Therefore, it is of utmost importance to use right techniques of performing the experiment and having provision of cross ventilation in the laboratory.
- ❖ Special care must be taken in some of the experiments, such as benzene should be replaced by methylbenzene, wherever possible; chlorine gas should not be prepared in large quantities on an open bench.
- ❖ Children are inquisitive by nature. It should be ensured that they do not touch or smell the toxic substances. They should be made aware of the harmful effect of those materials.

What if ...

In spite of taking all the precautions and minimising the risks, what to do if accident occurs? The most important consideration is to act quickly, quietly and methodically without being panic stricken.

It will be too late to think about procedure after an accident has happened. Keep the first aid box handy. A list of common accidents and their remedies approved by a good doctor should be hung on one side of the first aid cupboard, so that the right medicine can be applied in case of certain accident.

However, the purpose of first aid is not to substitute doctor's treatment, but to ensure that no further deterioration occurs. Following steps should be taken:

- Remove the injured person(s) from further hazard. This might be disconnecting electrical supply, gas or water or removing from fire, etc. Apply first aid immediately.
- If necessary, seek the help of your colleague to control the class.
- Inform the school office of the accident for making arrangement of medical care.
- After the accident, submit a written report to administration stating the facts.
- Some other actions may be necessary to take, such as calling a fire brigade, evacuating the class into open air, etc.

Lastly it should be remembered that **prevention is better than cure**.

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Unit - 7

Organization and Maintenance of Physical Science Laboratory

Syllabus : Structure and design of general, chemistry and physics laboratory– Storage of chemicals and apparatus – preparation of indent – maintenance of registers – accidents and first aids – Improvisation of apparatus – science kits and advantages.

Science Laboratory

"A laboratory is a room, or building or a special period of time equipped and set a part for practical or experimental studies to take place".

Every classroom is important, but special attention should be given to the design of school science laboratories. If safety recommendations aren't adhered to then they can become unsafe.

Physics laboratory

Essential facilities of a physics laboratory include adequate number of electrical outlets, dark room facility for optics experiments, and adequate storage space for all types of apparatus and equipment, space for carrying out project work, sufficient light and proper ventilation.

A physics laboratory can be used as a learning resource in various ways, such as verification of results of earlier experiment; development of concepts, principles and laws discussed in the classroom— may be during the discussion or preceded or followed by the discussion; problem solving, project work, etc.

A physics laboratory needs to be looked after to cater to all such needs. Most of the times we have been using physics laboratory in the context of verification of certain results prescribed as part of physics practical syllabus. In the previous chapters we have understood about the importance of inquiry and investigations in teaching-learning of science. Laboratory resources need to be used effectively for these purposes also.

In many schools, student and teacher ratio is so high that sometimes it is not feasible for the teachers to organize experimental activities involving students in individual practical work. In such situations group work should be encouraged. Teachers should be adequately trained in carrying out laboratory work and the skills required for working in physics laboratory**.**

Skills essential for working in the physics laboratory

Some of the essential skills for working in the physics laboratory are:

- taking measurements using various instruments such as vernier calipers, screw gauge, travelling microscope, etc.;
- connecting electrical devices; soldering of electrical connections; using electric meters;
- working with images in mirrors and lenses and taking required measurements; using watches and clocks;
- measuring weight with different types of balance;
- Locating magnetic poles in permanent magnets; constructing temporary magnets; using cells and batteries; and plotting and interpreting graphs.

Teachers should acquire proficiency in such skills and facilitate learners to learn many such skills.

Teachers should have understanding of calculation of different types of error occurring during the course of experiment and their correction. These may be identified and taken care of as personal or chance error, error due to external cause, such as room temperature, pressure, etc. or instrumental error of the apparatus.

(i) Assess yourself from the point of view of various skills required for maintaining and using a physics laboratory as learning resource. What skills do you have and what other skills do you need to learn?

(ii) Perform related activities/experiment in the laboratory of your college or nearby school to acquire those skills. You may take help of your classmates and the teacher-educator to achieve proficiency in those skills. Present your report in the class.

Apparatus:

Apparatus should be arranged in proper order in the laboratory. To avoid any damage, all apparatus should be handled carefully and cautiously. Most of the appliances, apparatus, devices, instruments and materials used in the laboratory come with some guidelines on how, when and why to use them with proper instructions of handling and care.

These guidelines may be very helpful in designing the experiences for the learners and should be consulted even if the teacher is sure that she knows everything related to the work to be done in the laboratory. Precautions suggested while using a particular apparatus should be observed strictly. Teacher must be well versed in setting up various experiments.

A **pre-laboratory session** can be a good idea in developing a framework for working in a physics laboratory. This prepares learners for the activity and issues related to safety of apparatus to be used and their own safety also.

A pre-laboratory session can be helpful in making the context of the concept and the approach (inductive, deductive or problem solving) to be followed. For example, following problem solving approach in the case of Ohm's law, discussion can be carried out on the issues of various conceptual clarity on Ohm's law, apparatus and arrangement needed in the investigation, availability and ways of using of those apparatus and arrangement, need for improvisation, if any, etc.

Just like pre-laboratory discussion, **post laboratory session** may be helpful in enhancing the learners' understanding of content and processes in physics, identification of learners' misconceptions and naive concepts, difficulties faced by them and whether they were successful in their pursuit, how did they arrive at their conclusions and results, how did they make interpretations of the result, etc. We have Such post-laboratory discussion might be helpful in exploring learners also. Students should provide reasoning for observing various precautions rather than following them mechanically.

The above cited guidelines for working in a physics laboratory are not exhaustive in nature. Depending upon the framework in which physics laboratory is being utilised as a learning resource, issues like nature of the resources needed, number of learners working simultaneously, etc. may arise.

Chemistry laboratory

A chemistry laboratory should have suitable and safe storage of chemicals, adequate supply of water and gas, proper drainage system and proper working tables with waterproof and acid proof tops for performing experiments using various equipments and apparatus. There should be provision of reagent racks, fume cupboard and good ventilation having exhaust fans in the laboratory.

We will discuss how to manage a chemistry laboratory and handle chemicals, apparatus, heating devices apart from working space for conducting experiments and activities.

(a) Chemical:

A large number of chemicals are made available in a chemistry laboratory for doing experiments. These chemicals are available as solids, liquids or their solutions. Whatever chemicals are required for a particular experiment, these should be made ready one day before the day of experiment to be performed by the students.

Teacher must also see that the chemicals are in sufficient amount. Let us take the example of an experiment in which concentration (strength) of a given sodium hydroxide solution is to be determined by titrating it against a standard solution of oxalic acid.

The chemicals required are oxalic acid, sodium hydroxide and phenolphthalein. All the three chemicals are used in the experiment as solutions. Therefore, teacher must know how the solutions of these chemicals are prepared, what should be the normality or strength of these solutions, how much chemical is required to prepare a solution for a particular group of students. At the same time, teacher should also know— how to store the solutions, how to distribute these solutions amongst students at the time of practical class and what to do with leftover solution.

(b) Apparatus:

The apparatus required for the experiments include burette, pipette, conical flask, burette stand, funnel, measuring flask and a white glazed tile. The glass apparatus must be neat and clean.

Teacher must see to it that the required apparatus is available in the laboratory for the group of students. She must know how to instruct students to clean and dry glass apparatus before using them. The setting of apparatus is another important part of every experiment.

This particular experiment of titration involves:

- clamping of the burette vertically in a burette stand;
- filling of sodium hydroxide solution into the burette and removal of air gap (if any) from the nozzle of the burette;
- Observing the initial reading of the burette. It may be zero or it may be some other reading suitable for the students;
- Observing readings of the burette which is very important. Student's eye should be exactly at the same level as the meniscus of the solution.
- filling of pipette with standard oxalic acid solution and then transferring this solution to the conical flask;
- Adding phenolphthalein to the conical flask before starting the titration. It is used as an indicator and the knowledge about the quantity to be added must be known to the teacher. In this case, 2-3 drops are sufficient; and
- Observing end point which is quite important in such type of experiments. In this case after adding sodium hydroxide solution slowly in the oxalic acid solution of flask, a faint permanent pink colour is obtained.

All these steps of the experiment involve proper use and handling of the apparatus with which the teacher must be thoroughly acquainted.

(c) Heating devices:

In a chemistry laboratory, heating of substances/ solutions is required during a number of experiments, especially during the chemical analysis of salts and their mixtures for detecting cations and anions present in them. Heating increases the speed of a chemical reaction.

The heating devices available may be gas burner (usually Bunsen burner), spirit lamp or kerosene lamp. Teacher must know every detail about these heating devices. She must know how to adjust the air flow of a Bunsen burner to get a non-luminous (blue coloured and non-smoky) flame.

If the flow of air is not properly adjusted or the air vent of the burner is closed, it will give a yellow coloured smoky flame. Such a flame is not suitable for proper heating and will make the test tube, flask or beaker to be heated black.

Sometimes the flame starts to strike back and burn at the nozzle near the base. This makes the burner very hot. It happens due to fully opened air vent. In such a situation, put off the burner, cool it and then ignite it again and adjust the air vent to get a proper non-luminous flame.

In using various heating devices, it is equally important to know how to put off a flame. A lighted heating device should not be put off by blowing at the flame. In case of Bunsen burner the supply of gas is turned off, in case of a spirit lamp, burning wick is covered with the help of a metallic cover and in case of kerosene lamp the outer sleeve is covered by a metallic or asbestos sheet.

(d) Glass tube and glass rods:

Both glass tubes and glass rods are used in chemistry experiments. The glass rods are used for mixing, stirring and transferring of chemicals and their solutions. The glass tubes are used in passing gas into solutions. Many times, we need to cut glass rods and glass tubes to obtain their desired length.

The glass tubes are bent also by heating them to get a desired shape. Thus, a teacher must be familiar with the technique of cutting and bending of glass rods and tubes and then rounding/smoothing the freshly cut edges.

(e) Weighing balance:

In a number of experiments in chemistry, approximate or accurate weights of substances are required. For weighing substances, different kinds of physical and chemical balances are used. Now-a-days digital balances are also in use. Chemical balances give exact weight of substances.

Generally the analytical balance used in a chemical laboratory may give exact weight up to fourth decimal place. A teacher must know all details of using and maintaining these balances. Some of the important precautions in using the balances are given here.

- Every balance has a capacity of weight. Therefore avoid overloading balance while weighing.
- Never weigh a hot substance.
- Keep the pans of the balance neat and clean.
- Check the balance before weighing any object. Make necessary adjustment, if required.
- Observe the reading of weight very carefully before noting it down.

(f) Setting of apparatus for various experiments:

Various types of apparatus are used in different chemical experiments. Teacher must be well-versed in setting up of the apparatus.

(g) Solutions:

In chemistry laboratory many chemicals are used in the form of solutions. In experiments related to titrimetric analysis a variety of solutions are used. These are termed as standard solutions, molar solutions, normal solutions, etc. The teacher must know how to prepare these solutions.

Methods of preparing these solutions are given in details in the laboratory manuals. One must also be very clear about the primary and secondary standards. It is also important to know how to prepare solutions of indicators like phenolphthalein, methyl orange, etc. for the acid base titrations and other experiments of titrimetric analysis.

(h) Use of Kipp's apparatus:

Qualitative analysis is done to find out nature of substances and to identify their constituents. For example, in the qualitative analysis of inorganic salt or mixture of salts the cations (such as Cu2+, Ca2+, Mg2+, etc.) and anions (such as Co3 2-, Cl-, So4 2-, etc.) are identified.

In the analysis of certain cations H_2S gas is passed in their solutions. Kipp's apparatus is generally used to prepare H_2S gas. Teacher must know how to set up the Kipp's apparatus to prepare the gas, even if the gas is prepared by a laboratory attendant.

(i) The basic concepts of experimental chemistry:

Teacher must be well versed with the basic concepts of all the experiments to be done in the school laboratory. She must be able to answer any question or problem which arises during the course of an experiment. Some examples are given here.

- Why are the burette and the pipette rinsed with the solution with which these are filled?
- Why should the last drop of the solution not be blown out of a pipette?
- Why can we not prepare a standard solution of HCl, H_2SO_4 or HNO_3 directly ?
- Why is dilute H_2SO_4 preferred over dilute HCl while testing anions?
- Why is silver nitrate solution stored in dark coloured bottle?
- Why is it essential to boil off H_2S gas before precipitation of cations of third group of qualitative analysis?

Similarly there can be many more questions, whose answers the students should know with the help of the teacher.

Preparation of Indent

Preparation of indent

Indent gives a clear idea about the name and number of equipments. The teacher has to prepare the indent. Preparation of indent needs some basic ideas. The indent can be prepared by the teacher after studying all the science lessons of different classes in school.

Factors to be considered while preparing indent

Stock before indent

Before preparing an indent, stock of materials and apparatus should be checked and the actual requirement has to be considered for purchasing

List of materials and apparatus required

Based on the stock verification, list needed apparatus and materials to be prepared. It helps avoiding overloaded purchasing of goods for laboratory

Choice of suppliers

Choice of suppliers will be considered based on the product make and cost of apparatus and materials

Budget allotted

Indent might be prepared within the scope of budget allotted by the institution

Size of the class

Students strength in the class and batch will be taken into account while preparing indent

Level of students

Indent will be prepared according to the standard and level of the students

Enough storage

School must has separate and enough space for storing purchased materials

Ability of a teacher

Teacher should have the realistic awareness of various apparatus, chemicals and their make with cost of various suppliers

Receiving quotations

Before purchasing quotations from various suppliers should be received

Comparing and negotiating quotations

After receiving quotations, cost of each item will be compared with all quotations.

If the teacher wishes, he may negotiate the cost of items with the suppliers

Finalizing the supplier

Finally supplier will be finalized with Cost effective materials and apparatus without quality compromising

Receiving goods-in good condition

This is the end stage, after indent preparation, materials and apparatus received will be checked for good conditions.

Advantages of indent

- A separate Purchase Indent makes the inventory management in laboratory work quite easier.
- Complete documentation is there regarding the required quantity and quantity in hand. Purchase indent is an authorized document which can help track the delivery of the ordered material before being received by the customer.
- It avoids over dumping of same items in laboratory

Types of indent in laboratory

- Indent for breakable items
- Indent for non breakable items
- Indent for chemicals and acids
- Indent for glass apparatus

Laboratory registers

The materials received should be properly checked and entered in the stock registers the same day. A correct and properly maintained record of articles it important to check any article at any time. The following registers are to be maintained in every laboratory.

1. Accession register:

The materials received from the companies should be entered in this register. This register will give an idea whether the amount allotted for the year has been spent, about the amount spent for the buying the equipments and the amount paid to a particular company

2. Non-consumable register:

Articles of metal, wood or any other thing of permanent nature which are not liable to broken or consumed should be entered in this register. All the articles should be entered in the alphabetical order in this register. Each article should be allotted a separate page.

3. Consumable register:

Articles that are liable to break, chemicals and other materials that are consumable should be entered in this register. Chemicals can be written in the first portion of the register and other materials can be written after that.

4. Breakage register:

Apparatus are liable to break accidentally while arranging for the practical class or while doing the practical. The apparatus broken during such occasions should be entered in a separate register.

5. Issue register:

The laboratory in-charge should enter the articles given to the other teachers in this register and get their signatures. When the articles returned he should make a note of its return.

6. Requirement Register

This includes items required for this priority should be given to those of immediate need. The most appropriate method of collecting suggestions for new resources for the science staff, is to note the ideas in a required register

Safety in the lab

Laboratory is a place where students and teachers do experiments in order to prove the theories in the textbooks. When the students do the experiments some accidents may occur. These accidents may not occur in well organized and maintained laboratories. Students inexperience they may come across accidents. We cannot give guarantee that accidents may not occur in a laboratory. But the occurrence of the accidents can be avoided or prevented.

Safety measures

The following articles should be kept in a place in the lab, which could be easily taken by anybody. These articles should be checked in the beginning of every term of the academic year.

- A carpet or rug should be kept in order to put ort fire on the dress.
- A bucket full of sand
- A fire extinguisher
- A first aid box. A handbook regarding the procedure for the first aid.
- An asbestos sheet to prevent fire in the inflammable articles.
- The doors of the laboratory should not be locked when the students are inside the lab
- The students should not enter and remain inside the lab without the permission of the teacher
- Concentrated acids, alcoholic, highly inflammable things should be kept in a separate storeroom.
- All poisonous substances should be kept in a separate almirah, locked and the key should be with the teacher

In order to minimize the accidents some safety rules should be followed both by the teacher as well as by the students

Guidelines for the teacher

- Students should not be allowed in the lab unless a teacher is present
- The teacher should maintain discipline among the students. Discipline is required in lab than the classroom
- The principles to be followed by the students in a lab should be neatly typed and exhibited in a place where all students can see it.
- Lab should be near and clean and all the articles should be in the respective places.
- The apparatus and materials required for the students practical work should be placed on the tables much before the students' arrival
- The procedure for handling new apparatus should be informed to the students and the precautions to be taken while doing experiments should also be told to them
- The experiments which involve some danger and require some skill, should be explained to the students
- The students must know the technique of handling gas and electricity during emergency situations
- Fire extinguishers should be provided and the teacher and students must know how to operate them.
- Each lab should possess a first aid box filled with required first aid materials. The teacher must know the basic principles of first aid.

Rules to be followed by the students

- Students should not take the lab materials out of the lab
- The apparatus should be used by the student to conduct the experiment told by the teacher. He should not use it to do in a different manner or different experiment
- Breakages or accidents must be reported immediately to the teacher
- They should not lift the bottles by the neck or cork
- The stopper of particulars bottle should replaced on that particular bottle
- Only small quantities of chemicals should be used
- Chemicals should not be tasted and smelled without care
- If any chemical has been put into the mouth that should be removed and the mouth should be washed with plenty of water

- When acid or alkali is poured on the body or cloth accidentally that part should be washed with water thoroughly
- Solids should not be put in sinks
- After use, all apparatus must be cleaned and replaced and the bench left clean
- Water and gas must not be wasted and should be turned off before leaving in the laboratory

Common accidents and first aid

1. Burns

Due to acids

When the skin is contact with corrosive acid the immediate first is to flood the part with water. The rest of the acid in the can be neutralized with $NaHCo_3$ solution. But this solution should be applied only after washing the part with water since neutralization produce heat.

Due to alkali

When alkalis like sodium hydroxide, potassium hydroxide come in contact with body they produce burns. The burn can be washed first with water and then with 2% acetic acid or saturated boric acid. Lime juice can also be used.

Due to Phosphorous

This has to first washed with water and the sticking phosphorous be removed. Then dilute silver nitrate or 1%sodium bicarbonate can be applied.

Due to sodium and potassium

The particles of these can be removed by the cotton dipped in spirit and then washed with much water.

2. Cuts and Scratches

Cleanliness is essential to prevent infection of wounds. In the majority of cases simple injuries can be treated with an antiseptic solution and covered with an adhesive dressing of suitable size. If there is any possibility of pieces of glass remaining in the wound then they can be removed with forceps and then tincture benzoic be applied.

3. Eye injuries

These cases should be immediately sent to the doctor. A drop of castor oil can be put in eye and then the eye can be tied with much cotton.

Copious irrigation of the eye with water is loudly recommended first aid while hospital aid is being summoned.

Acid in eye

The eye should be washed in gently flowing water for a long time and then 1% sodium bicarbonate solution or lime water can be added.

Alkali in eye

Washed with water and the with 1% boric acid

4. Poisoning

In the mouth: poisonous materials got in the mouth the student should be instructed to spit the material and rinse the mouth repeatedly with water. Neutralizing substance, $NaHCo_3$ for acids and acetic acid for alkali should then be used to rinse the mouth.

Swallowed: Acid, alkali or salts of heavy metals. Students should be encouraged to drink large amount of water but neutralizing solution or emetics should not be given without medical advice.

Inhalation of poisonous gas : it is possible for the students to inhale poisonous gases like carbon monoxide, H_2S, chlorine etc in the lab. On such cases they may cause a feeling of sickness or headache or result in irritation of the mucous membranes of the mouth, nose and throat. The student should be taken to the open place. In the event of the patient becoming unconscious artificial respiration in the fresh air is necessary.

5. Fainting

The patient should be laid flat and legs raised above the level of the head, clothing round the neck and waist should be loosened. Hot drinks can be given. After recovery the patient should be made to rest and be kept ward.

6. Electric shock

The main switch should be put off immediately. Then the person should be taken out and treated for the burns if there is any. If he has fainted, he should be taken out and given first-aid as that for fainting.

7. Fire accidents

- If he caught an individual student, the fire proofed rug or blanket should be used to put it off
- If the fire is in beaker or flask, asbestos sheet can be used to put it off
- If oil or phosphorous is burning the sand can be used
- If the gas tube is burning the main gas switch can be closed.
- If it is due to electricity, the connection can be cut off

- Fire extinguishers can be used if the entire lab is in fine. Before that all the students should be sent out and then only the fire extinguisher can be used. After that free air must be allowed to pass through the lab by opening all the doors and windows.

Recording of accidents

All accidents should be recorded in the record notebook with the nature of accident, the name of the person involved and the type of first aid given, date and time.

Improvisation of apparatus

Many schools are not well equipped and face financial constraints in buying materials and equipments for carrying out activities, demonstrations and experimentation due to availability of limited funds. But this does not mean that there is no way out. An enterprising teacher can critically look at local resources and find possibilities of carrying out innovative activities for teaching- learning of science using local, low cost, easily accessible materials.

Teacher can encourage and help students in making improvised apparatus. With a bit of creativity and imagination, a teacher with the help of students can convert day-to-day usable articles, household wastes or discarded materials and materials collected from immediate environment into valuable learning resources. Such learning resources, while being interesting and effective, do not result in financial burden on school. This is, however, possible when the experiment is of qualitative nature and does not require too much precision.

Students can also be involved in collecting locally available materials and improvising apparatus. This will enthuse the children to explore new things. It will provide them an opportunity of creativity, self-expression and self-development. They will be able to connect learning of science to their environment. In the long run, it would help to inculcate scientific temper in them.

The learning resources from the immediate environment can be used at all stages of school education.

At primary and upper primary stage of school education, almost all science activities and demonstrations can be done using resources from immediate environment. At secondary and higher secondary stage, many activities, demonstrations and some experiments also can be performed in physical science by using such improvised apparatus.

We have seen that many materials from the immediate environment can be used to make improvised apparatus for performing activities and experiments of physics. There are many inexpensive chemicals in our immediate environment that can also be used to perform activities and experiments in chemistry.

Students get the opportunity to appreciate the application of chemistry in their everyday life if common household products are used to conduct experiments and activities. Familiar materials provide a context of learning that can be more interesting to students.

Teaching-learning begins with the students' existing knowledge that can facilitate their conceptual development. Some inexpensive sources of chemicals are suggested below. Students may volunteer to bring in some of these materials.

Science Kits

A major idea of concern in science education is the gradual decline of practical work and experimentation at secondary and higher secondary stages. Also the concept of activity-based teaching- learning is yet to become a reality in many elementary schools. Lack of laboratory facilities and awareness among teachers about activities and experiments being fundamental to doing and learning science can be some of the reasons behind it.

The absence of laboratory facilities in school drastically narrows down subject options for students, denying them equal opportunities for learning and future life chances. Hence, it is important to make available resources to such schools to facilitate experimentations. Such schools can benefit largely from science kits.

Science kits are useful not only for schools lacking facilities of a science laboratory, but for all schools as they are convenient to use.

Use of science kits can be very helpful in motivating both teachers and students to integrate hands-on experience of science with day-today teaching-learning of science. Design, development, and production of various science kits meant for different stages of learning have been undertaken by many organisations and institutions of the country including NCERT.

For effective teaching-learning of science, it is essential to perform certain activities and experiments in classroom situations. Performance of these activities and experiments requires some special apparatus and materials. When these materials are made available at one place, say in a box, it is referred to as science kit.

Most of the apparatus and materials belonging to the kits can be conveniently available in the market while some of them can be improvised. While designing and listing items for science kits, attempts are made to ensure that the tools are not heavy or unsafe for the students. Now let us see its various advantages.

Advantages of science kits

- They provide easy availability of all the materials for performing experiments at one place and are moderately priced. Manuals are also provided with them.
- They save time required for collecting the materials and apparatus each time a teacher wants to perform activity or experiments.
- A large number of activities and experiments can be performed with a few apparatus and materials.
- They are portable and can be used both indoors and outdoors.
- Generally these kits do not require extra source of energy, such as gas, water or electricity supply for their use. Therefore, these can be used in smaller towns, rural areas or other places where other infrastructural facilities are not there.
- The material and the equipment kept in the kits are simple and locally available and are capable of improvisation and repair by the users according to their need. In this way kits may provide opportunity for the development of creativity.
- Students actively take part in handling and doing experiments. Learning by doing encourages self-confidence.
- Pieces of apparatus can be used for several times for various purposes. Kits, therefore, have multipurpose use.

The Workshop Department of NCERT has developed various science kits. These are upper primary science kits, secondary science kits, micro scale chemistry laboratory kit at secondary and higher secondary stages (separately), solid state model kit, molecular model kit, etc.

Using microscale chemistry laboratory kit, chemistry experiments can be performed taking small quantity of chemicals without compromising on the quality and standard of experiment. It covers very small storage area. The experiments can be performed very quickly as it saves time for preparation. Cost of the material and equipment are reduced to a significant extent. These are pollution and hazard free.

Conventional laboratory racks and bottles are replaced by a small box containing all the small laboratory wares and apparatus and on the top of the box are revolving circular racks to hold plastic bottles that dispense only a few drops of liquid at a time. Four students can work on this kit at a time. The kit is accompanied by a detailed manual describing the use of items and details of each experiment.

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Unit 8

Assessment of children's learning in Physical Science

Syllabus: Test, examination, measurement, assessment and evaluation –Continuous and Comprehensive Evaluation (CCE), objectives –Scholastic area: Formative, Summative Assessment– Co-Scholastic area, life skill – national talent search examination.

Introduction

Education is an activity which is undertaken to fulfill the needs of both the individual and the society at the same time. Schools in general and classrooms specifically are places where many processes take place such as teaching, learning and evaluation. Teaching, learning and evaluation are interdependent and a science teacher should take these aspects together to make teaching-learning process effective.

'Evaluation', as we know is an integral component of a teaching learning process, which comprises

- Objectives
- Curriculum
- Evaluation

Moreover, all the three components have a two-way relationship among them, i.e. each affects the other two and in turn is effected by them. For example, on the one hand through evaluation, we come to know how far our objectives have been achieved and only those parts of the curriculum get precedence in the eyes of learners and teachers both, which carry weightage in examination system. On the other hand evaluation method will depend on the kind of objectives and activities taken up in curriculum.

Test / Examination

A test is a powerful tool or instrument of measurement that is used to obtain data about a specific trait or characteristics. A test is a device or technique used to measure the performance, skill level, or knowledge of a learner on a specific subject matter.

In short, a test as an instrument of evaluation is a systematic procedure of description, collection and interpretation in order to measure the test taker's achievement ability, knowledge, and performance what they have been learned in learning process and to get a value judgment.

Types of Test item

Achievement tests are conducted using different types of test items. Hence science teacher should master the skills of constructing test items. A constructor should take the following precautions while framing the test items.

• The items should cover as far as possible, the whole range of topics prescribed in the syllabus.

• No item or part of the item should be set which is outside the syllabus.

• More items should be set to test higher objectives. For this purpose items should be in the context of new situations.

• Items should provide clear direction to the students regarding the scope and length of responses

• The language of the items should be simple and within the easy grasp of students

A. Objective Type test item

An objective type test item is one in which the response will be objective. The responses are made fixed and hence the freedom of the respondent to deviate subjectively is restricted. Objective type test item can be broadly classified into two they are

1. Supply Type (Recall Type)

2. Selection Type (Recognition Type)

For supply type test items the respondents have to supply the response where as for the selection type they have to select the responses from among the given responses. Usually five different forms of objective type items are in vogue. They are true-false type, multiple choice types, matching type, simple recall type and completion type. Of these simple recall and completion type items are supply type and the other three belongs to the selection type.

i) True – False Items (Alternate Response Type)

The respondent is asked to read a statement and indicate in some specific manner suggested, whether it is true or false, right or wrong, correct or incorrect, agree or disagree, yes or no. it tests the ability to discriminate between misconceptions and scientific truth. It is suitable for young children who have poor vocabulary. Large sample of subject matter can be covered within a short period.

ii) Multiple choice Test Items (Changing Alternative type)

These are items presenting four or more responses in which one is either correct or definitely better than the others. The examinee has to find this out and record this in the manner required in the paper.

Here the chances of guess work are minimized. Multiple choice items consist of two parts. The fast part of the item is called stem presented in the form of a direct `question or incomplete statements.

The second part of the item is called options or alternatives or responses, usually four or five in number among the options one is the keyed response and others are called distracters or misleads or foils. The stem gives data for the selection of the keyed response. The respondent has to read the stem and options and select the correct or best alternative. The different forms multiple choice test items in vogue are correct answer form, best answer form, multiple response form, etc.

iii) Matching Type Test Item

This is a modified version of the multiple choice test items. In fact matching type is an economized form of combining a number of multiple choice items in the same question- a condensation of several multiple choice items. It consists of two parallel columns, with each phrase, word or number or symbol in one column (Usually the first) being matched to a word, phrase or sentence in the other column.

The items in the column for which a match is sought are called premises or stem and items in the column from which selection is made is called responses or options. The respondent is required to make some sort of association between each premise and each response in the two columns.

iv) Simple Recall Type Test Items

This test requires the respondent to recall a response to a direct question. The typical response should be short preferably a word, a number or a small phrase. It eliminates the chance of guessing.

v) Completion Type Test Item

A completion type item consists of a series of sentences in which certain words are omitted and replaced by blanks. The respondents are expected to fill in the blanks with a word or a number or at the most a phrase. The probability of guess work is completely eliminated.

Advantages of Objective Type Item

1. As a large number of questions are set, a wide coverage of the syllabus is possible.

2. Questions can be set which are designed to assess one particular educational quality. For example ability to apply.

3. Marking of such tests is objective and can be done speedily

4. They are more valid and reliable, since the response/ answers are definite

5. There is greater administration use and control

6. They have higher diagnostic value

7. They are less time consuming

Disadvantages of Objective Type Items

1. Such tests do not encourage verbal fluency or a student's ability to development argument

2. Chancing of guessing are high

3. An objective test is difficult and expensive to construct

4. Emphasis on testing superficial knowledge

5. Inefficiency in testing complicated skill.

6. Objective type items are often ambiguous, particularly for the better students.

7. Such tests when over used can have a negative effect on teaching, since they encourage the student to learn bits of knowledge rather than the whole.

B. Short Answer Type

A question requiring value points at the most may be defined as a short answer question. The term value points indicate a point to be given credit in the expected answer. Thus the length of the answer expected from a short answer question becomes very short. This diminishes subjectivity. In this way it is an improvement upon essay type question. Such question are of great helping having wide coverage of content and each item can be set to a test a definite objective. Because of this reason, a fair proportion of such questions should be included in a test.

Advantages of Short Answer Type

1. Questions of this form can be made stimulating

2. Students can be trained to select relevant information and present it in a few short, crisp Sentences

3. Short answers are easy to score

4. Reliability of scoring is high

5. Questions can cover a wider content area than easy type test items. It is possible to achieve a more expensive sampling in the short answer test than in the essay type test

6. The short answer test is especially useful in diagnosis. In part, this follows from the factor of extensive sampling

Disadvantages of Short Answer Type

1. It is more subjective than the objective type of items

2. Its excessive use may encourage a student to memorize facts and develop poor study habits

3. Mechanical scoring is not possible because of the subjectivity involved

C. Essay Type

According to dictionary by Good, essay test is a type test is a type of examination in which the subject or examinee is asked to discuss, enumerate, compare, state, evaluate, analyze, summarize or criticize and involves writing at specific length on a given topic involving the processed listed above.

The essay type questions get its name from the manner in which the examinee responds. The term essay implies a written response which may consists of many sentences to several pages. The student is allowed freedom with respect to what his answer will include its wording length and organization.

Advantages of Essay Type

1. They are easy to construct

2. They can be used to test the student's language mastery, expression and organizational ability of a student

3. Chances of copying are minimal

4. A student's ability to use knowledge effectively can be assessed. It helps to develop a variety of skills. In addition to self-expression, students have to select pertinent material, organize this material into a coherent discussion and arrive at conclusions.

5. Guessing creates few problems

6. It encourages good study habits. A student preparing for an essay test is likely to highlight important units, look for relationships and exercise judgement in deciding points of emphasis.

Disadvantages of Essay Type

1. Subjective bias could creep in as these test are based on the examiner's moods and whims

2. Essay type encourages rote memory. The higher levels of the cognitive domain cannot be completely assessed by this method.

3. Sampling is limited. Adequate sampling is essential in good testing. But time limitations make it impossible to achieve good sampling in an easy test, assuming that a large body of subject matter has been covered.

4. There is danger of bluffing. The "gift of gap" can be encountered in written as well as in oral communication. It requires a discerning teacher to realize that nothing much is been said.

5. Essay type test are difficult to score. Besides no two teachers agree on the score given to a particular paper, the hand writing, presentation and so on. Thus score rating cannot be generalized.

Criteria / characteristics of a good test

1. Validity

Validity tells you how accurately a method measures something. If a method measures what it claims to measure, and the results closely correspond to real-world values, then it can be considered valid.

The test must really measure what it has been designed to measure. Validity refers to the extent to which an instrument really measures the objective to be measured and suitable with the criteria. In other words, a test can be said to be valid to the extent that it measures what it is supposed to measure.

Four main types of validity

1. Construct validity: Does the test measure the concept that it's intended to measure?

2. Content validity: Is the test fully representative of what it aims to measure?

3. Face validity: Does the content of the test appear to be suitable to its aims?

4. Criterion validity: Do the results correspond to a different test of the same thing?

2. Reliability

Reliability refers to the consistency of measurement that is, to see how

Consistent test scores or other evaluation results are from one measurement to another. It means that a test is administered to the same condition on different occasion, the extent that it produces different result, it is not reliable. Reliability of a test can be obtained by calculating reliability coefficient using following methods

- Test-retest method
- Equivalent forms/parallel forms method
- Split-half method
- Rational equivalence or kuder-richardson method

3. Objectivity

Objectivity is an important characteristic of a good test. It affects both validity and reliability of test scores. A test is objective when it makes for the elimination of the scorer's personal opinion bias judgment. There cognition of the quality objectivity in a test has been largely responsible for the development of an arised and objective type tests.

4. Usability:

Usability is another important characteristic of measuring instruments. The test must have practical value from time, economy, and administration point of view. This may be termed as usability.

So while constructing or selecting a test the following practical aspects must be taken into account

1. Easy of Administration

It means the test should be easy to administer so that the general class-room teachers can use it. Therefore simple and clear directions should be given. The test should posses very few subtests. The timing of the test should not be too difficult.

2. Time required for administration

Appropriate time limit to take the test should be provided. If in order to provide ample time to take the test we shall make the test shorter than the reliability of the test will be reduced.

3. Easy of Interpretation and Application

Another important aspect of test scores is interpretation of test scores and application of test results. If the results are misinterpreted, it is harmful on the other hand if it is not applied, then it is useless.

4. Availability of Equivalent Forms

Equivalent forms tests helps to verify the question able test scores. It also helps to eliminate the factor of memory while retesting pupils on same domain of learning. Therefore equivalent forms of the same test in terms of content, level of difficulty and other characteristics should be available.

5. Cost of Testing

A test should be economical from preparation, administration and scoring point of view.

Advantages of Examination / Test

1. Broadening of individual's knowledge

Exams are a fairway of telling the individuals how much knowledge they have of the respective course or subject. It encourages them to work hard and learn. They try to gain more and more knowledge.

2. Create competition

Exams also create competition among the individuals, which push them to acquire more knowledge. It also pushes the competitors to give their best

3. Develops personality and confidence

Knowledge not only helps to get good grades in exams but also helps to develop the personality.Theindividualsbecomemoreconfidentandexpertintheirrespective fields.

Disadvantages of Exams

1. Stress and anxiety

The exam season brings a lot of stress and anxiety with it. Many students are not able to memorize due to the increased level of anxiety and stress. Some may face difficulties in concentrating on studies. Since the school students do not grow enough to face such stressful situations, they will get panic and be trembling.

2. Not a fair way of testing knowledge

Three hours or one and a half hour exam is not enough to judge the skills of an individual. There is a possibility that one cannot perform well during the exam. A student may forget the answer at the exam hall because of anxiety or suffer from illness.

3. Comparison among students

Every individual has a different personality and knowledge from others and every individuals capable of something. Parents always compare their kids with other kids. This would happen mainly when exam results came. Students will become depressed and lose their self-confidence.

4. Cramming

In order to get good grades, students trying hard to memorize the subjects which they are being taught in schools. It would limit the amount of knowledge, the students are acquiring. Most of the students begin to cram the course, without understanding it properly. They may get good grades at school, but cramming will never help them in practical field as their concepts are not cleared completely. This is why the recruiting companies focus more on experience rather than the qualifications.

Measurement, Assessment and Evaluation

While evaluation is concerned with making judgments about instruction, a curriculum, or an educational system, assessment is concerned with the students' performance. In other words, one assesses an individual but evaluates a program, a curriculum, an educational system, etc.

Measurement

The word measurement simply means determining the attributes or dimensions of an object, skill or knowledge. We use common objects in the physical world to measure, such as tape measures, scales and meters. These measurement tools are held to standards and can be used to obtain reliable results. When used properly, they accurately gathered at a for educators and administrators. Some standard measurements in education are raw scores, percentile ranks and standard scores.

Assessment

One of the primary measurement tools in education is the assessment. Teachers gather information by giving tests, conducting interviews and monitoring behaviour. The assessment should be carefully prepared and administered to ensure its reliability and validity. In other words, an assessment must provide consistent results and it must measure what it claims to measure.

Evaluation

Creating valid and reliable assessments is critical to accurately measuring educational data. Evaluating the information gathered, however, is equally important to the effective use of the

information for instruction. In education, evaluation is the process of using the measurements gathered in the assessments.

Teachers use this information to judge the relationship between what was intended by the instruction and what was learned. They evaluate the information gathered to determine what students know and understand, how far they have progressed and how fast and how their scores and progress compare to those of other students.

Let us now see, how assessment and evaluation are intertwined in classroom situations.

(i) When the teacher starts any lesson, she needs to know the existing ideas of the students. She gets the learners involved in dialogue, conversation and inquiry. It helps to know about their prior knowledge. Various learning opportunities are provided to know about their capabilities, interest and needs.

(ii) During teaching-learning process the teacher is interested in knowing what are the existing ideas of the students? What are their misconceptions and naive concepts? What modifications are required to improve the performance of the student as a learner and her own performance as a teacher? How is the class progressing? How effective has been her approaches and strategies of teaching? In order to do so, she again has to make some kind of evaluation. Purpose of such an evaluation is to find if there is any learning gap between students' concept and scientific explanations of the concept.

Teacher monitors process of their learning and concept development, provides continuous feedback and encourages them to reflect on their learning. She facilitates them to construct and reconstruct the new knowledge.

(iii) A t the end of the lesson/unit/session, she has to make judgement of learning of the students and document their learning evidences. The teacher comes to know the extent of success of her teaching-learning processes. When the learner is promoted to next class a grade is allotted to her. Thus, she has to make a final assessment of the learners, for which she again has to take recourse to some kind of evaluation.

Thus, we see that assessment and evaluation are ongoing processes. These are seamlessly integrated with teaching learning process. Teacher has to make she aware of the learners' learning process and learning product (their performance) both, and evaluate the students holistically.

We evaluate the learners not only on the basis of their understanding of scientific concepts and process skills of science but also their critical thinking, creativity, curiosity, attitude and behaviour.

As a learner of science, we know that whenever we make any measurement, we take several observations and report the mean of consistent observations as the measured value of the parameter. Taking several observations makes the measurement reliable. Thus, while evaluating any indicator of learning of the student, we have to measure it several times at different time intervals to arrive at its reliable value which will ultimately form the basis for our evaluation.

Therefore, we see that in order to be able to judge the worth of a student's performance successfully, our process of evaluation has to be both continuous (i.e., each parameter is measured at different points of time) and comprehensive (i.e. it is based on assessment of all concerned parameters).

Thus, Continuous and Comprehensive Evaluation (CCE), possesses the following features:

(i) Since teaching-learning in a school is a continuous process and assessment is an integral part of this very process, therefore CCE is essentially a school-based evaluation.

(ii) Teacher uses a number of tools and techniques of evaluation.

(iii) Teacher provides feedback on different aspects of learning and understanding qualitatively. It motivates students for further learning.

(iv) Continuous aspect of CCE not only ensures reliability of our measurement process but also enables us to identify how learners' conceptual development is taking place. It helps us to observe existing concepts of the learners, identify their misconceptions and naive concepts and to deal with them.

(v) In order to ensure continuity, a particular performance parameter or learning indicator can be measured in the beginning of the lesson, during teaching-learning process (assessment for learning); at different intervals, at the end of each unit and at the end of the session (assessment of learning). These repeated assessments of the same parameter make evaluation continual and periodic.

(vi) The comprehensive evaluation includes assessment in curricular or subject specific areas that should be assessed informally as well as formally using multiple techniques. It also takes care of all-round development of the learner's personality.

(vii) It guides the learner in self-assessment and she takes responsibility of her learning. There is collective understanding among all concerned learners, teacher, parents, school and institute of higher education about what is being evaluated.

(viii) CCE does not mean more frequent tests and examinations. On the contrary, routine activities and exercises can be employed effectively to assess learning.

Aims and objectives of CCE

- To assess every aspects of child during their presence in school
- It helps in minimizing the stress on children
- Make assessment comprehensive and regular
- Provide space for teacher for prolific teaching
- Provide a tool for detection and correction
- Produce learners with great skill
- It makes teaching learning a learner-centered activity
- To make the assessment process an essential part of teaching and learning process
- To make a fair judgment and take timely decision for learners growth, learning process,
- To help develop cognitive, psychomotor and affective skills.
- To lay emphasis on thought process and de-emphasise memorization.
- To make evaluation an integral part of the teaching-learning process.
- To use evaluation for improvement of students' achievement and teaching-learning strategies on the basis of regular diagnosis followed by remedial measures.
- To use evaluation as a quality control devise to raise standards of performance.
- To determine social utility, desirability or effectiveness of a programme and take appropriate decisions about the learner, the process of learning and the learning environment.
- To make the process of teaching and learning a learner-centred activity.

Scholastic and Co-Scholastic assessment

Children's' abilities are generally classified into abilities in scholastic and co-scholastic areas. Scholastic areas cover activities in curricular or subject specific areas, whereas co-scholastic areas include life skills, abilities in co-curricular areas, attitudes and values.

Assessment in Scholastic Areas

Scholastic areas include all those academic activities which are associated with various subjects. The term 'Scholastic' refers to those activities, which are related to intellect or the brain. It is related to the assessment of learners in curricular subjects. It includes assignments, projects, practicals etc.,

The major subject areas associated with scholastic domain are language, mathematics, science, social science, physical education, Arts and craft, music and painting, games and sports, information technology, work experience etc.,

Tools and Techniques for assessing Scholastic aspects

Formative Assessment tool (Flexible Timing) : Questions, Observation, Interview schedule, Checklist, Rating scale, Anecdotal records, Document analysis, Tests and inventories, Port folio analysis.

Techniques-Examination, Assignments, Quizzes, Collections, Projects, Debates, Elocution, Group Discussions, Club activities, Demonstrations etc..

Summative Assessment tool (Written, End of Term) : Objective type, Short answer, Long Answer.

Assessment in Co-Scholastic Areas

Assessment in co-scholastic areas includes Life Skills, Attitudes, Social Values, Co-Curricular activities, Aesthetic values, Performing and Visual arts etc.,

Tools for Assessing Co-Scholastic Aspects

Observation schedules, rating scale, inventories, anecdotal records, socio-gram, interview, portfolio, e-portfolio, document analysis, running records, time samples, event samples, photographs, audio-video etc.,

Life skills

In order to prepare children for the social life, teacher has to develop life skills in them. This will enable them to manifest their inner potential with confidence and competence and face the challenges of life.

World Health Organization (WHO) has defined life skills as “Life Skills are abilities for adaptive and positive behavior that enable individuals to deal effectively with the demands and challenges of everyday life.”

The effective and appropriate utilization of life skills can influence the way one feels about one self and others and can enhance one’s productivity, efficacy, self-esteem and self confidence.

‘Adaptive’ means that a person is flexible in approach and is able to adjust to different circumstances.

‘Positive Behavior’ implies that a person is forward looking, and finds ray of hope, solution and opportunities even in difficult situations.

In particular, life skills are a group of psycho-social competencies and interpersonal skills that help people think critically, creatively, make informed decisions, solve problems, and communicate effectively, build healthy relationships, empathize with others, and cope with stress and emotions and manage their lives in a healthy and productive manner.

Types of Life Skills

UNICEF, UNESCO and WHO list ten core life skills which are problem solving, critical thinking, effective communication skills, decision-making, creative thinking, interpersonal relationship skills, self-awareness building skills, empathy, and coping with stress and emotions. These ten skills are further classified under three more groups namely: thinking skills, emotional Skills and social skills as Core Life Skills

1. Thinking skills: Self Awareness, Critical Thinking, Creative Thinking, Decision making and Problem solving

2. Emotional skills: Coping with Emotions and Coping with Stress

3. Social skills: Empathy, Inter personal Relations and Effective Communication

Formative Assessment

Formative evaluation is concerned with making decisions relating to forming or development of students as well as of the courses. It provides feedback at appropriate stages of the teaching learning process which helps in making changes in the curriculum, teaching strategies and the learning environment. Formative evaluation is done during the process of teaching learning with the following main purposes

- To monitor student learning for the purpose of providing individualized instruction
- To evaluate teaching effectiveness
- To evaluate courses and curricula with the purpose of modification, updating or replacement if necessary
- To evaluate curriculum materials
- To evaluate the learning environment with a view to improving it.

Since evaluation is an integral part of teaching and learning, students are observed in various situations continuously with a view to assess their level of achievement in terms of what have been expected of them. Written examination is one of the most commonly employed and widely acceptable techniques for measuring student's achievement. The construction of an achievement test has its importance in student evaluation.

Formative assessments maybe questions, tasks, quizzes or more formal assessments. Often formative assessments may not be recorded at all, except perhaps in the lesson plans drawn up to address the next steps indicated.

Advantages

1. Defined learning goals: Monitoring student progress regularly helps keep learning goals top of mind so students have a clear target to work towards and teachers can help clear up misunderstandings before students get off track.

2. Increased rigor: Practicing formative assessment helps teacher's collection formation that indicates student needs. Once teachers have an understanding of what students need to be successful, they can create a rigorous learning environment that will challenge every student to grow.

3. Improved academic achievement: Providing students and teachers with regular feedback on progress toward their goals is the main function of formative assessment that will aid in increasing academic achievement. Formative assessment helps students close the gap between their current knowledge and their learning goals.

*4. Enhanced student motivation: F*ormative assessment involves setting learning goals and measuring the progress towards those, this increases motivation. When students have a focus on where they're aiming, results skyrocket.

5. Increased student engagement: Students need to find meaning in the work they are asked to do in the classroom. Connecting the learning objectives with real-world problems and situations draws students into the instructional activities and feeds their natural curiosity about the world.

6. *Focused and targeted feedback:* Descriptive feedback should highlight gaps in understanding and specifically inform students on how they can improve their learning rather than listing what they got wrong, thus facilitating a reciprocal learning process between teachers and students.

7. Personalized learning experiences: It's the close analysis of formative assessment data that allows the teacher to examine his or her instructional practices and determine which are producing the desired results and which are not. Some that work for one group of students may not work for another group.

8. Self-regulated learners: Teaching students the requisite skills to monitor and take responsibility for meeting their goals creates self-regulated learners. Give students examples of high-quality work along with multiple opportunities to review and correct their own work to build independent and autonomous thinkers.

9. Data-driven decisions: Using the data gathered from frequent learning checks empowers teachers to make sound, informed decisions that are grounded in data.

Summative Assessment

Summative assessment sums up what a pupil has achieved at the end of a period of time, relative to the learning aims and the relevant national standards. The period of time may vary, depending on what the teacher wants to find out. There may be an assessment at the end of a topic, at the end of a term or half-term, at the end of a year or, as in the case of the national curriculum tests, at the end of a key stage.

A summative assessment may be a written test, an observation, a conversation or a task. It may be recorded through writing, through photographs or other visual media, or through an audio recording.

The summative evaluation follows certain strategies for evaluation by means of assignments, tests, projects and more.

Advantages

1. To know if students have understood the subject taught

2. They are also utilized to estimate the effectiveness of educational programs. Utilized to measure the improvement towards objectives and goals.

3. Course-placement decisions are also made with summative evaluation.

4. The results of summative evaluations are ones that are recorded as scores or grades into the students' academic records.

5. The presence of summative evaluation is a motivator as it assists the individuals and offers them an opportunity to develop a learning environment.

6. The outcome of the summative evaluation is considered as a boosting factor when it's positive.

7. With the help of summative evaluation results, trainers and instructors can find out weak areas where the results are steadily low.

8. This type of evaluation helps in determining the success of methods used for training programs. They are equated with others and evaluated.

9. Summative evaluations are considered as tools, as they have the capability to evaluate the usefulness of any program, they work towards the improvement of the school or institution; they help in aligning curriculum and also helping students to get placed in the appropriate programs.

10. They assist a lot as they offer a lot of information in the classroom level.

11. The summative design is utilized as an evaluation technique in the course of instructional design

12. With the help of summative evaluation, the supervisor can measure the educational faculty or the instructor.

13. The level of performance of all the teachers, instructors can be measured by means of this evaluation.

Compare and Contrast formative and summative assessment

	formative assessment	**summative assessment**
1	It is an ongoing process, so it is performed during the process.	It is done only after the completion of the process.
2	With the help of formative evaluation, you will be able to help the student if he needs help during the process or any assistance	Whereas with summative evaluation we can understand how the student is performing and assigning the grades
3	This evaluation process helps in improving a student's learning capacity or skill.	Through summative evaluation, we can analyze the students' achievements.
4	Formative evaluation deals with small areas of content as it an n ongoing process.	Summative evaluation deals with the whole project as it is performed after the completion.

5	The formative evaluation considers the assessment as a process	Summative evaluation is considered more of a product.

National Talent Search Examination (NTSE)

The National Talent Search Examination (NTSE) is a National Level scholarship program in India to identify and nurture talented students. It honors and helps talented students by providing financial assistance in the form of a monthly scholarship for the entire Academic Career. Students studying in Class X are eligible to appear for the selection process.

As it is organized by an official body (NCERT), it is widely regarded as the most prestigious examination at high school level in India. For more details of NTSE, students can visit www.ncert.nic.in.

NTSE Eligibility Criteria

Candidates must be an Indian national. Candidates must be studying in class 10 in a recognized private or government school in India. Unemployed candidates below the age of 18, studying in class 10 from open or distance learning are also eligible to apply.

Two-stage selection procedure

There is a two-stage selection process for award of scholarship.

Stage-I: State level examination

This stage is conducted by the State/UT(usually in November)- for class x students. Selection will be done by States/UTs through the written examination. Each State/Union Territory has been allotted a quota to recommend a specific number of candidates.

The first level exam is the state level examination, which has two parts for nominating the required number of candidates for the second level test to be conducted by the DSERT.

Part-I: Mental Ability Test (MAT), and

Part-II: Scholastic Aptitude Test (SAT) (with questions on History, Civics, Geography,\ Economics, Maths, Physics, Chemistry and Biology.)

Students of any Board studying at any recognized school can participate. Those who get qualified an enter the Second Level National Exam. The results of the same will be out on March of the next year.

Stage–II: National level examination

NTSE Stage-II conducted at the National Level (usually in May)- for stage-I qualified students only.

Candidates acquiring more than the required percentage in the state level examination and standing within a specified number of top ranks (state quota) are eligible to appear for the national level examination (about top 4000 students from the entire country). The national level examination has two parts for nominating the required number of candidates for the interviews to be conducted by the NCERT in May:

Part-I: Ability Test (MAT)

Part-II: Scholastic Aptitude Test (SAT) (with questions on History, Civics, Geography, Economics, Maths, Physics, Chemistry and Biology.)

Declaration of Results

The results of the National Level Examination shall be out by July–August the same year. Students are divided into 4 quotas: General, SC, ST, and Disabled. Around 750 students will be selected from General quota, 150 from SC, 80 from ST and around 20 from Disabled quota. The results will be displayed on the website www.ncert.nic.in mid of –July or early-August.

Reward

The NTSE scholarship is awarded to the selected students all through the different stages of their education.

NTSE Scholarship: Other Advantages of Being an NTSE Scholar

Apart from the monetary benefits of being an NTSE scholar, there are additional advantages as well.

- Preparing for and cracking the NTSE builds confidence to appear for various other competitive exams. In fact, most of the NTSE scholars become top rankers in competitive entrance exams JEE Main, JEE Advanced, NEET, and AIIMS.

- NTSE Scholarship is your gateway to the top most colleges in India. Many colleges in India have seats reserved for NTSE scholars.
- Students planning to join foreign universities for their higher studies get an edge over other students if they are NTSE scholars.
- NTSE scholars are given higher preference when it comes to jobs, both in private and government sectors.
- NTSE scholars also get preference in selection for NDA.
- Study material and various courses are available at a discounted price for NTSE scholars.
- As you can see, getting NTSE Scholarship could help in every aspect of academic life and career.
- Every student studying in Class10 must appear for NTSE and give their best shot in the exam. Being an NTSE scholar is highly prestigious that guarantees security in academics and provides high job prospects.

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Unit - 9

Tools and techniques of assessment in physical science

Syllabus : Purpose of assessment – tool and techniques of assessment: Project work, Field trips and field diary, Laboratory work, Concept mapping, Interview/oral test, written test including types and construction.– Recording and reporting: measurement of students' achievements, grading system and type. – Measures of central tendency – measures of variability – correlation.

Assessment

Teaching, learning and evaluation are interdependent and a science teacher should take these aspects together to make teaching-learning process effective. A lot of psychological data suggest that different learners learn differently. Hence, there should be more varied modes of assessment beyond the examination hall paper–pencil test. To test all learners through a written test of the same type in subject, after subject is unfair to those whose verbal proficiency is superior to their writing skills, those who work more slowly but with deeper insight or those who work better in group than individually.

For a learner-centered approach to assessment, more focus should be given to assess learner's individual performance. The performance of one learner should not be compared with that of other learner. Learner's existing ideas, misconceptions, naive concepts, and her performance should be communicated to her in order to improve her performance.

The emphasis should be given to assess learner's individual progress based on her skills, attitude, approach and ability which are changed during learning process. Opportunity for feedback leading to revision and improvement of performance should constantly be available without examination and evaluation being used as a threat to study.

To cater to the needs of different learners and allow flexibility in assessment systems, Position Paper of National Focus Group on Examination Reforms (NCERT, 2006) has broadly proposed following solutions for examination reforms:

- Using more varied modes of assessment including oral testing and group work evaluation.
- Do not expect everything from everybody in every subject.
- Flexibility in time when examinations are taken.
- Enhanced reporting of performance.

Purpose of assessment

The purpose of assessment is necessarily to improve process and materials of the teaching-learning. This is feasible only if teacher is prepared with not only the tools and techniques of

assessment, but also with the learning indicators. Assessment is an integral part of teaching-learning process spread out to entire teaching-learning process and throughout the year.

- To collect, analyse, and interpret evidences to judge the extent of students' learning.
- To give students the feedback about their performance.
- To give feedback to the teacher about the learning gaps and conceptual changes taking place in the students.
- Plan teaching-learning situations in more suitable way.
- Support and improve every learner's learning and development.
- Provide evidences of learner's progress so as to communicate the same to parents and administrators.
- Reflect on the teaching-learning practices.

Tools and techniques of assessment

There is a wide choice of tools and techniques of assessment. Tool is a device to perform a task. For example, assignment, project work, field diary, laboratory work, unit test, etc. are tools of evaluation. Technique is a way of doing something in a systematic way. Oral examination, written examination, practical examination, observation, self assessment, peer assessment-etc. are techniques of assessment.

Tools and techniques must evaluate not just the achievement levels in understanding and process skills of science. Evaluation of the process of thinking of the learner; whether she knows where the information could be found, and how it can be found and used and how this information can be analysed and evaluated is also important.

Though many of the tools such as written tests, projects, assignments, activities/experiments, field visits, etc. are being used in schools, there are a large number of teachers who are seen not adopting all the different tools and techniques to the extent desired, thereby limiting their own understanding of the learner's learning and progress.

Let us now discuss why different tools and techniques of assessment need to be used. These are required, so that:

- ❖ learning in different areas of subject and aspects of concept development are to be assessed;
- ❖ learners are given an opportunity to be able to respond better to one tool and technique as compared to another; and
- ❖ each tool and technique contributes in its own way to the teacher's understanding of student's learning.

No single assessment tool or technique can provide information about a child's progress and learning in different areas of development. No tool or technique is superior to other and all are viable, if used properly. A lot can be understood from observing students, listening to them, discussing informally with their peers and parents as well as talking to other teachers, reviewing their classwork and homework and other articles made by students.

We shall discuss following tools and techniques of assessment:

(i) Written test

(ii) Project work

(iii) Field trips and field diary

(iv) Laboratory work

(v) Interview/oral test

(vi) Journal writing

(vii) Concept mapping

`We shall also discuss assessment of collaborative learning that can take place in a number of teaching-learning situations. We all agree that every student learns differently and the teacher is the main person who assesses student's learning. Teacher can use the following basic process of organising assessments, in using above tools and techniques:

Individual assessment: It focuses on one student while she is doing an activity/task and thus, on their individual work and accomplishments.

Group assessment: It focuses on the learning and progress of a group of students working on a task together with the objective of completing it. This method of organisation is found to be more useful in order to assess social skills, cooperative learning processes and other value related dimensions of a learner's behaviour.

Self assessment: Since assessment is part of the learning process, students themselves can and also need to play an important role in assessing their own learning and progress in knowledge, skills, interests, attitudes, etc. Teachers can help students assess themselves by enabling them to develop a better understanding of process of learning by involving them in critically looking at theirown work and performance.

Peer assessment: refers to one student assessing other students. This can be conducted in pairs or in groups.

Project work

A project work is a planned and definitely formulated piece of study involving a task or problem taken up by the learner either individually or in a group, to supplement and apply classroom and laboratory learning. It follows the approach of *Learning by Doing* and *Learning by Living*.

Project work attempts to promote problem solving, creativity and spirit of inquiry in science. Project work is a more or less open-ended activity and its type depends on the nature of the task.

Selecting a project

- Students may choose a project depending on their abilities, enthusiasm and interests. However, the complexity of the project, availability of the material resources, and time available to finish the project shall always influence the selection of task.
- The situations which can raise suitable questions amongst the students are identified. Such situations may be arrived at through libraries, laboratories, magazines, discussions, field trips, print and electronic media, internet, science journals, etc.
- The working on a chosen project must first include the tentative objectives that might be attained. The execution of the task must be properly planned. It is advised that the project team keeps a complete record of work including the choice of project, planning, discussions held, distribution of work assigned to different team members, references and books consulted observations, difficulties faced, guidance sought, etc.

Types of project

The nature of a project work may be categorised on the basis of tasks involved.

- ***Practical tasks****:* In which the emphasis is given on actual construction of material such as model making.
- ***Appreciation****:* In this type various direct experiences, such as reading or listening stories, etc. are involved.
- ***Problem solving:*** In which the purpose is to solve a problem involving the intellectual processes.
- ***Acquisition of a skill:*** In which the emphasis is aimed to attain a certain degree of skill, such as designing and performing experiments, and activities.

Approaches

Following approaches may be adopted in taking up a project work:

- building apparatus/model;
- performing experiments;
- carrying out survey;
- observing nature;
- using and interpreting available data;
- doing field work;
- engagement in exploration; and
- generation of information, etc.

Technical and academic guidance

- This is an important factor for smooth running of the project work. Students should plan for the project well in advance and discuss its design with the teacher. If improvisation of the apparatus or some instruments is needed or a chemical is not available in the laboratory, the help of teacher may be taken.
- If some academic guidance is required, help may be taken not only from concerned subject teacher but also from other science teachers as well.
- If a project work is carried out in the laboratory, the arrangements should be made in such a way that at a given time all students of the class are not involved in doing the laboratory work. Some students may be engaged in collecting references in the library or doing calculation while others may design experiments.
- Problem may arise in carrying out the long-term experiments such as corrosion, fermentation, etc. in the laboratory. It is suggested to have a separate bench in the laboratory, where long-term experiments can best be set up for storing the samples of certain chemicals and apparatuses relevant to the project work or cardboard boxes, with student's name written on them.
- Many students work at home. If parents understand the importance of project work, they sometimes help their children with the required facilities. Many students attend summer camps or attend some camps orgainsed by science centres during vacation time.

Reporting and recording of the project work

Some form of reporting on project is needed so that entire class can benefit from the experiences of those who have worked on the project. It is also essential to record the actual observation in the project work. Students should be encouraged to record the negative results also.

A general format for writing the project report is suggested below.

- Title of project reflecting objectives
- Principles used for investigation
- Apparatus and materials required.
- Improvisation, if any
- Procedure
- Observations and calculations
- Conclusion
- Precautions
- Result and discussion
- Suggestions for further investigations
- References

To illustrate the format outlined above, sample project reports are presented for upper primary, secondary and higher secondary stages.

Assessing the project work

Generally, following set of learning indicators is used to assess a science project

Table : Assessment of project work

Learning Indicators (LI)	Tasks specific to indicators
Creativity	• How unique is the project? • Is the project age appropriate and within the cognitive level of the child? • Is it student's original idea or suggested by parent or a teacher or a senior student.
Understanding of the topic	• Understanding of the objectives of the project. • Investigation of the literature for the project. • Mention of references/ bibliography used in the project.
Investigative procedure	• Suitable answers to the original questions.

	• Appropriateness of the procedure. • Completeness of information collected. • Accuracy of the conclusions.
Quality of the project	• How organised is the display of the project? • Are Tables, graphs and illustrations used effectively in interpreting data? • Are conclusions justified on the basis of experimental data? • Is the help of the group members, teachers, parents and others acknowledged?
Presentation	• Is there clarity in the written and oral presentation regarding their investigation? • Were they able to communicate clearly the nature of problem and how they could arrive at the conclusion. • How did they respond to the answers and questions raised by the class and the teacher related to their project?

Each project should be evaluated on its own merits and not in competition with other projects. Ability, interest and background of the student should be given full consideration while evaluating the project. Teacher should write comments and suggestions about each project while evaluating it. It encourages students to further improve quality of their projects.

Benefits/advantages/merits of project work

1. Collaboration: Relationships formed during collaboration is a huge part project. Not only do students learn how to work better in groups by providing their own input, listening to others, and resolving conflicts when they arise, they build positive relationships with teachers, which reinforce how great learning is.

Students also form relationships with community members when working on projects, gaining insight for careers and beyond.

2. Problem Solving: Students learn how to solve problems that are important to them, including real community issues, more effectively, even learning from failure and possibly starting over.

3. Creativity: Students apply creative thinking skills to innovate new product designs and possibilities for projects.

4. In-Depth Understanding: Students build on their research skills and deepen their learning of applied content beyond facts or memorization.

5. Self-Confidence: Students find their voice and learn to take pride in their work, boosting their agency and purpose.

6. Critical Thinking: Students learn to look at problems with a critical thinking, asking questions and coming up with possible solutions for their project.

7. Perseverance: In working on a project, students learn to manage obstacles more effectively, often learning from failure and possibly starting over from scratch.

8. Project Management: Students learn how to manage projects and assignments more efficiently.

9. Curiosity: Students get to explore their curiosities, ask questions and form a new love for learning.

10. Empowerment: Students take ownership over their projects, reflecting on and celebrating their progress and accomplishments.

Field trips and field diary

Field trips are actually the first-hand study of many things which cannot be brought into the classroom. A well planned field experience can be the most powerful educational tool for the teacher. A field visit should be viewed as innovative activity. A well organised field trip enriches educational experiences of all students learning with different paces and styles.

Students should know well in advance that where they are going; why are they going; and what are they going to do, etc. Some field experiences need only a few minutes for completion and can be done within the limit of a class period. Like in the above example, the activity was conducted in the school ground. Usually less preparation and planning are required if visits are arranged within school boundaries.

Some schools arrange field trips that can be as short as a few hours. Most commonly, students are taken to zoos, planetariums, museums, botanical gardens, hospitals and factories. While evaluating, the teacher should:

- See whether the students are able to relate the field experience to the concept that had already been discussed in the classroom. Teacher should set problems, experiments, review content on the basis of field trip;
- check the observations written by the students in their field diary; and

- Initiate the discussion about what all they have noted in their field diary and what all they have learnt from the field trip.

This makes learning realistic, concrete and interesting. Learners get opportunity to discover the concept and their connection with their environment. They can use this opportunity to learn various skills in interacting with the physical world, materials, technology and other people. It helps students to create knowledge by figuring out the components of objects, events, people, and concept. Let us now see the various advantages of field visits in teaching-learning of science.

Advantages of the field visits

The field visit:

- ❖ helps in providing first-hand experience to the students which is not possible within the four walls of the classroom;
- ❖ Enriches general knowledge of students. It supplements the classroom learning;
- ❖ helps in broadening the outlook, deepens insight and widens vision of students;
- ❖ gives the students new ideas and vision for taking up projects;
- ❖ Helps to deepen understanding of the concepts and brings clarity in the subject. It also helps in concretising the abstract ideas;
- ❖ helps the students develop an inquiry attitude towards the environment;
- ❖ develops skills in science processes like observation, collection, classification and analysis of data;
- ❖ brings the awareness that science is all around us and not just in books;
- ❖ relates the community to the learners, teachers and school and encourages sharing of responsibility of child's learning with the community;
- ❖ Acknowledges the authenticity of community knowledge, etc.

Organisation of the field visits

Planning: The entire planning can be done by students under the guidance of a teacher. First a guide sheet can be prepared. It should have learning details, physical details and administrative details.

Learning details: Consist of sites to be visited, data to be collected, list of questions to be asked to the persons working at the site and any process which is to be studied, etc.

Physical details: Route to be taken, time schedule, personal equipments, provisions for refreshments, meals, first aid box, materials to be carried such as umbrella, camera, etc.

Administrative details: Teacher needs to give details, purpose and outcome of the trip for getting permission from the administration of the school for the field trip.

The checklist of a planned field trip can be

- objective of the field trip;
- date of the field trip;
- time of departure;
- date and time of return;
- name of the supervisors accompanying students;
- rules of conduct for students;
- materials students need to bring for the trip, such as water bottle, umbrella, field diary, etc;
- cost for the trip; and
- Permission from parents. Transport facility should be also planned in advance.

Prior to students field visit, the place to be visited should be seen by the teacher and a student representative. They should find out, whether learning objectives would be achieved or not. The main aim of the visit should be providing learning experiences; pleasure should be the secondary aim. The objective of the visit should be clear to all learners in order to optimise learning.

Teacher should plan follow-up activities in order to make learning experience, a fruitful one. After coming back from the field visit students can discuss their observations and experiences, ask questions and share photographs. Teacher needs to encourage students to submit the report and mention explicitly what they learned from the visit. Evaluation of the field visit can be done in the light of the planned objectives.

Limitations

- At least a whole is required for the field trip, it is not possible to conduct it in few hours.
- Co-operation is required between teacher and students for its success.
- There can be accidents during field trip.
- There should be enough finances for field trips.

Role of teacher

- First of all the teacher should know about his students as regards to their age, previous knowledge and capabilities.

- The teacher should permission from the college in charge for the fieldtrip. Then he should complete all formalities and obtain permission of the in charge for the place selected for the trip.
- Everyone should be briefed about the main objectives of field trip so as to obtain expected co-operation.
- The teacher should also plan out how he would reply to the queries.
- After the field visits either at the meeting place or in school, time for discussion should be fixed.
- The students should be imparted knowledge of the prior knowledge of the trips.

Precautions during field visit

- The organizing teacher should gather all relevant information about the meeting place. If possible he should visit the meeting place and find out about the facilities and problems of that place. Accordingly he should make necessary arrangements and prepare instructions.
- A suitable and economical vehicle should be used. A first aid kit should be taken along in the vehicle.
- The students should be given necessary instructions to bring torch, phone, tape recorder and camera etc.

The resources maintained by the community can provide great learning experiences for students. These resources if tapped properly can help us in moving from science as an interpretation of visual and auditory symbols (words) to science as an experience. These community resources vary from place to place.

Laboratory work

Experiments play a crucial role in the progress of science. A large number of path-breaking discoveries and inventions have been possible through investigations done usually in laboratories. The experimental work is, therefore, an essential component of any course in science.

A course on practical work in science curricula in schools at the secondary stage is essentially designed to acquaint the learner with the basic tools and techniques used in a science laboratory. It also envisages developing problem solving skills. These skills help the learner to acquire ability to identify a problem, to design and to set up an experiment, to collect and analyse data through experiment. These are long-term objectives of laboratory work and play a major role in the learner's construction of knowledge.

Approaches to laboratory work

Some laboratory exercises focus onto verify a concept already transacted in the class, some can be used to achieve various learning experiences, other types of laboratory exercises might be used to develop a particular manipulative skill that is needed for a particular experimental work.

Deductive Approach laboratory work

Laws, principles and concepts when transacted in science classroom through discussion and then followed by laboratory work/ activity/experiment is called deductive laboratory work. In deductive laboratory work, students have some idea of what they are expected to find out. Many laws of physics and chemistry can be illustrated by deductive laboratory work which reinforces the concepts transacted.

Inductive Approach laboratory work

When students get an opportunity to develop concepts, principle and laws through first-hand experiences before concepts are discussed in the classroom, it is called inductive laboratory work. It is opposite of the deductive laboratory work. This approach provides students with a better understanding.

Technical skills Approach of laboratory

To conduct laboratory activities and experiments successfully, one should have good technical skills. These basic laboratory skills may be part of learners' first laboratory work and can be kept in mind while developing various learning indicators. Examples of some of the techniques and manipulative skills for science laboratory are:

- Using an analytical balance.
- Cutting and bending of a glass rod/glass tube.
- Heating liquid in the test tube.
- Folding filter paper for filtering solutions.
- Boiling liquid in a beaker.
- Pouring liquid from a reagent bottle.
- Transferring powders and crystals.
- Smelling a chemical/boiling liquid.
- Preparing solution of a given concentration.
- Titrating with a burette.

- ❖ Taking solution with the help of a pipette.
- ❖ Using paper chromatography to separate chemicals.
- ❖ Measuring solution using measuring cylinder.
- ❖ Connecting electrical devices in parallel and series.
- ❖ Measuring weight with a spring balance.
- ❖ Measuring temperature with a thermometer.
- ❖ Measuring various other quantities with suitable measuring devices. Determining the focal length of mirrors and lenses.
- ❖ Locating images in mirrors. Using and taking care of microscope.
- ❖ Washing of glassware, etc.

Assessment of laboratory work

Following points must be kept in mind while assessing the students regarding laboratory work:

- ➢ Collecting and using right apparatus/equipment.
- ➢ Drawing ray diagram/circuit diagram and planning appropriate procedure.
- ➢ Observing and collecting data systematically.
- ➢ Calculating the physical quantity using proper unit and significant figure.
- ➢ Interpreting the data and deriving the conclusion.
- ➢ Building up essential technical and process skills. Recording and reporting data honestly and supported with graph(s) and figure(s).
- ➢ Posing inquiry-based questions.
- ➢ Observing the laboratory rules including safety rules properly.
- ➢ Behaving properly in the laboratory.

In addition to oral questions, laboratory notebooks are also used by the teacher to assess learners' experimental work. Oral and written questions can be designed based on the activities, experiments and technological modules for testing students' critical understanding, problem solving and inquiry skills. Their performance in these activities should be assessed as an ongoing process.

Concept Mapping

Concept maps are graphical tools for organising and representing knowledge about certain concepts. A concept map represents an understanding of the relationship and hierarchy between important set of concepts. They promote meaningful learning in science. This can be understood by studying the following components of a concept map.

(i) **Concept:** Concept may be thought of as a mental framework of an event or an object. Any event or object is a concept because it has some identifiable properties or ideas associated with it. In addition, a concept also has a label (name).

For example – A 'ball-point pen' is a concept because it has certain properties, i.e., it is long; it has a refill and it is used for writing. Also it has this label 'ball-point pen.' In a concept map, concepts are usually presented enclosed within a circle or a box. The first step is to identify and enlist various key concepts in the topic. These concepts are then arranged in a two dimensional array hierarchically in descending order, i.e. the more general concepts are placed at the top followed by the less inclusive concepts. Concepts occurring at same level of observation are placed at the same horizontal level.

For example – For transacting the topic *Structure of atom*, the arrangement of the concepts can look like the one given in Fig. a,b

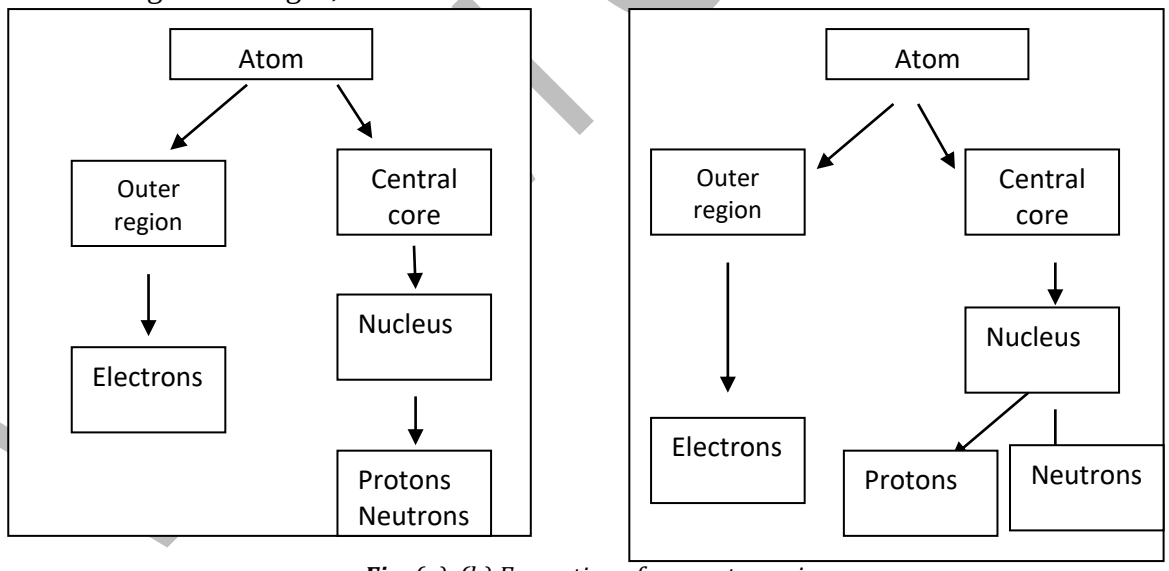

Fig. *(a), (b) Formation of concept map in process*

(ii) **Linkages:** They are usually represented by arrows or lines. They link two concepts appropriately.

(iii) **Labels for linkages:** The label for most linkages is a word/s or a phrase— although sometimes we use symbols such as +, –, x or ÷ for linkages in mathematics. Labels highlight the relationship between two concepts (Fig.). **These labels for linkages are also named as proposition.** Two or more concepts can be cross linked, if significant relationship exists between them.

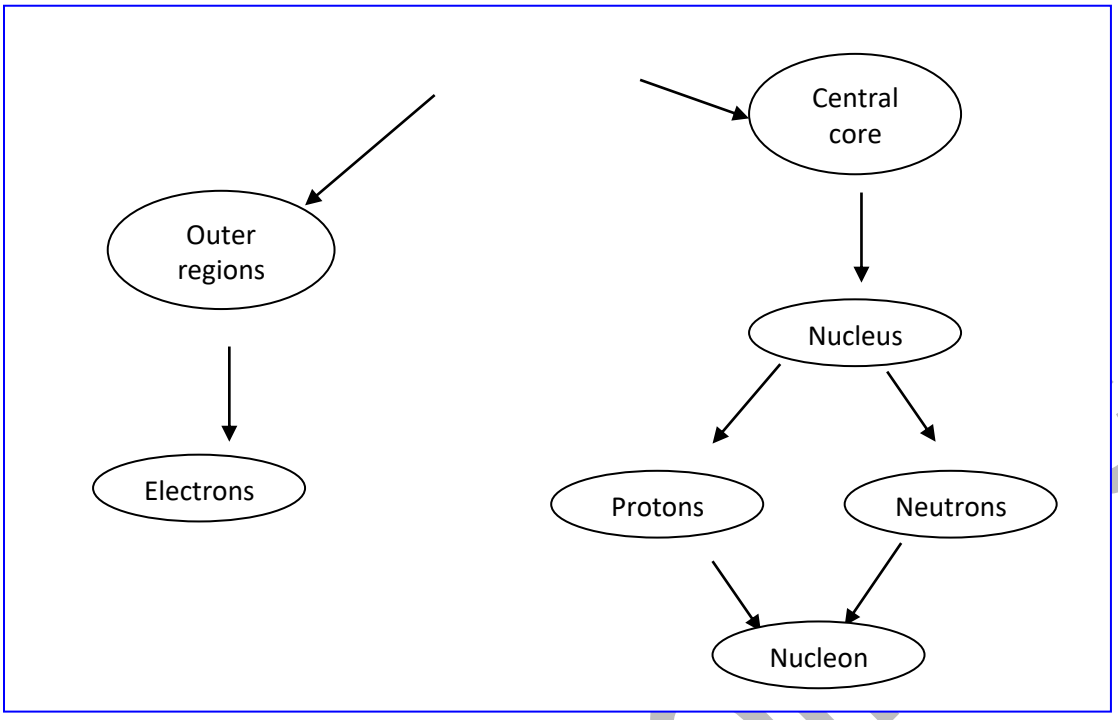

Fig. *A concept map*

Thus, we observe that concepts in a concept map are not isolated collection of the concepts. They are interconnected together through well labelled linkages. Cross-links are particularly powerful connections, which form a 'web' of relevant and interrelated concepts. These links enhance the anchorage and stability in the cognitive structure of concepts rather than just connecting general concepts to specific concepts. They tend to connect different sub conceptual structure. There is no limit on the number of connecting lines. As a matter of fact greater number of connecting lines represents integrative thinking and depth of knowledge of the learner.

Concept mapping (as developed in its standard form by Novak in 1984) is considered to be an offshoot of the Ausubelian approach. Novak himself asserts: "My work and the work of my students on concept mapping has been based upon Ausubel's theory of meaningful learning (1963, 1968). It is this fundamental principle that has led our research group to search for better ways to represent what the learner already knows."

Phases of the concept mapping

Phase I: Presentation of abstraction

- Students are presented with a definition or generalisation, which is linked to their existing cognitive structure.
- Students are asked to identify various concepts and sub-concepts and enlist them.

- Students' understanding of these concepts is assessed by asking them to provide new and unique examples.

Phase II: Propositional phase

- The teacher uses prompts and cues to guide the learners to arrange the concepts hierarchically with the broader/general concepts at the top and the less inclusive concepts at the bottom, giving the whole structure the look of a pyramid.
- The various concepts are interlinked logically by using (arrowhead) lines.
- These lines are supplemented by word/words/phrases, which define them and illustrate meaningful relationships between the various concepts.
- The whole concept map is viewed as a network of concepts.

Phase III : Application

The learners apply their knowledge to generate new examples and reflect on the existing ones.

Phase IV : Closure

The learners summarise the major ideas evolved during discussion (Fig.).

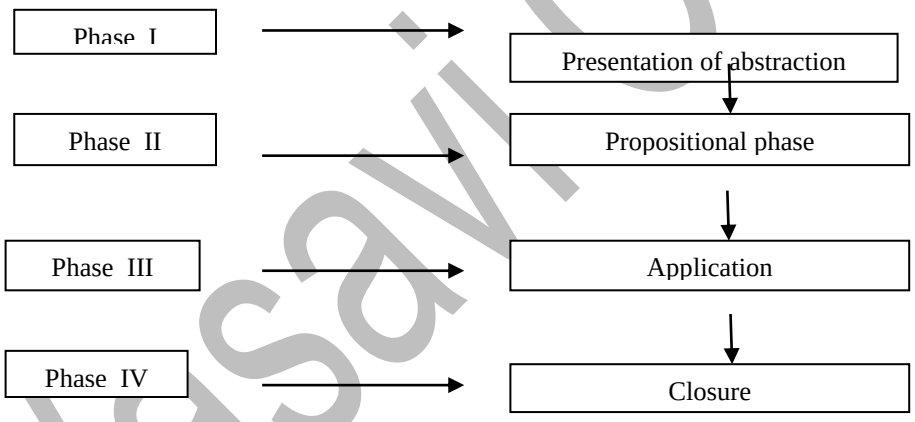

Fig. *Phases of Concept Mapping*

Uses of concept maps

The potential of concept maps needs to be explored in our schools as they are of tremendous use for learners, teacher, curriculum developers and evaluators. Some of the uses of concept maps are highlighted here.

(i) **For learners:** Concept maps can be used by learners for meaningful acquisition of concepts. This can be accomplished through various mechanisms, such as:

- ❖ Providing a visual representation of a particular material (e.g. text material). This helps the students to make better sense of the material, especially when the material is complex. A conceptual framework can be provided to elaborate on the key concepts.
- ❖ Helping learners develop new relationships among concepts in one or more related areas, thereby creating new meaning.
- ❖ Summarising material when preparing for examinations.
- ❖ Motivating learners to think and engage in active learning as they try to construct the most plausible relationships.
- ❖ Helping learners identify gaps in their knowledge.
- ❖ Making learners aware of the explicit roles that language plays in the exchange of information.
- ❖ Promoting reflective thinking associated with pushing and pulling of concepts, putting them together and separating them again.
- ❖ Allowing learners to exchange view, thereby achieving shared meaning, which is possible, because concept maps are explicit.
- ❖ Analysing an activity and an experiment in terms of procedure or content and reduce subsequent burden on working memory.
- ❖ Providing practice by using specific concept labels which act as attention catchers especially for students struggling to learn.
- ❖ A study (Prabha, 2005) shows that concept mapping as a teaching-learning strategy can be applied to facilitate learners to draw the ray diagrams of the formation of images by the lens and mirrors for different position of the object. It provides a holistic view of the phenomena of reflection and refraction of light.

(ii) **For teachers**: Concept maps may serve teachers in several ways such as:

- Helping in planning a lesson by identifying key concepts, their prerequisites and relevant examples.
- Serving as a means for providing an overview of some unit.
- Providing an operational definition of a teaching-learning goal by indicating the learning objectives that are to be attained.
- Serving as a remarkably effective tool for helping learners to identify their alternative framework (misconceptions and naïve concepts).

- Helping in planning interdisciplinary teaching-learning by developing a conceptually coherent programme that integrates concepts from different areas.

Thus, Construction of concept maps may be provided as an activity prior to a lesson to reveal previous knowledge of the learners; as homework; for consolidation; to summarise and review the lesson; in a group discussion; as an individual assignment in evaluation, etc.

(iii) **Concept maps as effective tools in complex laboratory environment**: The connection between theoretical concepts and experimental observations can be considered as criteria for meaningful learning of scientific concepts in complex laboratory environment. New experiments can be designed to understand integration and linkages with the theoretical part of the concepts using concept maps. Concept maps can also be created as a part of post-laboratory activity.

Interview/Oral test

Interview/oral test is a useful tool of assessment particularly for group work, project work and laboratory work. It can also be used as a follow up of other tools of assessment. It could be a personalised interview which helps to develop better rapport with student and get an insight into the process of work, the student has done/contributed. Many a times it becomes difficult to find out the individual's contribution in a group work or project. Interview may be even recorded, so that it can be analysed and applied to other findings.

Recording and Reporting

Recording and reporting of learning evidences are crucial components of assessment and evaluation. These should be carried out in holistic manner, so that these:

- convey a feeling of individual attention;
- reaffirm a positive self-image of the students;
- communicate personal goal for students to work towards its achievement; and
- Qualitative statements support the assessment.

Providing feedback to the students and parents is of paramount importance as it goes a long way in enhancing students' performance. Students' self-growth as well as development needs to be assessed and reported. Giving rank to the students should be avoided. The feedback regarding students given to their parents in the form of marks or grades fail to inform the scope of improvement in each subject. It is better to give qualitative feedback on the work done in each subject on continuous basis.

Position paper on Examination Reform NCERT 2006, recommends that the word 'Fail' should not appear on mark sheet. It can be represented by phrases such as 'unsatisfactory' or better 'needs more work to attain desired standards'. The word 'Fail' carries social stigma and often victimises a student for systematic deficiencies in teaching, textbook availability, etc.

Finally, students' progress in learning science needs to be consolidated on the report card. Each student can also assess herself and include this as self-assessment in the report card. Analysis of various areas of learning, such as process skills of science and scientific attitude, interest and inquiry can also be included on the report card.

This would assist students by pointing out the areas of study that they need to focus on, and also help them by providing a basis for further choices that they make regarding what to study further. The analysis of the performance of students, whether it is of Continues and Comprehensive Evaluation (CCE) or public examination is a very important activity. CCE has many advantages. Its feedback helps students immediately. The feedback to the students should be provided with positive suggestions, so that they feel a sense of achievement.

Measurement of students' achievements

The achievement of the students is mostly measured and recorded in terms of marks. This is being carried out by way of awarding numerical marks on an interval scale that runs from 0 to 100. The comparison of students' performance from subject to subject and from year to year is not possible. It is because neither the zero, nor the 100 are absolute. Zero does not indicate nothingness and 100 does not indicate the perfection in achievement.

This limitation results in variations in spread of scores in different subjects. Further, the measurement error may vary and as such comparison on the basis of variation of 1 or 2 marks is not justified. This shortcoming can be overcome if the students are placed in ability bands that represent ranges of scores. The National Policy on Education (1986) recommended the introduction of Grade system for assessment of achievement of the students.

Grading system

The word 'grade' is derived from the Latin word *Gradus* which means 'step.' In educational measurement, grading involves the use of a set of symbols to communicate the level of achievement of the students.

Types of grading

(a) Direct Grading: In direct grading, the performance exhibited by an individual is assessed in qualitative terms and the impression so obtained by the examiner is directly expressed in terms of letter grades.

The advantage of direct grading is that it minimises the inter-examiner variability. Moreover, it is easier to use in comparison to indirect grading. Direct grading, however,may lack transparency.

(b) Indirect Grading: In this method, the performance of an examinee is first assessed in terms of marks and subsequently transformed into letter grades by using different modes. This transformation may be carried out in terms of both 'absolute grading' and 'relative grading' as discussed below:

(i) Absolute Grading: Absolute grading is based on a pre-determined standard that becomes a reference point for assessment of students' performance. It involves direct conversion of marks into grades, irrespective of the distribution of marks in a subject. It is just like categorisation of students into five groups, namely, distinction (75and above), first division (60% and less than 75%), second division (45% and less than 60%), third division (33% and less than 45%) and unsatisfactory (Below 33%).

It is possible to divide the absolute grading into any number of categories. Though, the range of marks may be the same in different subjects in each of the category, the grades so awarded are not comparable as the marks themselves are not comparable. The number of students placed in different categories will differ from subject to subject and from year to year making them incomparable.

An example of absolute grading is given below

Letter of grade	Range of marks	Description
A	90% and above	OUTSTANDING
B	80%-89%	EXCELLENT
C	70%-79%	VERYGOOD
D	60%-69%	GOOD
E	50%-59%	ABOVEAVERAGE
F	40%-49%	AVERAGE
G	30%-39%	BELOW AVERAGE
H	20%-29%	MARGINAL
I	below 20%	UNSATISFACTORY

This method is simple and straight forward. Meaning of each grade is distinctly understandable. Each student has the freedom to strive for the attainment of the highest possible grade, as the

classification of grades is pre-announced. The limitation of this method is that the distribution of scores is taken on its face value regardless of the errors of measurement creeping in due to various types of subjectivity.

(ii) Relative Grading: Relative grading is generally used in public examination. In this system, grade of a student is decided not by her performance alone rather than performance of the group.

This type of grading is popularly known as ‘grading on the curve. 'The curve refers to the normal distribution curve or some symmetric variant of it.

This method amounts to determine in advance approximately what percentage of students can be expected to receive different grades, namely, A, B, C and so on with reference to a specific group. If the perceived curve is transformed into a normal curve, it allows us to categories the obtained scores in to any desired number of grades in a scientific manner. If we decide to use an in point grade system, we may simply divide the entire measurement scale into nine (5or7or11) equal parts.

Advantages of relative grading

- Performance of individual student is rated in terms of grades and no grade signifies the failure of students, thereby eliminating the negative effect of pass or fail.
- Grades indicate the relative position of an individual with reference to her peer group, serving the purpose of norm-referencing, i.e. whether the individual student has performed better or worse than other students.
- Test difficulty does not affect the distribution of grades.

MEASURES OF CENTRAL TENDENCY

1. Arithmetic mean
2. Median
3. Mode

1. Arithmetic mean:

“The arithmetic mean or more simply the mean is the sum of the separate scores or measures divided by their number.”- II.E. Garett

Calculation of Arithmetic mean:

1. Direct Method or Long Method

In this method the mean is calculated directly from the given series. In this method we can calculate mean from the ungrouped data and the formula for calculating mean from un-grouped data. The formula for calculate mean from un-grouped data is

$$M = \frac{\sum X}{N}$$

Where M = mean
$\sum$ = sum total of score
X = scores
N = Total number of class

From the grouped data the mean is calculated by the following formula:

$$M = \frac{\sum f X}{N}$$

Where M = The mean
$\sum$ = sum total of score
f = frequencies of the distribution
X = scores
N = Total number of class

Illustration

Calculate the mean from the following frequency distributions by direct method

Scores	f	x	fx
40-44	2	42	84
45-49	1	47	47
50-54	4	52	208
55-59	7	57	399
60-64	9	62	558
65-69	10	67	670
70-74	7	72	504
75-79	9	77	693
80-84	4	82	328
85-89	3	87	261
90-94	2	92	184
	58		$\sum f X$ = 3936

By applying formula

$$M = \frac{\sum f X}{N}$$

$$= \frac{3936}{59} = 67.86$$

2. Short Method or Assumed Mean Method

It is known as assumed mean method because instead of calculating mean from the mid-points we take assumed mean to find out the mean. First we 'guess' or assume a mean and then we apply a correction to this assumed value in order to find the exact value.

The formula to find out the mean in the assumed mean method is given below:

M=A.M.+ C.i

Where M = Arithmetic mean

A.M. = Assumed mean

$$C = \frac{\sum f x'}{N}$$

i = Size of the class interval

We can write the formula as following by replacing $C = \frac{\sum f x'}{N}$

$$M = A.M. + \frac{\sum f x'}{N} \times i$$

Scores	f	x	fx	
80-89	1	4	4	48
70-79	6	3	18	
60-69	8	2	16	
50-59	10	1	10	
40-49	12	0	0	
30-39	7	-1	-7	
20-29	3	-2	-6	-19
10-19	2	-3	-6	
	58		$\sum f x' = 29$	

Here we have taken 44. 5 the mid-point of C.i. 40-49 as assumed mean. Now we can Find out mean by using formula

$$M = A.M. + \frac{\sum f x'}{N} \times i$$

$$= 44.5 + \frac{29}{50} \times 10$$

$$= 44.5 + .58 \times 10$$

$$= 44.5 + 5.8$$

$$= 50.3$$

Mean = 50.3

Benefits of Mean

1. Mean is the centre of gravity in the distribution and each score contributes to the determination of it when the spread of the scores are symmetrically around a central point
2. Mean is more stable than the median and mode. So that when the measure of central tendency having the greatest stability is wanted mean issued.
3. Mean issued to calculate other statistics like S.D., coefficient of correlation, ANOVA, ANCOVA etc.

2. Median

The value of the middle item of a series arranged in ascending or descending order. As such it divides a series into two equal parts. ”-D.Patri

Calculation of Median

Calculation of Median from Ungrouped Data

In case of ungrouped data the scores are arranged in order of size. Then the midpoint is found out, which is the median.

Illustration-when N is odd

In a class 9 students have secured following marks in a vocabulary test. Find out the median.

Marks—6,12,8,13,7,10,7,11,9

In ungrouped data

$$\text{Mdn} = \frac{n+1}{2} \text{ th item}$$

To solve the above problem first we have to arrange the scores

in order of size of 6,7,7,8,9,10,11,12,13

Now $\text{Mdn} = \frac{n+1}{2}$ th item

$= \frac{9+1}{2} = \frac{10}{2}$ 5th item

*Illustration-when **N** is even*

Calculate the Mdn of the following data of 10 students of a spelling test in English.

Marks=7,6,8,12,7.9,11,10,13,14

To solve the problem we have to arrange in order of size 6,7,7,8,9,10,11,12,13,14

Now applying formula we get

$\text{Mdn} = \frac{n+1}{2}$ th item

$= \frac{10+1}{2} = \frac{11}{2}$ 5.5 th item

Here in order to find out 5.5th item we have to find out the average of 5th and 6th item

i.e. $= \frac{5\text{th item} + 6 \text{ th item}}{2}$

$= \frac{9+10}{2} = \frac{19}{2} = 9.5$

So 9.5 is the Mdn.

Calculation of Median from Grouped Data:

We know that median is a point which distributes the distribution into two equal halves.

The formula to find out median from grouped data

$$\text{Mdn} = L + \frac{\frac{N}{2} - F}{fm} \times i$$

Where L = Lower limit of the Median Class.

Median class is that class whose cumulative frequency is greater than the value of N/2

i.e. N/2 > c.f. (cumulative frequency)

N/2 = Half of the total number of scores.

F = Cumulative frequency of the class internal below the median class.

fm = Frequency of the median class.

I = Size of the class internals.

Illustration

Find out the median of the distribution.
Below are given the scores of 40 students in a test of mathematics:

Scores	f	c.f
70-71	1	40
68-69	2	39
66-67	3	37
64-65	5	34
62-63	5	29
60-61	7	24
58-59	6	17
56-57	4	11
54-55	3	7
52-53	2	4
50-51	2	2
	40	

$$= \frac{N}{2} = \frac{40}{2} = 20$$

L = 59.5. Because the N/2 i.e. 20 is included in the cumulative frequency of the class interval 60-61, and the exact limits of the C.i. = 59.5-61.5.

F = 17.bThe cumulative frequency below the mdn class.

fm = 7. The exact frequency of the mdn class.

i = 2. Size of the class interval.

Now putting the value into the formula

$$\text{Mdn} = L + \frac{\frac{N}{2} - F}{fm} \times i$$

$$= 59.5 + \frac{20 - 17}{7} \times 2$$

$$= 59.5 + \frac{3}{7} \times 2 \quad = 59.5 + 0.85$$

$$= 60.36$$

Mdn of the distribution is 60.63.

Mdn can also be calculated from the upper limit of the distribution. The formula to find out mdn by taking upper limits reads like this.

$$\text{Mdn} = U - \frac{\frac{N}{2} - F1}{7fm} \times i$$

Where U = The upper limit of the Mdn class.

F1 = The cumulative frequency of the class interval above the Mdn class.

fm = Frequency of the median class.

I = Size of the class-interval.

In case of calculating Mdn from upper limit the only difference is we have to compute cumulative frequency from the upper end.

Illustration

Scores	f	c.f
70-71	1	40
68-69	2	39
66-67	3	37
64-65	5	34
62-63	5	29
60-61	7	24
58-59	6	17
56-57	4	11
54-55	3	7
52-53	2	4
50-51	2	2
	40	

Here $= \frac{N}{2} = \frac{40}{2} = 20$

U = 61.5. Because the cumulative frequency 23 includes the N/2 i.e. 20.

F = 16. Cumulative frequency of the class interval above the Mdn class.

fm = 7 frequency of the median class.

i = 2

Now Mdn = $U - \frac{\frac{N}{2} - F1}{7fm} \times i$

$= 61.5 - \frac{20-16}{7} \times 2$

$= 61.5 - \frac{4}{7} \times 2$

$= 61.5 - 1.14$

$= 60.36$

The Mdn is 60.36.

Illustration

30 students have secured following marks in a test of mathematics. 4 students have secured below 10 marks. 6 students have secured marks between 10 to 20, 10 students between 20-30, 8 students between 30 to 40, 7 students between 40 to 50 and 3 students above 50. Find out the Mdn.

Scores	f	c.f
Below 10	4	4
10-20	6	10
20-30	10	20
30-40	8	28
40-50	7	35
50 - above	3	38
	N = 40	

Here $\frac{N}{2} = \frac{38}{2} = 19$

L = 19.5. Lower limit of the Mdn class i.e. 20-30.

F = 10. C.f. of the C.i below Mdn class.

fm =10

I = 10

so Mdn = L= $+\frac{\frac{N}{2}-F}{fm}$ x i

$= 19.5 + \frac{19-10}{710}$ x 10

$= 19.5 + \frac{9}{10}$ x 10

$= 19.5 + 9 = 28.5$

So Mdn of the distribution is 28.5.

Benefits of Median

1. Median is used when the exact midpoint of the distribution is needed or the 50 % point is wanted.
2. When extreme scores affect the mean at that time median is the best measure of central tendency.
3. Median is used when it is required that certain scores should affect the central tendency, but all that is known about them is that they are above or below the median.
4. Median is used when the classes are open ended or it is of unequal cell size.

3. Mode

Mode is the most frequently occurring scores in a distribution.

Methods to Determine Mode

1. Inspection Method
2. Grouping Method
3. Empirical Relation Method

1. Inspection Method

In this method mode is determined just by observation. Here mode is determined by observing the most frequently occurring score or the class interval against which the maximum frequency stands is taken as the modal class.

2. Grouping Method

When the value difference between the highest frequency and the next highest frequency is very low at that time it is not safe to determine mode in inspection method. In such doubtful cases were uses grouping method.

Illustration

Find out the mode of the following distributions

Scores	25	30	35	40	45	50	55	60	65
Frequencies	10	20	18	19	21	6	22	24	22

First of all we shall prepare the following statement

Scores	f					
	1	2	3	4	5	6
25	10	} 30	} 38	} 48	} 57	} 58
30	20					
35	18	} 37	} 40	} 46	} 49	} 52
40	19					
45	21	} 27	} 28	} 68		
50	6					
55	22	} 46	} 46			
60	24					
66	22					

Let us prepare the analysis table

Probable values of classes ▶ / Frequency Columns ▼	25	30	35	40	45	50	55	60	65
1								1	
2							1	1	
3							1	1	1
4								1	1
5	0	1	1	1					
6	0	0	1	1	1				
Total	0	1	2	2	1	-	2	4	2

The above analysis table shows that around the score 60, maximum clusters i.e. total 4.

So here 60 is the modal value.

When the data is in the continuous series we can calculate mode by applying the following formula:

$$M_0 = L_0 = + \frac{f2}{fn+f9} \times i$$

Where M_0 = Mode

L_0 = Lower limit of the modal class

F_2 = frequency of the class succeeding modal class.

F_0 = frequency of the class preceding modal class.

i = Size of the class interval.

Illustration

From the following data determine the mode

Marks	10 -15	15 -20	20 -25	25 -30	30 -35	35 -40	40 - 45	45 -50
No. of sts	5	6	15	10	5	4	2	2

Solution:

Here class interval 20-25 contains highest frequency. So that it can be considered as the modal class

Here
L = 20
$f_2 = 10$
$f_0 = 6$
i = 5

$$M_0 = L + \frac{f2}{f0+f2} \times i$$

$$= 20 + \frac{10}{6+10} \times 5$$

$$= 20 + \frac{10}{16} \times 5$$

$$= 20 + 3.13 = 23.13 \text{ (Approx)}$$

3. Empirical Relation Method:

This is the most effective method of determining mode. Prof Karl Pearson has envisaged this method. The distance between the mean and Median is 1/3 rd of the distance between the mean and mode.

Therefore 1/3 (Mean-Mode) = Mean – Median. From this relationship Pearson has observed that

Mode = Mean – 3 (Mean – Median)

= 3 Median – 2 Mean

Illustration

Find out the Mode from distribution given above.

Solution

The mean of the distribution is 25.94

The Median of the distribution is 23.83

M_0 = 3Median – 2Mean

M_0 = 3 x 23.83 – 2 x 25.94

= 71.49 - 51.88

= 19.61 (Approx.)

Benefits of Mode

(i) When we want a quick and approximate measure of central tendency.

(ii) When we want a measure of central tendency which should be typical value.

Advantages of Measures of Central Tendencies

1. Average provides the overall picture of the series. We cannot remember each and every fact relating to a field of enquiry.

2. Average value provides a clear picture about the field under study for guidance and necessary conclusion.
3. It gives a concise description of the performance of the group as a whole and it enables us to compare two or more groups in terms of typical performance.

MEASURES OF VARIABILITY

"The scatter or variability of the observations of a distribution about some measure of central tendency." C.V. Good

1. The Range
2. The Quartile Deviation
3. The Average Deviation
4. The Standard Deviation

1. The Range (R)

Range is the difference between in a series. It is the most general measure of spread or scatter. It is a measure of variability of the varieties or observation among themselves and does not given an idea about the spread of the observations around some central value.

Range = H - L

Here H = Highest score

L = Lowest score

Example

In a class, 20 students have secured the marks as following:

22,48,43,60,55,25,15,45,35,68,50,70,35,40,42,48,53,44,55,52

Here – the highest score is 70

The lowest score is 15

Range = H – L = 70 -15=55

Benefits of Range

- Range is used as a measure of dispersion when variations in the value of the variable are not much.
- Range is the best measure of variability when the data are too scattered or too scant.
- Range is used when the knowledge of extreme score or total spread is wanted.
- When a quick estimate of variability is wanted range is used.

2. The Quartile Deviation (Q)

It is based upon the interval containing the middle fifty percent of cases in a given distribution. One quarter means 1/4th of something, when a scale is divided into four equal parts. "The quartile deviation or Q is the one-half the scale distance between the 75th and 25th percentiles in a frequency distribution."

- 1st quartile or Q1 is position in a distribution below which 25% cases and above Which 75% cases lie.
- The 2nd quartile or Q2 is a position below and above which 50% cases lie. It is the Median of the distribution.
- The 3rd quartile or Q3 is the 75th percentile, below which 75% cases and above which 25% cases lie.

So the quartile deviation (Q) is one half the scale distances between the 3rd Quartile (Q3) and the 1st quartile (Q1). It is also known as the Semi-Inter quartile Rage.

Symbolically

$$Q = \frac{Q3 - Q1}{2}$$

Therefore order to compute quartile deviation first of all we have to compute 1st Quartile (Q1) and the 3rd quartile (Q3)

$$Q1 = L + \frac{\frac{N}{4} - F}{fq1} \times i$$

Where = L = Lower limit of the 1st quartile class,

The 1st quartile class is that class, whose cumulative frequency is greater than the value of N/4 when if is calculated from lower end.

N/4 = One fourth of the total number of cases.

F = Cumulative frequency of the class interval below the 1st quartile class.

Fq1 = The frequency of the Q1 class

I = Size of the class interval 3N.

$$Q3 = L + \frac{\frac{3N}{4} - F}{fq2} \times i$$

Where: L = Lower limit of the 3rd quartile class

The 3rd quartile class is that class whose cumulative frequency (Cf) is greater than the value of 3N/4 i.e. Cf >3N/4, when Cf is calculated from lower end.

3 N/4 = ¾ th of N or 75% of the total number of cases.

F = Cumulative frequency of the class below the class.

fq2 = The frequency of the Q3 class.

I = Size of the class interval.

Computation of Quartile from Group Data

Example

Find out the quartile deviation of the following data

Class intervals	f	c.f
95-99	1	50
90-94	2	49
85-89	4	47
80-84	5	43
75-79	8	38
70-74	10	30
65-69	6	20
60-64	4	14
55-59	4	40
50-54	2	6
45-49	3	4
40-44	1	1
	N = 50	

Step-1

Compute N/4 i.e. 25% of the distribution and 3 N/4 i.e. 75% of the distribution.

Here N = 50 so N/4 = 12.5 and 3N/4 = 37.5

Step-2

Compute the Cf from the lower end. As in above table column -3.

Step-3

Find out the Q1 and Q3 class.

Here

C.i, 60 – 64 is Q1 class because the Cf > N/4

C.i. 75 – 79 is Q3 class because the Cf > 3 N/4

Step-4

Find out F for Q1 class and Q3 class. In this example

F for Q1 class = 10

F for Q3 class = 30

Step - 5

Find out Q1 by putting the above values in formula.

Q1 = L+N/4 – F/fq1xi

Here L = 59.5 because the exact limits of the Q1 class 60—64 is 59.5 - 64.5.

F =10 the Cf below the Q1 class

Fq1 = 4: the exact frequency of Q1 class

I =5, size of the class interval

N/4 =12.5

Now Q1 = 59.5+12.5-10/4x5

= 59.5+2.5/4x5

= 59.5+0.63x5

= 59.5+3.13=62.63

Step - 6

Find out the Q3 by putting the values in formula.

Here L = 74.5 because the exact limits of the Q3 class 75-79 is 74.5-79.5.

F =30 the Cf below the Q3 class.

3N/4 =37.5

Fq1 = 8 the exact frequency of Q3 class.

I = 5 size of the class intervals.

Q3 =74.5+37.5-30/8x5

=74.5+7.5/8x5=74.5+.94x5

=74.5+4.7=79.2

Step- 7

Find out Q by putting the above value in formula.

Q =Q3-Q1/2=79.2–62.63/2

=16.5/2=8.285=8.29

Benefits of quartile deviation:

1. When Median is the measure of central tendency at that time Q is used as the measure of dispersion.
2. When extreme scores affect S.D. or the scores are scattered at that time Q is used as measure of variability.
3. When our primary interest is to know the concentration around the median-the middle 50% of cases, at that time Q is used.
4. When the class intervals are open ended, Q is used as measure of dispersion.

3. The Average Deviation (A.D.)

"Average deviation is the arithmetic mean of all the deviations of different scores from the mean value of the scores without the regard for sign of the deviation."

"The average deviation or A D is the mean of the deviation so fall the separate scores in a series taken from their mean (occasionally from the Median or Mode)." - H.E. Garrett

Symbolically

$AD = \frac{\Sigma |x|}{N}$

Where AD =Average deviation

£ = Capital Sigma, Means Sum total of

II = Modulous in short Mod, means no respect to negative sign.

X = deviation, (X—M)

Computation of AD from ungrouped data

Example

Find AD of the following 10 scores given below

23,34,16,27,28,39,45,26,18,27

Solution

ΣX/N

$M = \frac{\Sigma x}{N} = \frac{283}{10} = 28.3$

Find out the absolute deviation as shown in table and then Σ|x|

Sl. No.	Scores X	Deviations x=(X-M)	Absolute deviation IxI
1	23	-5.3	5.3
2	34	5.7	5.7
3	16	-12.3	12.3
4	27	-1.3	1.3
5	28	-0.3	0.3
6	39	10.3	10.3
7	45	16.7	16.7
8	28	-2.3	2.3
9	18	-10.3	10.3
10	17	-11.3	11.3
			Σ|x| = 75.8

$AD = \frac{\Sigma |x|}{N} = = \frac{75..8}{10} = 7.58$

The A.D.=7.58.

Computation of AD from grouped data

Example

Find out the AD of the following data

Class Intervals i	Frequency f
95-99	1
90-99	2
85-99	4
80-99	5
75-99	8
70-99	10
65-99	6
60-69	4
55-99	4
50-99	2
45-99	3
40-99	1
	N=50

Mean=70.80

c. i	f	X midpoint	fx	X(X-M)	|x|	l(x)
95-99	1	97	97	26.20	26.20	26.20
90-94	2	92	184	21.20	21.20	42.40
85-89	4	87	348	16.20	16.20	64.80
80-84	5	82	410	11.20	11.20	56.00
75-79	8	77	616	6.20	6.20	49.60
70-74	10	72	720	1.20	1.20	12.00
65-69	6	67	402	-3.80	3.80	22.80
60-64	4	62	248	-6.80	8.80	35.20
55-59	4	57	228	-13.80	13.80	55.20
50-54	2	52	104	18.80	18.80	37.60
45-49	3	47	141	-23.80	23.80	71.40
40-44	1	42	42	-28.80	28.80	28.80
	N=50		Σfx=3540			Σlx= 502.00

$AD = \frac{\Sigma |fx|}{N}$

Where =AD=Average deviation

Σ=Sum total of

f=frequency

x=deviation i.e.(X—M)

N=Total Number of cases i.e Σf.

Substitute the values in formula

$$AD = \frac{\Sigma |fx|}{N}$$

$$= \frac{502}{50} = 10.04$$

AD = 10.04

Benefits of Average Deviation:

1. Average deviation is used when it is desired to weight all the deviations from the mean according to their size.

2. When extreme scores influence standard deviation at that time AD is the best measure of dispersion.
3. AD is used when we want to know the extent to which the measures are spread out either side of the mean.

4. The Standard Deviation (SD)

It is commonly used in experimental research as it is the most stable index of variability. Symbolically it is written as σ (Greek small letter sigma).

"A widely used measure of variability, consisting of the square root of the mean of the squared deviations of scores from the mean of the distribution." - C.V.Good

Computation of SD from Ungrouped Data

Example

Find out the SD of the following data
6,8,10,12,5,8,9,17,20,11.

Solution

x	x	x^2
6	-6.6	31.36
8	-3.6	12.96
10	-1.6	2.56
12	0.4	0.16
15	3.4	11.56
8	-3.6	12.96
9	-2.6	6.76
17	5.4	29.16
20	8.4	70.56
11	-0.6	0.36
Σx=116		Σx^2 =178.4

Mean = $\frac{\Sigma X}{N} = \frac{116}{10} = 11.6$

Step -3 Find out the x^2

Step – 4 Find out the Σx^2

Step – 5 substitute the value in formula

Formula for $\sigma = \sqrt{\frac{\Sigma x^2}{N}}$

Where Σ = Sum total of
x = deviation of the scores from the mean.
N = Total number of scores

Now substitute the values in formula

$$\sigma = \sqrt{\frac{\Sigma x^2}{N}} = \sqrt{\frac{178.4}{10}} = \sqrt{17.84}$$

$$= 4.22$$

Computation of SD from grouped data

In grouped data SD can be calculated in two methods

1. Direct method or Long method

2. Short method or Assumed Mean method

1. Direct method or Long method

Example

Find out the SD of the following distribution

Class intervals	f
95-99	1
90-94	2
85-89	4
80-84	5
75-79	8
70-74	10
65-69	6
60-64	4
55-59	4
50-54	2
45-49	3
40-44	1
	N = 50

Solution

Step-1

Find out the midpoint of each class interval.

ci	f	X	fX	x	fx	Fx^2
95-99	1	97	97	26.20	26.20	686.44
90-94	2	92	184	21.20	42.40	898.88
85-89	4	87	348	16.20	64.80	1049.76
80-84	5	82	410	11.20	56.00	627.20
75-79	8	77	616	6.20	49.60	307.52
70-74	10	72	720	1.20	12.00	14.40
65-69	6	67	402	-3.80	-22.80	86.44
60-64	4	62	248	-8.80	-35.20	309.76
55-59	4	57	228	-13.80	-55.20	761.76
50-54	2	52	104	-18.80	-37.60	706.88
45-49	3	47	141	-23.80	-71.40	1699.32
40-44	1	42	42	-28.80	-28.80	829.44
			Σfx = 3540			Σfx^2 =7978.00

Step-2

Find out the mean of the distribution

Here M = Σfx/N=3540/50

=70.80

Step-3

Find out the deviation(x) by deducting the mean from points.

Step-4

Find out the fx by multiplying the f (col-2) with x (col-5)

Step-5

Find out the fx by multiplying fx (col-2) with x (col-5)

Step-6

Compute Σ fx by adding the values in col-7.

Step-7

Substitute the values in formula.

The formula for SD = $\sigma = \sqrt{\frac{\Sigma f x^2}{N}}$

Where Σ = sum total of

f = frequency of the class intervals

x = deviation of scores from their mean

N = Total number of scores (Σf)

Now putting the values in formula we get

$\sigma = \sqrt{\frac{\Sigma f x^2}{N}} = \sqrt{\frac{7978.00}{50}} = \sqrt{159.56}$

= 12.63

Thus the σ *is* 12.63

2. Short Method or Assumed Mean Method:

Example : Compute the S.D of the following distribution

Class intervals	f
95-99	1
90-94	2
85-89	4
80-84	5
75-79	8
70-74	10
65-69	6
60-64	4
55-59	4
50-54	2
45-49	3
40-44	1
	N = 50

Solution

1	2	3	4	5
ci	f	x'	fx'	fx'^2
95-99	1	5	5	25
90-94	2	4	8	32
85-89	4	3	12	36
80-84	5	2	10 (+43)	36
75-79	8	-1	8	20
70-74	10	0	0	8
65-69	6	-1	-6	0
60-64	4	-2	-8	6
55-59	4	-3	-12	36
50-54	2	-4	-8 (-55)	32
45-49	3	-5	-15	75
40-44	1	-6	-6	36
	N = 50		$\Sigma fx'$ = -12	$\Sigma fx'^2$=322

$\sigma = i \sqrt{\frac{\Sigma f x^2}{N}} - c^2$

Where I = Size of the class interval

Σ = Sum total of

f =frequency

x'=deviation of the scores from their assumed mean.

C = correction = $\frac{\Sigma f x'}{N}$

Now if we shall substitute Σfx'/N in place of C.

The formula will be as following:

$$\sigma = i\sqrt{\frac{\Sigma f x'^2}{N} - \left(\frac{\Sigma f x'}{N}\right)^2}$$

Now substitute the values in formula we get

$$\sigma = 5\sqrt{\frac{322}{50} - \left(\frac{-12}{50}\right)^2}$$

$= 5\sqrt{6.44 - 0.058}$

$= 5\sqrt{6.38}$

= 5x2.5258 = 12.629 = 12.63

So the SD of the distribution is 12.63

Benefits of S.D

1. S.D. is used when our thrust is to measure the variability having greatest stability.
2. When extreme deviations might affect the variability at that time S.D. isused.
3. S.D. is used for calculating the further statistics like coefficient of correlation, standard scores, standard errors, Analysis of Variance, Analysis of Co-variance etc.
4. When the interpretation of scores is made in terms of the NPC, S.D is used.
5. When we want to determine the reliability and validity of test scores, S.D. is used.

ADVANTAGES OF MEASURES OF VARIABILITY

1. The measures of variability help us to measure the degree of deviation, which exist in the data. By that can determine the limits within which the data will navy in some measureable variety or quality
2. With the help of measures of validity we can compare the original data expressed in different units.
3. It is useful to supplement the information provided by the measures of central tendency.
4. It is useful to calculate further advance statistics based on the measures of dispersion.

CORRELATION

"Correlation is the tendency for corresponding observations in two or more series to vary together from the averages of their respective series that is to have similar relative position." - C.V.Good

Types of correlation

1. **Positive Correlation**: When increase or decrease in one variable brings corresponding increase or decrease in the other variable

A positive relationship ranges from 0 to +1. When it is+1the correlation is Perfect positive correlation.

2. **Negative Correlation**: Where increase in one variable results in decrease in other variable and vice-versa, the relationship is said to be negative correlation. The negative correlation may range from 0 to-1.
3. **Zero agreement or no relation** : When there is no systematic relationship between two sets of scores or variables in that case it is known as zero agreement or no correlation. The change in one variable is not any way associated with the change of other variable.
4. **Linear Correlation:** When the relationship between two variables is proportional and it can be described by a straight line, it is called Linear Correlation.
5. **Non-Linear or Curve-Linear Correlation:** When the relationship between the variables is not proportional throughout the series and it can be described by a curve line is called as curve linear correlation.

Coefficient of correlation

"Coefficient of correlation is a pure number, varying usually from +1through 0 to1,that denotes the degree of relationship existing between two (or more) series of observations" - C.V.Good.

- The coefficient of correlation is designated in two ways. In Karl Pearson's Product moment it is expressed as 'r'.
- In Spearman's Rank difference correlation it is expressed as 'p' (rho)

Symbolically

$$\rho = 1 - \frac{6x\Sigma d^2}{n(n^2-1)}$$

Where ρ = Spearman's Rank Correlation coefficient

D = $R_1 - R_2$

Σd^2 = sum of the squares of difference in rank

n = Number of pairs

Find out the co-efficient of correlation between two sets of scores by rank difference method.

Students	A	B	C	D	E	F	G	H
Marks in Test -1	15	14	20	12	22	15	12	10
Marks in Test -2	24	20	20	16	26	18	14	14

Table

Pupils	Marks in Test-1	Marks in Test-2	R_1	R_2	D	D_1
A	15	24	3.5	2	1.5	2.25
B	14	20	5	3.5	1.5	2.25
C	20	20	2	3.5	1.5	2.25
D	12	16	6.5	6	0.5	0.25
E	22	26	1	1	00	00
F	15	18	3.5	5	-1.5	2.25
G	12	14	6.5	7.5	-1	1
H	10	14	8	7.5	0.5	0.25
						Σd^2 =10.5

$$\rho = 1 - \frac{6x\Sigma d^2}{n(n^2-1)} = 1 - \frac{6x10.5}{8(8^2-1)}$$

$$= \frac{63}{8x63} = 1 - 0.13 = 0.87$$

Benefits of Coefficient of correlation

1. To find out the degree of relationship or inter dependence between two variables r is used.
2. To predict the dependent variable from the independent variable r is used.
3. To determine the reliability of a test result r is used.
4. To determine the validity of test scores r is used.
5. To take decisions in educational and vocational guidance r is used.
6. To compute other statistics like fact or analysis, regression prediction and multiple correlation etc. r is required.

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Unit - 10

Professional Development of Physical Science Teachers

Syllabus :Teaching as a profession – need for pre–service professional development programmes – special qualities of a science teacher – ethics of a teacher–need for in-service professional development programmes – opportunities for in-service professional development – reflective practice – Teacher as researcher – Action research in physical science.

Introduction:

A teacher of science needs to remain engaged in her professional development throughout her career as a teacher. Her learning and professional development does not end with the completion of pre-service education programme. She needs to continue her growth for enhancing her effectiveness as a science teacher. One of the main reasons behind it is that knowledge in science and its applications are ever expanding. Approaches to teaching-learning of science are being continually improved and made innovative as a result of researches in science education and educational psychology. New and better apparatus and kits are being developed and used in teaching-learning process of science. Information and Communication Technology (ICT) has opened up new opportunities in the field of education.

Moreover, teacher carries an enormous responsibility on her shoulders. The task of shaping the future generation lies in her hand. She has to pay attention to the holistic development of the students who can contribute constructively to the society. Thus, it is imperative that she realises the importance of her own contribution towards society and takes pride in her job of being a science teacher.

Teacher has to remain sensitive to the social, professional and administrative contexts in which she works. She has to consciously attempt to formulate her own professional orientation as a teacher in situation-specific manner.

Teaching as a profession

Defining profession is the most challenging task at hand in general and teaching as profession in particular. Redefining teaching as a profession is no less a critical task in the world of today where every day the same age old concept gets a new meaning in the light of experiences emerging out of interactions and confrontations with changed meaning of life. However, some **characteristics of profession** can be enumerated that are found to be relevant towards determining its existence as a profession.

- A profession requires specialised knowledge with extensive training and an advanced level of intellectual skills in carrying out its service to society.
- A profession provides an essential service that is both unique and definite to society and only the people within that profession should provide the service
- Members of a profession enjoy a considerable degree of autonomy and decision-making power. They are largely free of closely supervised performance. Members of a profession primarily make their own decisions and regulate their own activities.
- Members of a profession are required to accept personal responsibility for their actions and decisions.
- A profession is responsible for monitoring its own members and self-governing. The implications of the previous statement make it essential for professional groups to perform various duties to keep the level of their services high and to watch for the economic and social well–being of the members of the profession.
- A code of ethics exists within a profession that sets out acceptable conduct for its members. The existence of this code is necessary to enforce a level of high standards.
- A profession emphasises the services it provides over the financial rewards.
- It is generally agreed that members of a profession not only get paid for their work, but receive a high salary commensurate with the time and effort required to obtain their specialised knowledge and skills.
- Society must recognise an occupation as a profession.
- A profession is considered a lifework or terminal occupation. Those involved usually stay in the field for the rest of their careers.
- Professional development of a person in a profession is a continuous process.

It is important to remember that a profession needs not have all the above characteristics we have discuss above. Many professions do not satisfy all of the characteristics. You can reflect on the nature and dynamics of action of a teacher as a professional. Teacher needs to recognise herself as a professional endowed with the necessary knowledge, attitude, competence, commitment, enthusiasm, spirit of seeking new ways and means of dealing with teaching-learning situations and capability of reflection on her own practices. She should be sensitive and perceptive not only to the learners and the institution but also the emerging concerns in a larger social perspective within which one functions. Do you think teaching profession is a profession which makes all other professions possible?

Need for Pre-service Professional Development Programmes

With proper planning, teacher acquires confidence and presents the content with flexibility. In other words, teaching-learning becomes effective, if planned properly as teacher has more options to choose approaches and strategies of teaching-learning and assessment tools. While planning teaching-learning experiences of physical science, a teacher has to consider many factors required for effective teaching learning experiences such as:

- individual differences;
- cognition level of learners;
- importance of learners' experiences and their existing ideas;
- process of learning- assimilation, accommodation and construction and reconstruction of concepts;
- learning styles of learners;
- approaches and strategies of teaching-learning, tools and techniques of assessment;
- Management of discipline in class, etc.

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

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

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

NCF-2005 recommends the Teacher can acquire these knowledge from her B.Ed course.

Teachers needs to be prepared to

- care for children, and should love to be with them;

- Understand children within social, cultural and political contexts.
- be receptive and be constantly learning;
- view learning as a search for meaning out of personal experience, and knowledge generation as a continuously evolving process of reflective learning;
- View knowledge not as an external reality embedded in textbooks, but as constructed in the shared context of teaching-learning and personal experience.
- Own responsibility towards society, and work to build a better world;
- appreciate the potential of productive work and hands-on experience as a pedagogic medium both inside and outside the classroom; and
- analyse the curricular framework, policy implications and texts.

Pre-service professional development programmes for physical science teachers

A. At Elementary Level (Up to Class VIII)

(i) *Diploma in Elementary Teacher Education*

(a) Duration of course: 2 years

(b) Eligibility: 12th Pass

(c) Admission criteria: Entrance test

(ii) *Bachelor of Elementary Education*

(a) Duration of course: 4 years

(b) Eligibility: 12th Pass

(c) Admission criteria: Entrance test

B. At Secondary and Higher Secondary Level

(i) Bachelor in Education

(a) Duration of course: 2 years

(b) Eligibility: Graduate for Trained Graduate Teacher (TGT); Post Graduate for Post Graduate Teacher (PGT);

(c) Admission criteria: Entrance test and interview or only Entrance Test

(*ii) Bachelor in Education through Distance Mode*

(a) Eligibility and admission criteria are same for regular B.Ed. programme.

(b) Additional requirement: 2 years full-time teaching experience in a school

(c) Duration: 2 years

(iii) Bachelor in Education for TGTs & PGTs for Special Educational Needs students. (SEN)

All criteria for admission are same for regular B.Ed Programme.

(iv) Four year integrated B.Sc.B.Ed. Courses

(a) Duration of course: 4 years

(b) Eligibility: 12^{th} Pass

(c) Admission criteria: Class 12th marks and Interview

NCF-2005 observes that the existing teacher education programmes neither accommodate the emerging ideas in the context and pedagogy nor address the issue of linkages between school and society. There is little space for engagement with innovative educational experiments. The new vision of teacher education programme is more responsive to the changes in the school system as it envisages a major shift.

Special qualities of Science teacher

1. Good Academic Back ground:

For primary school, the teachers should possess at least 12^{th} standard. For Secondary school, the teachers should possess at least UG degree and For Higher secondary school; the teachers should possess at least PG degree. In addition to knowledge of his subject, he should have sufficient general knowledge. For this he should have literary tastes .He must be a well read person.

2. Professional Efficiency:

Teacher must have some pre-service training like D.El.Ed. for primary level and B.Ed for secondary and higher secondary level. While in-service, he should attend short term Refresher courses, workshops, seminars and educational conferences so that he goes on adding to this professional efficiency. The teacher should have a sense of dedication to the teaching profession. Teacher's enthusiasm, professional insight and sense of dedication are his valuable assets.

3. Personality Traits:

Teacher's personality traits have deep impact on the pupils.

Children friendly: The teacher must love his pupils. He must understand them individually and try to help them in overcoming their difficulties. His attitude should be sympathetic and friendly.

Sound character: The teacher should have high moral character. He should have sound Principle of life as his ideas and conduct will affect the children profoundly.

Emotionally Stable: The teacher must be emotionally stable. He must be free from complexes, worries and frustration. An emotionally unstable teacher cannot do justice to his work.

Clarity in thoughts: The teacher must be able to express his thoughts clearly His oral and written expression must be good. He has to write reports and so many other things. His speech, pronunciation and voice must also be impressive.

Sense of Humor: In the school, the teacher should have smiling face and a cheerful look while teaching. His sense of humor will help him to overcome very serious situations, which can be sometimes laughed away.

Social Traits: The teacher should be sociable in nature. He must maintain good relations with his colleagues, pupils and their parents and general public. He must be mixing with people. Only then he will be able to develop social virtues in students.

Leadership quality: The teacher should be able to provide effective leadership to the children who are immature and need guidance in matters of study, activities and other courses etc.

Ethics of a teacher

The Code of Professional Ethics for teachers provides a framework of principles to guide them in discharging their obligations towards students, parents, colleagues and community. Increased awareness of the ethical principles governing the teaching profession is essential to ensure 'professionalism' among teachers.

All teaching is founded on ethics–whether it be the teacher-student relationship, pluralism or a teacher's relationship with their work.

Dignity: It means respect for humanity. Teachers must respect every person, regardless of gender diversity, sexual orientation, , appearance, age, religion, social standing, origin, opinions, abilities and achievements.

Truthfulness: Truthfulness is one of the core values in teachers' basic task, which involves steering learners in navigating life and their environment.

Honesty: Honesty with oneself and others and mutual respect in all communication is a basic aspect of teachers' work.

Fairness: Fairness is important both when encountering individual learners and groups but also in the work community. Fairness involves in particular promoting equality and non-discrimination and avoiding favouritism.

Teachers and relationship towards work

- Teachers are entitled to their own values, but in their work, teachers' responsibility is tied to their basic task and its standards such as legislation and the curriculum
- Teachers commit to the standards and ethics of their work
- Teachers manage their duties responsibly
- Teachers develop their work and expertise and assess their own actions
- Teachers teach in a manner that reflects their personality, so developing and caring for their individuality is their right and obligation
- Teachers are entitled to be treated fairly in their work

Teachers and relationship towards learners

- ❖ Teachers accept and treat learners as unique human beings.
- ❖ Teachers respect the rights of learners and react to them humanely and fairly.
- ❖ Teachers try to understand the learners' starting point, thoughts and opinions.
- ❖ Teachers considerately handle matters linked to the learner's personality and privacy.
- ❖ Teachers pay special attention to learners who require care and protection and do not, under any circumstances, tolerate bullying or the abuse of other people.
- ❖ Teachers' work also includes teaching learners to co-operate and to become good members of society. Building up confidence and good relationships is part of teachers' work.

Teachers and relationship towards community

- ➢ Teachers value their work and respect their colleagues
- ➢ Teachers try to pool their resources and find a balance between their autonomy and the work community
- ➢ Accepting the individuality of colleagues, understanding them and helping and supporting each other are key principles of the work community

Teachers and relationship towards society

- Teaching is one of the most important jobs in society.
- Teachers' ability to be effective in their work and take care of their professional development is dependent not only on their commitment, but also on the resources allocated to teaching and education
- Teachers promote the opportunities offered by education and growth

- Teachers represent, above all, learners' rights and interests–even critically, if necessary. In their work, they also teach learners to become responsible members of a democratic society.

Teachers and relationship towards stakeholders

Teachers work together with learners' parents, guardians and other parties responsible for education, training and well-being. These include social and health care expert groups, authorities and numerous other collaborating parties. The co-operation supports learners' learning and development.

Teachers and plurality

Teachers need to ensure that all learners have the same rights and obligations as members of society. They make sure that learners and their parents' cultures and world views are respected equally and that no one is discriminated against based on them.

Need for In-Service Professional Development Programmes

Though the pre-service professional training is very important, the professional training received by a teacher during a pre-service teacher training programme is not always sufficient for her entire career. When a teacher starts her teaching career, the situation faced by each teacher is unique. She has to think creatively for context-specific examples and to come up with the innovative ideas for using local resources to provide meaningful teaching-learning experiences in physical science to the learners.

New developments in science and pedagogy of physical sciences are occurring continuously. Unless teachers are facilitated to keep themselves barest of these developments, they are bound to show resistance to new ideas no matter how sound they look to educationists.

Therefore, in-service training programme is conducted by many organizations and institutes that can contribute significantly to the professional development of new teachers as well as experienced teachers. Teachers can identify the areas related with learning of physical science where they feel the need of training, and send them to such organisations for consideration of their participation.

Science teachers also need to keep track of developments in other curricular areas so that they can adopt integrated approach and provide holistic learning experiences to the learners. The society is also changing with time and this has a great impact on education. The teacher has to adapt her teaching-learning strategies to these changes.

To achieve all this, a science teacher will have to continuously strive for her professional development. A sincere and dedicated teacher can have to devote extra time and efforts beyond school hours for her professional development.

Position paper of *National Focus Group (NFG) on Teaching of Science* recommends, "All in-service programmes for science teachers should be need-based. Need assessment of teachers should be taken on continuous basis. It is practically impossible to provide in-service education to all science teachers in 'face-to-face' mode within a reasonable time frame and with limited resources. Distance learning options for teacher empowerment should be put in place. Online courses and website for each class level could be another potential option. Teachers get about 60 days of vacation in a year.

A good part of this should be meant for professional development. Most of the in-service programmes should be organised during these breaks. However, teachers may be compensated suitably by providing leave. Teachers should be encouraged to display self-directedness and responsibility for honing their professional competence."

Science teachers need to develop their abilities to align the teaching-learning experiences to learners' environment, to find learning resources from their environment, locally available resources and the community. Local indigenous knowledge and practices in the local area are important to consider in the training of teachers. In order to make generalised knowledge relevant and meaningful, school knowledge should be connected to local knowledge.

The teacher should continuously improve her skills in development of teaching aids, science kits, improvised apparatus; laboratory work; writing better test items; continuous and comprehensive assessment of learners and how to:

- Create and organise constructivist learning situations such as observation, collaboration, multiple interpretation, etc.
- move beyond textbook and classroom; and
- Engage learners to reflect, analyse and interpret in the process of knowledge construction, etc.

The teacher has to continuously hone her abilities of integrating a variety of learning experiences such as debate, discussion, drama, poster making, celebrating specific days and field trips with classroom experiences. In-service training provides opportunity to the participating teachers to work collaboratively; share ideas, thoughts and experiences on learning resources, activities, experiments

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

Let us now see how a teacher took initiative to share his knowledge and skills acquired in a training programme with his colleagues. Many times teacher has to find the way out to work on a problem. Science teachers also need to understand the problems of students having special needs such as:

- ***Dyslexia*** is the difficulty to write and read, however students with this problem may be smart at other skills.
- ***Dyscalculia*** is the problem associated with numbers. They interchange the places of digits. This makes it difficult for children to learn mathematics.
- ***Dyspraxia*** is characterised by lack of or poorly developed skills in skilled tasks like typing, sewing, etc. Such children can also show sign of difficulty in speaking and can be slow at eating and drinking.

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

Opportunities for in-service professional development

Some of the opportunities through which a science teacher can achieve continuous professional growth are shown in Fig. and discussed below.

(A) Interacting with peer teachers

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

Integrated approach to science teaching-learning implies continuous interaction with the teachers of other subjects as well. Interacting with other teachers, science teachers learn to see better correlation between science and other subjects such as mathematics, social science, literature, art and computer science. It provides enrichment of their teaching-learning experiences. This practice can initiate the breaking of tight boundaries between various disciplines.

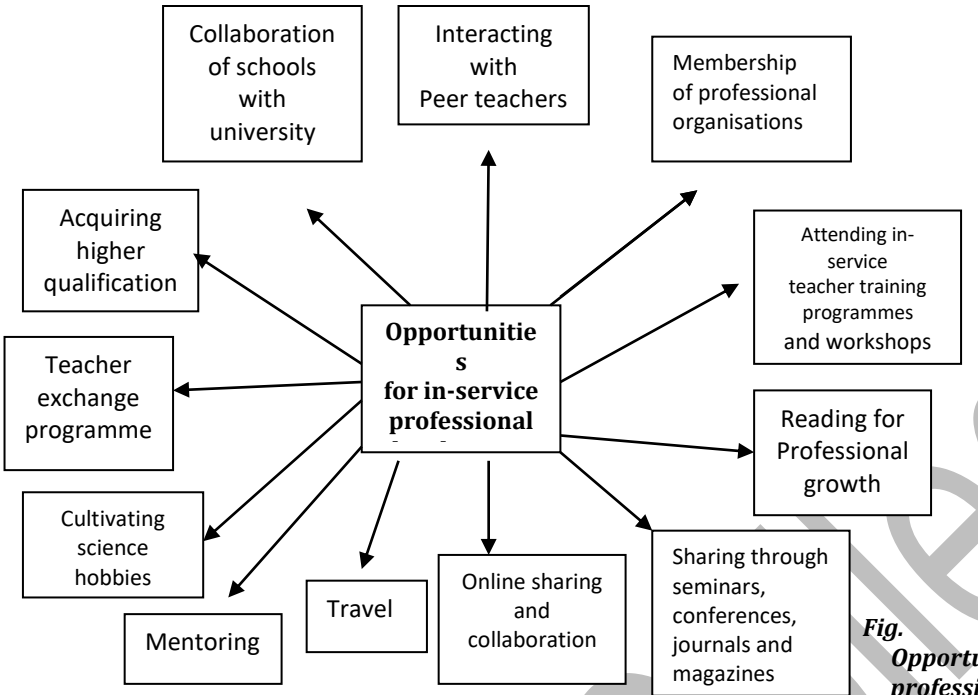


Fig. Opportunities for in-service professional development

Science teachers should not restrict their professional interactions with teachers of their own schools only. They should also interact with teachers of neighbouring schools through informal/formal meetings, e-mails and various social networking sites. They can create occasions to meet each other without institutional initiative. Contributing in the magazines for science teachers, organising seminars, symposia, science exhibitions, interacting with scientists and educationist of eminence can all contribute to the development of quality in teachers.

(B) Reading for professional growth

Science teachers should devote time to reading for their professional growth. They should regularly read various books, journals and periodicals related with science and science education. Reading of these on regular basis can keep science teachers up-to-date on contemporary developments in content and pedagogy of science. For this, they can spend some time in school library. They can subscribe to a few journals also.

Teachers should become members of a professional library to get access to science books, educational journals and various curriculum materials prepared by state education departments. They may find such a library at block/district level. They may periodically visit DIET (District Institute of Educational Training). SCERT (State Council of Education Research and Training) and B.Ed. colleges for library reference work.

Teachers may request their school authorities to subscribe to some affordable journals. They can try to develop a common library to be shared amongst teachers of many neighbouring schools. Science teachers can also visit library of a neighbouring science college to enrich their science content knowledge.

Teachers can search internet and get lots of ideas for activities, teaching-learning materials, test items, audio-visual (AV) aids, etc. Teachers may also watch various science programmes on television and listen to science talks on radio.

(C) Attending in-service teacher training programmes and workshops

Many teacher training programmes and workshops are conducted round the year, all over the country, by various organisations such as NCERT, SCERTs, DIETs, KVS (Kendriya Vidyalaya Sangathan), NVS (Navodaya Vidyalaya Sanghtan), Teacher Education Colleges, Teacher Associations,University Education Departments and NGOs. In-service training programmes and workshops are conducted by experts to take care of the particular needs of teachers. Some of the areas in which teacher training programmes and workshops are conducted regularly in Physical sciences are *Designing improvised apparatus, Developing Low cost teaching-learning materials, Writing test items, Improving laboratory skills, Content enrichment in science/physics/chemistry, activity based teaching-learning and Use of Science kits.* Whenever teachers feel a need for training in a particular area, they may request the authorities to provide them opportunity to attend such a training or workshop.

(D) Membership of professional organisations

There are many national and international professional organizations which provide an excellent forum to teachers for exchanging their ideas. These are dedicated to the promotion of science education and professional growth of science teachers. A list of some such organisations is given below. You may add on the names of some moreassociations by searching the websites and collectings information regarding the activities carried out by them. You can also become a member of such organisations.

Some professional organisations for science teachers are:

- All India Science Teachers' Association (Kolkata)
- Indian Science Congress Association (Kolkata)
- Indian Association of Physics Teachers (Chandigarh)
- Delhi State Science Teachers' Foum (Delhi)

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

(E) Sharing through seminars, conferences, journals and magazines

In seminars and conferences, one gets an opportunity to meet a large number of teachers and exchange teaching-learning experiences and innovative ideas with them. By attending relevant science seminars and conferences, a science teacher can learn about the innovations that other teachers are doing. The science teacher herself might have developed a new idea to improve teaching- learning of science/physics/ chemistry and she may present it as a paper in seminar or conference.

The notifications for seminars and conferences come out in newspapers and journals. These information are also available on the relevant websites. The teachers can send their request for participation after seeking permission from their school authorities. They should use opportunities of attending such programmes to enrich their professional experiences.

The teachers can also send their articles to any national or international journal or magazine for publication and wider dissemination. This is the most convenient way to exchange ideas with other science teachers. Usually, directions for submitting an article are given in each issue of the journal/magazine. Each journal/ magazine prescribes a special format and style that one has to follow for submitting the article.

(F) Online sharing and collaboration

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

In recent years, ICT and internet has emerged as a powerful and dependable media of interaction. We need to recognise the potential of internet to promote universal access, facilitate participatory forums and develop a learning community. This can be sound investment for continuous

and on-demand teacher training and support, research and content depositories and value-added distance education.

Many online courses for professional development aim at increasing the access, equity and quality of education. Teachers can take courses on the topics for which learning resources are not available locally. They can also get ideas for teaching-learning on any topic from a variety of internet sites. They can evaluate website content for its quality and usefulness.

(G) Travel

Science teachers can get lots of information and materials when they go out even on their personal visit to other places without cutting down the enjoyment and relaxation of the travel. Their information and material can be shared with the students and colleagues.

Science teachers must always be on a lookout for an opportunity to visit science parks, science museums, planetariums, industries, mines, refineries, national laboratories and institutions, power stations, etc. During such visits they should try to observe, learn and gather as much information as possible. If an expert is available to explain, teacher should seek her/his help. Such visits will help in deepening the understanding of a science teacher regarding various processes, concepts and phenomenon. This in turn will enrich the learning experiences provided by the teacher to her learners.

During such visits, science teacher should also try to obtain descriptive literatures, collect samples of materials and click photographs. All these resources can be utilised by the teacher while designing teaching-learning experiences. Proper advance planning is needed to obtain the greatest benefit from such visits.

(H) Cultivating science hobbies

Science teachers can enrich their knowledge in a specific subject by cultivating science hobbies that may be directly or indirectly related to their teaching area. For example, a physical science teacher can pursue hobbies in the field of electronics, robotics, etc. If a science teacher has a flair for writing and she can explain a concept in a lucid style then she may write articles on science topics for spreading scientific awareness among public and send them for publication in newspapers and magazines. A teacher with good oral communication skill can approach radio station to give talks related to popular science topics. Teacher can also approach television transmission centre and give a presentation related to science topics on television.

Science hobbies help not only to understand the subject better but also provide more confidence in classroom situations. Many science exhibitions and fairs are organised all over the country. Some of them are Jawaharlal Nehru National Science, Mathematics and Environment Exhibition for Children, State Level Science and Environment Exhibition for Children, National Science Congress for children, etc. Helping children to participate in these events enables the teachers to deepen their own content understanding.

(I) Mentoring

Experienced science teachers may play the role of mentors for lessexperienced teachers. Mentoring can be done to improve teachinglearning practices, to encourage lifelong learning, to motivate teachers to work in emerging areas, to plan activities, experiments and projects, etc. Mentor can help in brainstorming problems that a beginner teacher faces. They can evaluate the performance of the biginner teacher in the class and provide constructive criticism for her betterment. Mentors may also provide handholding to teachers taking up action research.

(J) Teacher exchange programmes

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

(K) Acquiring higher qualifications

A physical science teacher may try to improve her qualifications by enrolling for M.Sc., M.Ed., Ph.D. or other such programmes. Some schools allow their teachers to take study leave/sabbatical leave to obtain an advanced degree. Teacher should apply for study leave well in advance so that the school management can recruit a replacement for the teacher proceeding on leave. If obtaining study leave is not feasible, teacher may pursue these programmes through open universities. Acquiring higher qualifications is beneficial for enriching content and pedagogy knowledge of science and making teaching-learning more effective. It may enhance the possibility of promotion of the teacher in future.

(I) Collaboration of schools with university

Many colleges, universities and institutions conduct training for teachers in various areas of physical science. Teacher herself can visit laboratory and library and discuss with the professors on the concepts she needs elaborations. This can help her to plan field visit to these places for her students also. She can involve herself in the preparation of training modules, textbook development, research project, etc. taken up by colleges and other institutions. This would break isolation among science teachers teaching at various stages at the school and college.

Role of reflective practices in professional development

A reflective teacher reflects on her action and strives to improve her practices continually for the growth in her career. Reflective practices help a teacher to make right choice and decision on the issues related to teaching-learning of physical science.

Reflective practice is a continuous and cyclic process as depicted in Fig. The cycle starts with planning. The teacher plans on the basis of evaluation of the existing ideas of her students and her previous science lesson. Next, she transacts the concepts. In this process she continuously assesses and evaluates performance of her students as well as her own practices. On the basis of this evaluation, she plans her next lesson. Thus, the reflective teacher never stops thinking about what is being learnt by her students and her own practices. She is engaged in self-analysis and self- evaluation for the improvement of teaching-learning of science.

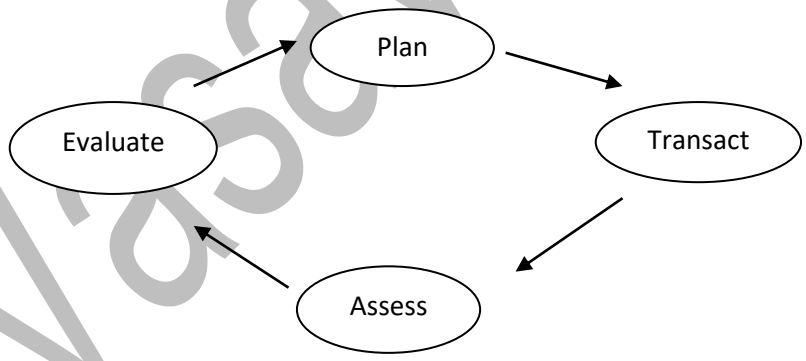


Fig. Reflective practice is a continuous and cyclic process

Thus, for her professional growth, it is essential for a science teacher to evaluate her classroom performance and be self-critical. After each class, teacher should reflect back and try to self-analyse the effectiveness of her classroom transactions. However, sometimes self analysing may not be the best way because a teacher may overlook certain things.

So, the teacher may invite other science teachers to observe her classroom transactions to evaluate her performance and provide constructive feedback. She should develop professional skills not only in science and pedagogy of science but also in documentation, analysis and interpretation of performance of students. Teacher needs to remain open-minded, listen with attention to others and work collaboratively for her professional development.

i) Questionnaire

Teacher can get feedback about her performance in the classroom by giving a questionnaire to students. The questionnaire can be prepared by the teacher herself or by a committee of teachers and administrators. The students in the class can be asked to complete the questionnaire. Statement in the questionnaire should be written in a positive manner along with suitable alternative such as yes/no; true/false or rating scale such as 1 to 5.

Students should be assured that their marks would not be affected by completing the questionnaire in order to encourage them to give response of all questions. Such feedback can be obtained from the colleagues also. Information obtained from the questionnaire can be very useful for self-assessment of the teacher and to make further improvements in the teaching-learning experiences designed by her.

These can be responded by the students, peers and administrators. In many cases, teacher can get the feedback through group e-mail or any other tools of Information and Communication Technology. A teacher may maintain a reflective log on regular basis. These examples are suggestives, not prescriptive.

ii) Research

Research is one of the important components of professional development of science teacher. Teacher can perform a systematic evaluation of her own problems related to various aspects of teaching-learning of physical science to find their solution and test her process and materials in the classroom. This type of research in the classroom is *Action Research.* It does not require extra time beyond daily routine.

Teacher can publish findings of her work in science journals and magazines. Such teachers are recognised by their students, colleagues, authority and communities for their work. A few enthusiastic students may come forward to help on the research. Observing their teachers actively engaged in the

research, they can get motivated to work on their own investigatory projects. In fact many teachers do such type of study. However their work needs to be properly documented and disseminated.

"Research is the process of obtaining a dependable solution of the chosen problem by collecting data and its analysis and interpretation. Research is principled effort of obtaining new knowledge."

In the light of the above definition, following important points emerge in relation to research:

- Research is a planned process of finding the solution of the problem based on certain strict principles.
- As a result of research, there is an increase in the knowledge of humankind.
- It is necessary to go through certain steps for conducting research.
- It is apparent that a formal training is required for conducting research and may everyone not find himself/herself proficient to conduct the research, though everyone in his/her field of work faces several work related problems and has to find a solution for them to proceed ahead.
- Formal research findings are many a time not applicable at ground level as in a formal research, professional maneuvers and limitations may make them impracticable.

On such a scenario, a functionary who needs an immediate solution of his/her problem, though may not be having the formal training in research, has to find a solution himself/herself. In order that solution is dependable, he/she himself/herself has to conduct a certain kind of study. Such a study is called action research.

Thus, action research is a research which a functionary conducts to find the solution of a problem; he/she is facing for his/her own benefits. The solution so found by applying the systematic procedure is the solution of his/ her particular problem and may or may not be generalisable. Action research is done by the practitioners themselves rather than professional researchers. In this case, the teacher is a part of the situation, rather than an outside spectator.

iii) Maintaining a portfolio

Teacher should maintain a portfolio to keep record of her all professional activities. It may include certificate of participation in training programmes, and honours and awards received. The portfolio may also include nature of her contributions to the various science programmes, copy of action research paper if published or report of finding of research, degree/diploma earned or report on progress made towards it, record of any innovation done in teaching-learning of science, anecdote of an event that shows her professional achievement, academic contribution outside the school such as

member of science research project conducted by a professor, nature of participation in professional organisation, etc.

The portfolio should be continuously updated with a mention of dates. Maintaining a portfolio may take time but it is rewarding in terms of professional growth and development. Portfolio also helps a teacher in reflection of her performance. Portfolio provides retrievable evidences of your work that can be accessed easily. There is less possibility of missing out information about any important achievement.

Teacher as a researcher

A successful teacher would always like to improve teaching-learning practices and grow in his career. If he collects evidences of problems and solutions regarding these practices and apply systematically in the class room, it would create more dynamic learning environment and lead to better understanding of students.

Moreover, the findings of the research will give him a sense of achievement, boost self-confidence and develop a sense of ownership to his own learning. Development and research in any field of life cannot be separated from each other. Development in any field is based on the quality of research under taken in the field.

Teaching-learning is no exception to the above statement. In order to effectively handle the intricacies of teaching-learning process, a teacher on the one hand has to be fully trained and on the other hands he should be able to comprehend the problems emerging at every step of the process and to find their appropriate and scientific solution.

A teacher comes across many problems and she tries to find an instant solution through her understanding of the problem based on her previous experiences. But many a time, such a solution is either partial or temporary. Thus, a teacher needs to find a solution which is based on ‘research’, so that the solution obtained really solves her problem. Generally, the procedure adopted by the teacher to solve the problem faced by her is based on:

- Analyzing her problem scientifically in the specific perspective in which the problem has emerged.
- Suggesting a solution based on the above analysis
- Testing the solution her self
- Accepting the solution only when it satisfies the above test

Such a process adopted by the teacher to solve her own problem is commonly called 'Action research'. One of the important aims of action research for teacher is to hold himself accountable for his work and influence the learning of his students. An understanding and true appreciation of the matter that follows, can equip a prospective teacher with a solution of the problems she might face during her conduct of teaching learning process.

Action research

Action research is described as "small scale intervention in the functioning of the real world and close examination of the effects of such intervention" (Halsey, 1972). "Action research can be described as a process whereby in a given problem area, research is undertaken to specify the dimensions of the problem in its particular context; on the basis of this evidence a possible solution is formulated and is translated into action with a view to solving the problem; research is then used to evaluate the effectiveness of the action taken" (Town, 1973). "Basically classroom action research helps a teacher who is concerned with her own teaching and tries to improve its quality" (Elliott, 1978).

The teacher observes and understands what is happening in the classroom, realizes the problem, then tries to solve it by collecting information. In this way the teacher can attempt to make teaching-learning process more interesting and effective to improve the performance of herself and of her students. When the teacher comes across a problem like poor performance of the students or absenteeism, the teacher may try to find out the cause and solve the problem, thereby helping the students, school system and the society in general.

The action research helps the practitioner who may be a teacher, a headmaster/principal or any other functionary, or an NGO (Nongovernment Organisation) concerned with the school system to perceive the problem, analyse and assess the situation, and find possible reasons for the unsatisfactory condition. Similar way of carrying out action research may not work in all situations. Different persons may have different approaches to solve the problem.

Areas of action research

The action research may be carried out in different contexts related to:

- Learner
- Teacher empowerment
- Teaching-learning approaches and strategies
- Evaluation and assessment
- Curriculum

- School administration
- Parental Cooperation
- Societal Cooperation

Within some of these areas, the research problems may be:

Learner: The learners' achievement can depend on many factors such as her motivation, learning style, attitude towards learning and interest in particular area of content. One can carry out action research for each of these aspects to improve the achievement of the student.

Teacher empowerment: Teacher empowerment allows teachers to bring into their classrooms their own unique expertise, talents and creativity, so that they can implement teaching-learning programmes to best meet the needs of their students. For effective teaching-learning, some of the aspects that can be related to a teacher are commitment to her profession, updated knowledge of the content, teaching style, motivation, attitude towards students learning with different paces, etc.

Teaching-learning approaches and strategies: The teacher's effectiveness is reflected in her students' achievements. Achievements of the students are directly related to the teaching-learning approaches and strategies adopted by the teacher. The teacher should be well versed with new development in this area. She can conduct study to find the efficacy of various strategies for transacting the concept of science.

Evaluation: The action research related to evaluation may be carried out in different areas such as assessment for learning, assessment of learning, and various ways of Continuous and Comprehensive Evaluation (CCE).

Curriculum: One can do action research related to curriculum. It may include curriculum design, curriculum revision, curriculum structure, etc.

School administration: Classroom management, absenteeism, discipline and infrastructure facilities are some of the topics related to school administration on which action research can be carried out.

Parental cooperation: Without parental cooperation a child cannot utilise her optimum potential. Hygiene, distraction of students from studies, performance of activities and environment of study at home are some of the aspects which need parental support. One can do action research to evaluate parental cooperation rendered to the child.

Societal cooperation: Without the help of society neither the school administration nor the parents can help the children to have overall development of their personality. The society should create a

conductive atmosphere for children providing them with learner friendly atmosphere. How community can be involved for the progress of the student? Should the use of loudspeakers, running of video game parlour in the vicinity of school premises be prohibited? Action research may be initiated in the above related topics which may contribute to the effective teaching-learning process.

A teacher can adopt a systemic approach to find solution when she realises concrete problems such as:

• Class X students do not understand the concept of magnetic induction;
• The differential achievement of boys and girls in the class;
• Understanding why do students find certain concepts difficult in science;
• Formation of misconceptions and naive concepts in science in various students; and
• The effect of using computers and various audio-visual aids for teaching-learning of science.

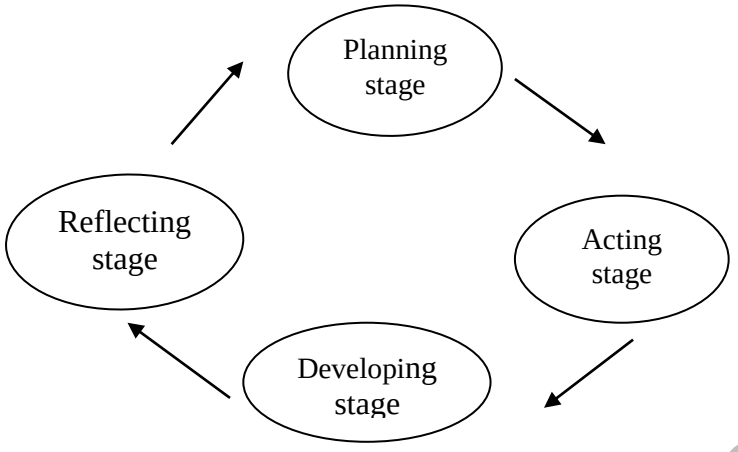
These are only suggestive examples. In fact, there are many aspects for which action research may be undertaken to improve the teaching learning and school system. Basically, action research is a form of systematic investigation that helps you to look into the answers of the questions like, how am I doing? What do I need to do to improve teaching-learning process? How can I improve upon them? Action research enhances a teacher's professional learning. Teacher has to identify the problem and its solution herself. She may discuss and negotiate with others. However, no one instructs her how to solve the problem.

Steps in action research

Action research is a systematic inquiry into one's own practice. It allows teachers to review their own classroom practices in order to improve their effectiveness. The basic process of conducting action research consists of four stages.

1. Planning stage
2. Acting stage
3. Developing stage
4. Reflecting stage

If a problem is not solved, the planning can be modified. Accordingly, there can be some changes in the remaining three stages. Thus, there is action and reflection cycle which may lead to another cycle of action and reflection until the problem is solved (Fig.).



Step 1–Identifying and limiting the topic or problem

In this step the teacher decides exactly what to study. She identifies area on teaching-learning situation in which she observes some difficulties and likes to take up the study to make things better, improve some specific practices or set right something which is not working well. She always tries to select a topic that she can manage with her own resources, expertise and time budget.

Step 2–reviewing the related literature

Any information that is related to the topic selected for investigation should be searched. The sources could be books, journals, internet, reports, manuals, etc. which can provide guidance for defining or limiting the problem, designing the research study and selecting tools and techniques for collecting data

Step 3–developing a research plan

After identifying the topic, it is appropriate to frame one or more research questions and develop specific hypotheses. Ideas can be noted down.

Step 4–Implementing the plan and collecting data

For implementing the plan, teacher collects the data using various techniques of data collection. The main data collection techniques are,

- Observing participants involved in the educational process. The participants might include students, other teachers, parents and administrators.
- Conducting interviews to collect data from students or other individuals.
- Interviews may be done orally or by using written questions called questionnaire or survey.

- Examining and analyzing the data already acquired by the students during teaching-learning process like answer scripts, assignment book, practical record book etc.
- Besides, teacher can use some other innovative methods like checklists, rating scales, tests, etc. for collecting data.

Step 5–Analyzing data

Teacher can analyze the data qualitatively or quantitatively. Quantitative data may be analyzed by either descriptive statistics or inferential statistics. Qualitative data may be analyzed by studying the patterns or categories that emerge. She analyzed step wise calculation done by students and her interaction with them.

Step 6–developing an action plan

After analyzing the data, the next step is to develop an action plan. This is the 'action' part of the action research

Step 7-sharing and communicating the results

The result of the research may be communicated to your colleagues. The colleagues may implement the action plan in their own classroom in their own way. The results may be communicated to the education boards, principal, administrators, parents as well as students and their opinion can be used to improve the action research.

By presenting the account of what the teacher has done, her work becomes evidence of how she has learned to do things differently and in a better way. Teacher can publish her research work in the research journals for its wider dissemination. She can get critical response that may help her to work further

Step 8–reflecting on the process

In this step teacher reviews what she has done. It gives her opportunity for possible revision for future implementation of the research project. Here, the teacher critically examines her own practice. For effective work, the teacher would like to examine the process not at the end only, but at each and every step.

Teacher can send the report of her work to the administration and invite their critical review. She can also point out the implications of her work for the betterment and benefit of teaching-learning

of physical science and the school system. The teacher can setup a discussion forum on various websites and publish her work in the journals.

Pros/Merits of Action Research

- Action research keeps the teaching learning process on the right way
- It helps the teacher to identify the strength and weakness of learning
- It provides suitable solution to the classroom problems
- Action research encourages desirable changes in schools
- Fosters democratic approaches in education
- Empowers individuals through collaboration on educational projects
- Encourages educators to reflect on their practices
- Promotes a process of testing new ideas
- It connects theory and practice
- It provides solution to the problems related to curriculum, text books, and methods of teaching, system of examination, discipline and co- curricular activities
- It helps in solving day-to-day classroom and administration problems
- It helps in making effective use of audio-visual aids
- It provides solution in solving problems related to backwardness and irregularity in attendance
- It creates healthy environment for teaching and learning
- Action research creates awareness among teachers and administrators on research mindedness

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