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राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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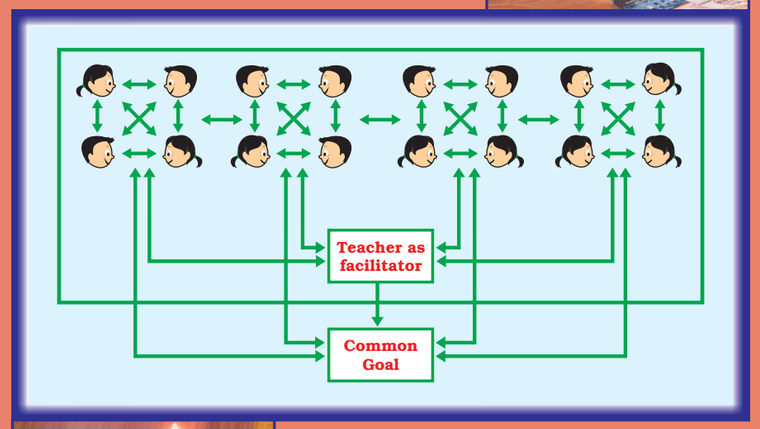
PEDAGOGY OF SCIENCE Textbook for B.Ed. Part II NCERT

PHYSICAL SCIENCE

PEDAGOGY OF SCIENCE

Textbook for B.Ed.



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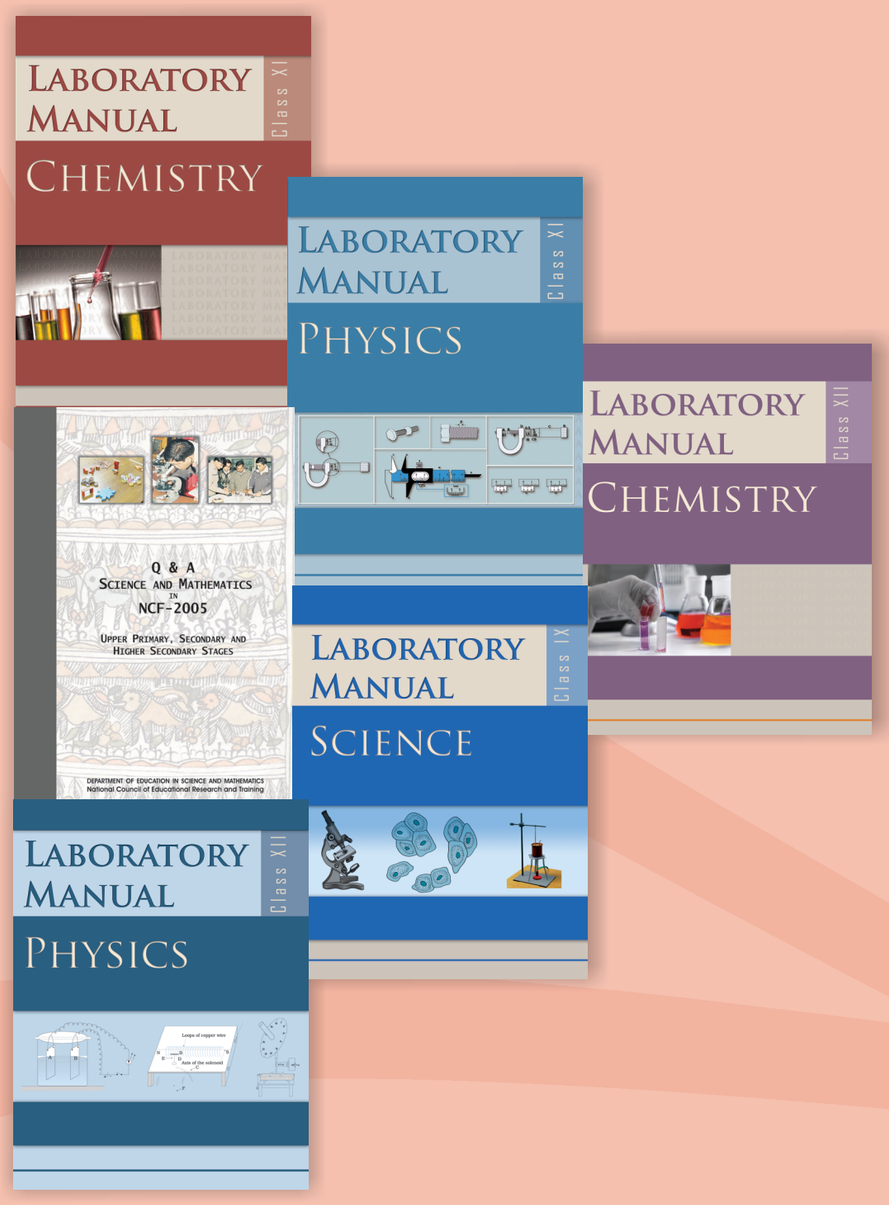

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PEDAGOGY OF SCIENCE

PHYSICAL SCIENCE

PART II

Textbook for B.Ed.

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राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
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FOREWORD

The Position Paper on *Teacher Education for Curriculum Renewal* of NCERT observes that the exercise of revising school curriculum with the aim to revitalise school education cannot be achieved without addressing the need for creating reflective teaching practitioners. It envisions that the learning inputs in new teacher education programmes will be predominantly learner oriented as it would provide for variety in learning exposures, accommodating differential learning and encouraging divergence, reflection and insightful treatment of a learning situation. The exercise of revising curriculum also provides for critical examination of disturbing social conditions of learners, larger issues of social disparity, inequity, gender divide and field specific administration and organisational anomalies. All these contribute to each teacher evolving one's own conviction about teaching as a profession and a professional commitment. In this context the National Council of Educational Research and Training (NCERT) has developed syllabi for teacher education programme that attempt to implement the above ideas. Based on the syllabi all the concerned departments have initiated the development of textbooks to support the student-teachers. In this series, the Department of Education in Science and Mathematics has prepared textbooks entitled *Pedagogy of Science* (Physical Science and Biological Science) and *Pedagogy of Mathematics*. We hope that these books will serve the purpose of teacher education programmes that can engage them in a child-centred system of education.

The success of this effort would be possible if freedom and flexibility are given to teacher-educators, student-teachers and teachers at the school level in their teaching learning endeavours. Teachers need to recognise that every child learns in her/his own unique way. Therefore, every teacher has to find her/his own way of engaging the learners in the learning process. Teaching learning of science and mathematics should be closely intertwined with the content and pedagogy of science and mathematics respectively. Involving learners in the process of inquiry and investigation helps the teachers to gain a better insight into the nature of science and mathematics and purpose of science and mathematics education. We hope the textbooks will serve as a guide to teacher-educators and student-teachers in enhancing their professional competencies and motivating learners to learn science and mathematics as a process of investigation and to solve day-to-day problems in a socially responsible manner as a global citizen.

The National Council of Educational Research and Training appreciates the hard work done by the textbook development committees constituted for these textbooks. Several teachers also contributed to the development of the textbooks. We are grateful to their Heads of Department and Principals for making this possible. We are indebted to the institutions and organisations which have generously permitted us to draw upon their resources, materials and personnel.

I sincerely acknowledge and appreciate the hard work done by Dr Shashi Prabha, Professor B.K. Tripathi and Dr R.P. Maurya, member coordinators, DESM and faculty members of NCERT who contributed to the development of the textbooks. I would also like to acknowledge the efforts of Professor Hukum Singh, Head, Department of Education in Science and Mathematics (DESM) for his keen interest and continuous support. As an organisation committed to systemic reform and continuous improvement in the quality of its products and teacher education programmes, NCERT welcomes comments and suggestions which will enable us to undertake further refinement.

Director
National Council of Educational
Research and Training

New Delhi
April, 2011

PREFACE

The National Focus Group on teacher education formed during NCF–2005 exercise strongly recommends that teacher education programme should be redesigned to respond to the school curriculum renewal process and in accordance with the state and regional context in which they are situated.

Existing teacher education programmes neither accommodate the emerging ideas in content and pedagogy, nor do they address the issue of linkages between school and society. NCF – 2005 envisions a teacher education programme that should facilitate prospective teachers to understand that learners are active participants rather than passive recipients in the process of learning. They construct their own knowledge by connecting new ideas to the existing ideas on the basis of activities/materials presented to them. If student-teachers themselves are provided such opportunities to construct their knowledge, they can appreciate how knowledge is constructed by actively involving the learners in teaching-learning process. This can help them to become active participants in a wider context of their professional role as teachers.

Science is dynamic, expanding body of knowledge covering ever new domains of experience. It is an organised system of knowledge which is based on inquiry born out of natural curiosity, logical reasoning and experimentation. Role of science teacher has evolved over recent years from transmitter of knowledge to that of facilitator of knowledge. The teacher is also expected to be a participant in the construction of knowledge and develop in students an understanding of the nature of science.

Keeping in view the above concerns of science and its pedagogy and to bring quality, excellence and acceptance of diversity in the field of science teacher education in the country, Department of Education in Science and Mathematics (DESM) has made an attempt to develop a textbook on *Pedagogy of Science* (Physical Science). This book is based on the syllabus of the two years B.Ed. designed by the NCERT for RIEs. It is hoped that this book would be equally helpful to the prospective teachers of other teacher education institutes of the country and to the wider clientele in the field of pre-service and in-service training in teaching-learning of physical science. The book will also help practising teachers and teacher-educators to update their knowledge of pedagogy and to deal with context based understanding and analysis of their classroom experiences.

This book is intended to be unique in the sense that various aspects of pedagogy of physical science spread over fifteen chapters are discussed on the basis of concrete context of the school and the learners by forging linkages among learners, context and the content and processes of the subject matter in a seamless manner. Concepts of pedagogy are illustrated with the help of classroom experiences of practising teachers. It is a book not just for reading, but to get actively involved in the teaching-learning process. It is suggested that student-teachers perform a number of activities which can be done while interacting with their classmates, immediate environment and various teaching

learning materials including textbooks of Science, Physics and Chemistry from Classes VI to XII. The idea is that the student-teachers are able to contextualise their teaching-learning experiences. It is expected that this would discourage the tradition of studying the content of the subject matter and pedagogy separately. There are many open ended activities included with a view that the student-teachers can dwell on them and then try to perform them sharing their views with others. This will enable them to develop various skills such as communication, team spirit, respect for other's ideas, inquiry and self-reflection.

Keeping in view that knowledge evolves continuously from experiences and is constructed through the active process of exchange of ideas, beliefs and reflection on issues in shared and collaborative contexts, ample opportunities have been provided to student-teachers to revisit the concepts of physical science at Upper Primary, Secondary and Higher Secondary stages.

It is important to adopt such pedagogic practices in science that engage the learners in groups in meaningful investigations – particularly of the problems they perceive to be significant and important. The classroom atmosphere should be such that it provides space for questions, discussions and debates and enhances learners' metacognitive skills. However, no such reform in science education can succeed unless a majority of teachers feel empowered to put it in practice. Teachers need exhaustive training in pedagogy as well as in the content to transact it through observation, experimentation and investigation. With active participation of student-teachers and teacher-educators, the ideas discussed in the book could have a cascading effect on all stages of science teaching-learning in our schools to meet the needs of all learners in a flexible manner.

The content in this book was prepared through a series of workshops organised by the DESM for its development and refinement involving practising teacher-educators, teachers, subject experts from universities and institutes of higher learning and the members of the science group of DESM. We gratefully acknowledge their efforts and thank them for their valuable contributions in our endeavour to provide good quality teaching-learning materials to student -teachers and teacher-educators.

I express my gratitude to Director and Joint Director, Professor, G. Ravindra, NCERT for his valuable motivation and guidance from time to time. Special thanks are also due to Dr. Shashi Prabha, Assistant Professor in Physics, DESM for coordinating the programme, and making the manuscript press worthy.

We welcome suggestions and comments from our valued user, especially student-teachers and teacher-educators for further refinement and improvement of this book.

Hukum Singh
Professor and Head
DESM

New Delhi
April, 2011

ABOUT THE BOOK

This book is an attempt to assist you in your pursuit of enhancement of effectiveness, excellence, diversity and creativity in the area of teaching-learning of physical science. We have tried to provide you with some basic ideas and strategies to help you in the development of concepts of physical science among your students. We intend to encourage you to organise learner-centred, activity-based, participatory learning experiences through observation, dialogue, discussion, projects and field work to integrate the learning of physical science with its content and process. This book is meant not only to be read, but to be engaged with. This can be done by your involvement in thinking critically about what it says, performing the suggested activities, reflecting on your experiences, developing motivation to inquire and to look for various resources of teaching-learning.

In order to achieve these aims we have tried to give many examples emphasising basic principles and relating content and process of physics and chemistry at Upper primary, Secondary and Higher secondary stages with its pedagogy. This book contains plenty of activities to encourage you to inquire and reflect on your work as a regular feature and as a continuous process of your professional development. It will also help you to acquire the skills of self-learning and critical thinking in a collaborative set up. You can think of some new activities suited to the teaching-learning situations and academic environment around you. You should try to perform as many activities as you can. However, do not get discouraged if you cannot perform all of the them in the first go. You will get insight into many activities during your practice teaching. It is important that you work on these activities in collaboration with your classmates and communicate your ideas through multiple channels. In some cases you might need to collaborate with the teacher-educator also. While sharing your views and experiences, many a time you will find that your classmates come out with different approaches to an activity as there can be many ways to perform that activity. Similarly, your classmates may respond to an exercise question in different ways as there can be divergent thinking among them. A large number of exercises given at the end of each chapter will provide you an opportunity to reflect on your teaching-learning process of physical science.

Some conventions followed in the book are as under:

- Each activity is meant to highlight the process of construction of knowledge for conceptual understanding as indicated by the jigsaw pattern appended to the activity. The pattern is also meant to highlight the communication among prospective teachers and teacher-educators.
- In the book, 'she' has been used for the learner, teacher and student-teacher instead of he/she for the sake of convenience.
- In order to visualise teacher preparedness in a learner-centred context where learning goes on in learner specific ways at various paces and with

various styles, the word 'teaching-learning' is used instead of teaching. The word 'teaching' has an underlying tone of what a teacher does in a teacher centred class and therefore is not appropriate.

- Some box items are introduced in many chapters to highlight some features of the contents requiring additional attention of the student-teachers.
- Classroom experiences of practising teachers and examples to illustrate the concepts are presented in boxes of a different colour for the ease of reading.

We wish you a joyful reading and learning!

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CONTENTS

Chapter 10

Print and ICT Resources in Learning Physical Science

10.1 INTRODUCTION

The earliest printed book appears to have been printed in China in 868 BC. Since that time, the printing technology has had a profound effect on knowledge dissemination. An author can write a book, print it in large numbers and make it available for worldwide use. A variety of books is being printed everyday. The print material has revolutionised knowledge.

It is of utmost importance for a teacher to communicate effectively with her students. We have already discussed about importance of explicit communication in science in Chapter 8 (section 8.15). In the recent past, information technology has seen considerable development. Information and Communication Technology (ICT) has changed the way people interact and communicate with one another. The school system cannot remain aloof from this development. Gradually ICT has entered into schools and has started influencing teacher-learner interaction. The teacher of twenty-first century must be proficient enough in using ICT for her teaching-learning in the classroom. In today's world, modern technology offers very exciting possibilities for this purpose. In this chapter we shall discuss on various forms of print and ICT resources.

Note: Student-teachers should be given enough exposure in computer laboratory to have hands-on experience. Each training institute/college must have a computer laboratory and this course should be preferably discussed in the computer laboratory itself where the student-teacher sits on the computer and learns/practices the use of various software packages and internet search engines for all her activities.

10.2 PRINT RESOURCES

10.2.1 Textbooks

A teacher gets print resources in different forms. The textbook is the most familiar print resource for the teachers and the students. It is developed on the basis of guidelines provided in the curriculum. A case study of the development of textbook by National Council of Educational Research and Training (NCERT) is given below. It provided guidelines for teaching-learning facts, principles, theories and processes in science.

Textbooks are the most familiar print resource for the teachers and the students.

10.2.1(a) Development of NCERT textbooks of science at upper primary stage : a case study

The textbooks were developed based on the recommendations of NCF-2005. Keeping in mind learner's existing knowledge and experiences, the textbooks introduced simple activities to explain the associated concepts.

The present science textbooks focus on activities, experiential learning and teamwork. These textbooks emphasise on learning by doing. Some guidelines for developing science textbooks are as follows:

- Make use of children's own experiences, or start the lesson with some observations or situations familiar to children.
- Do not attempt to start from the 'beginning'. These are usually more difficult at this stage and may prevent children from learning useful things. For example, children can learn the useful skill of reading a thermometer without knowing its construction, or how it works.
- Introduce chemical changes and chemical equations without teaching symbols of elements and their valencies. A common symbol H_2O, which children may come across in other contexts, is explained simply as another name for water. They are told that they will learn the 'language' of chemistry in later classes.

- Do not introduce abstract concepts too early in their lives as it makes them shun thinking and resort to rote learning.
- Lay little stress on formal definitions. For example, it has been thought sufficient at this stage to define acids and bases through their tastes, and not through a pH scale. When there is little understanding of the underlying concept, children tend to cram the definitions without understanding their content.
- List 'simple' activities which can be performed without a laboratory or a kit by using mostly things lying around and discarded. Having done something herself, the child is not likely to forget it soon. She also feels more confident of her abilities to perform activities. Choose examples from child's own environment, and from within her experience. For example, in the Chapter on *Pollution of Air and Water,* make use of children's own experience the basis to compare the quality of air in places such as parks, busy roads, residential complexes and industrial areas.
- Have language which is simple and direct, so that children can themselves read and understand; they can use the books even when the teacher is not present.
- Provide opportunities to learn by cooperation and collaboration, by role play, and from peers.
- Minimise information overload by transferring much of it to the *non-evaluative* boxes. In a box in Chapter *Sound*, (NCERT Textbook of Science Class VIII, Section 13.5) for example, a Table gives the loudness of sound from various sources. This is useful information, but children do not need to cram it.
- Let teachers have the freedom to replace the suggested activities by those that they consider more interesting and suitable in their situation. They can develop their own activities, too. This flexibility aims at unleashing the creative potential of teachers.
- Attempt to help children learn the real-life skills for protecting themselves, their families and community at the time of natural disasters like floods, storms, cyclones, lightning and earthquakes.
- Attempt to sensitise children to issues related to environment, health and hygiene, gender, water scarcity, energy conservation, differently-abled persons, superstitions, prejudices, myths and taboos and their social responsibilities now and in future as citizens of India.
- Connect life outside classroom by means of non-evaluative boxes, case studies, extended learning and exercises highlighting social issues.

- Pay special attention to the development of skills like reading scales, data presentation in the form of tables, and making graphs; and habit of inquiry. Include interesting stories, facts, anecdotes and case studies, so that children enjoy going through the books. Issue cautions, wherever necessary, to prevent accidents in the classroom and outside during the performance of activities.
- Design varied types and varied difficulty levels of 'Exercises' at the end of chapters. They should require application of learning to unfamiliar situations. These should also include the open-ended questions, which are aimed at stimulating thinking, enhancing the power of expression, and discouraging rote-learning.
- Provide addresses of websites where material for further reading, better illustrations and animations are available.
- Use better printing and colour illustrations to make books attractive to children.

10.2.1(b) Criteria for evaluation of a textbook

Following criteria may be considered for evaluation of a textbook:

1. **Correctness of the content:** Is the textual content of the topic accurate, authentic and up-to-date?
2. **Science as an integrated subject:** Are the concepts of science integrated with environmental component and social issues?
3. **Age appropriateness of content:** Is the content appropriate for the age level of the learners?
4. **Appropriateness of language:** (i) Is the language appropriate and effective for the learners of that particular class? Is it easy to understand? Is the language correct (spelling, grammar, etc.) and style (vocabulary, sentence structure, etc.) simple?
5. **Representing ideas:** Does the material include appropriate representations of the key ideas?
6. **Taking account of students existing ideas:** Does the material take into account of learners' existing ideas related with the concept?
7. **Introducing terms meaningfully:** Does the material introduce technical terms only in conjunction with experiences of learners? Does it facilitate thinking, promote inquiry and effective communication?
8. **Promoting students thinking about phenomena, experience and knowledge:** Does the material include tasks and questions to promote learners' thinking and reasoning about observations and experiences with phenomena?

9. **Providing relevant variety of experience with phenomena:** Does the material provide relevant multiple and varied experiences with phenomena to support the key concepts?
10. **Encouraging curiosity and inquiry:** Does the material help teacher to create a classroom environment that welcome learners' curiosity and encourages inquiry?
11. **Engaging students with relevant context:** Does the material provide relevant context of learners' environment?
12. **Justifying activity sequence:** Does the material include a logical or strategic sequence of activities (versus just a collection of activities)?
13. **Providing practice:** Does the material provide tasks or questions for learners to practice skills or use knowledge in a variety of situations?
14. **Assessing for understanding:** Does the material asses understanding of key ideas and avoid allowing leaners a trivial way out, such as repeating a memorised term or phrase from the text without understanding?

10.2.2 Popular science books

Over the past few decades a large number of voluntary organisations have been established that engage themselves in bringing out popular science books in print form.

These books try to explain the involved scientific concepts in a simple manner through examples, illustrations and anecdotes. Such a material is now available in the country in different regional languages. A science teacher can make use of these books to learn and explain scientific concepts effectively.

ACTIVITY 10.1 

Go to NCERT website (www.ncert.nic.in) and look for the list of popular science books. Make a list of books relevant or of interest to you.

10.2.3 Journals and magazines

Science organisations and science associations usually bring out journals in science. These journals publish research-based, experience-based and popular science articles. A number of magazines also publish articles on scientific issues. These material can be helpful for the enrichment of teaching-learning of science. Some of the journals that might prove useful are listed in Table 10.1. **It should be noted that the list is not prescriptive.**

Table 10.1 Some journals in science and science education

S.No.	Journal	Frequency of Publication	Publishers	Website/E-mail
1.	School Science	Quarterly	NCERT, New Delhi	www.ncert.nic.in
2.	School Science Review	Quarterly	Association for Science Education, England	www.ase.org.uk
3.	Research in Science Education	Bimonthly	Springer, Australia	www.springer.com
4.	Resonance	Monthly	Indian Academy of Science, Bangalore	www.ias.ac.in
5.	School Science and Mathematics	Monthly	Wiley Subscription Services, Inc., A Wiley Company, U.S.A.	www.online library.wiley.com
6.	Science Education	Bimonthly	Wiley Subscription Services, Inc., A Wiley Company, U.S.A.	www.wiley.com
7.	Science and Culture	Bimonthly	Indian Science News Association, Kolkata	www.scienceand culture_isna.org
8.	Science and Children	Monthly	National Science Teachers Association	www.nsta.org

9.	The Physics Teacher	Monthly	The American Association of Physics Teachers, U.S.A.	www.aapt.org
10.	Physics Education	Bimonthly	IOP Publishing, UK	www.iop.org
11.	Innovations in Education and Teaching International	Quarterly	Taylor & Francis, UK	www.tandf.co.uk
12.	Journal of Science Teacher Education	Bimonthly	Association for Science Teacher Education	www.springer.com
13.	Instructional Science	Bimonthly	Springer, The Netherlands	www.springer link.com
14.	Journal of Research in Science Teaching	Monthly	Wiley Subscription Services, Inc.	www.wiley.com
15.	Journal of Chemical Education	Monthly	The American Chemical Society, U.S.A.	www.acs.org
16.	Education in Science	Five times a year	The Association for Science Education, UK	www.ase.org.uk
17.	Science, Technology and Society	Bimonthly	SAGE Publications, New Delhi	www.sagepublicat ions.com
18.	Science	Weekly	The American	www.sciencemag.com

			Society for the Advance--ment of Science	
19.	Chemistry Education Research and Practice	Quarterly	Royal Society of Chemistry, UK	www.rsc.org
20.	Contemporary Physics	Bimonthly	Taylor & Francis, UK	www.tandf.co.uk
21.	International Journal of Science Education	18 issues per year	Taylor & Francis, UK	www.tandf.co.uk
22.	American Journal of Physics	Monthly	American Association of Physics Teachers (AAPT)	www.aapt.org
23.	American Secondary Education	Thrice in a year	The College of Education, Ashland University	rhannan@ashland.edu
24.	Journal of Indian Education	Quaterly	NCERT, New Delhi	ncert.nic.in

ACTIVITY 10.2 

Find out the name of the science magazines and journals of science/physics/chemistry and science education that the library of your institute/college subscribes. Review an article and discuss how it can be used to enrich teaching-learning experiences for students.

10.3 DALE'S CONE OF EXPERIENCE

Edger Dale's cone of experience is a model that includes several theories related to teaching-learning design and processes. During the 1960s, Edgar Dale theorised that learners retain more information by what they 'do' as opposed to what is 'heard', 'read' or 'observed'. His research

led to the development of the 'Cone of Experience'. Today, this 'learning by doing' has become known as 'action learning.' Modified diagram of this cone is depicted in Fig. 10.1 This diagram is self-explanatory.

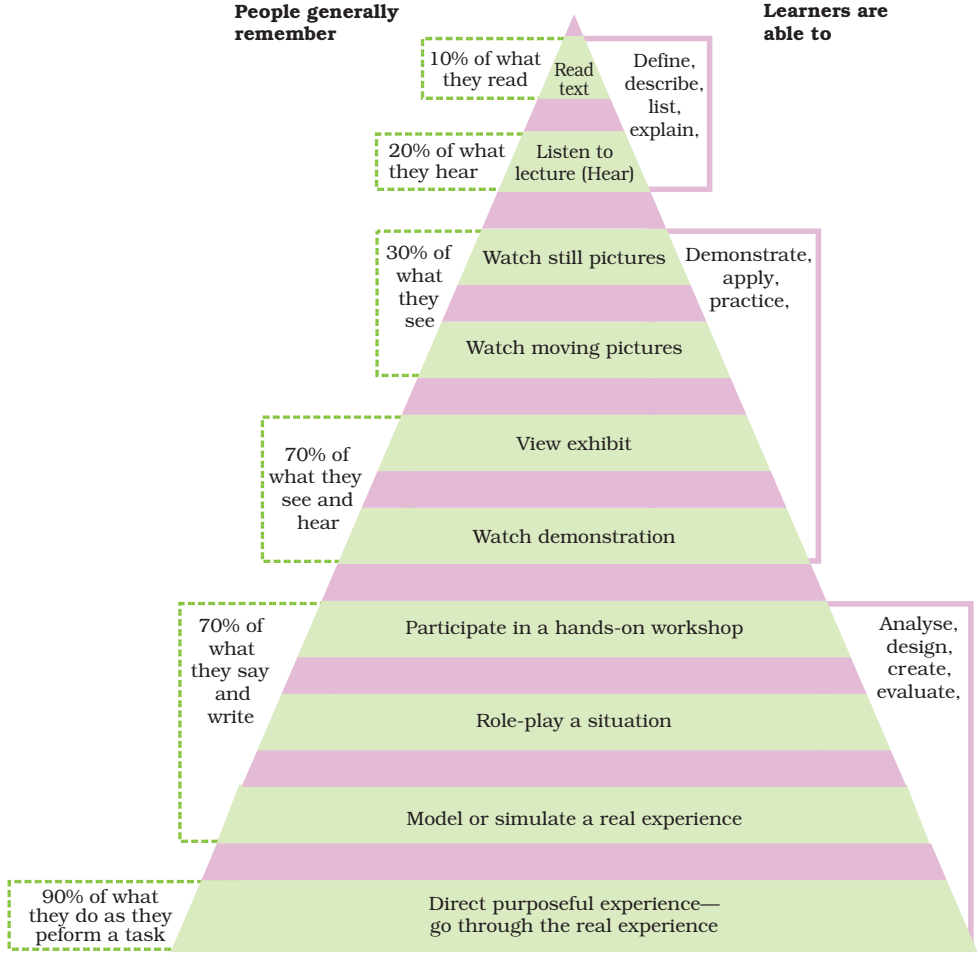


Fig. 10.1 *Cone of Experience (modified)*

10.3.1 Using the Cone of Experience

The least effective method at the top involves learning from information presented through verbal symbols, i.e. listening to spoken words or audio 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 strategies of teaching-learning. As we progress down the Cone, the greater the learning and deeper the understanding. It also suggests that involving learners in the process of selecting a teaching-learning resource is important. It facilitates to strengthen their knowledge.

Dales' Cone of Experience is a tool to help teachers make decisions about teaching-learning resources and activities. The teachers can think on the line of following questions for making a decision.

- Where will this teaching-learning resource fit with the learner's experience 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 information supplied by the textbook?
- What and how many senses can learners use to learn this teaching-learning material?
- Does the teaching-learning material enhance learning?

10.4 DIFFERENT FORMS OF ICT AND ITS APPLICATION IN SCIENCE EDUCATION

Student-teachers need to be empowered to use emerging ICT to explore the huge reservoir of knowledge, information and vast amount of data available anywhere in the world and to communicate with the learning communities of physical science for enriching their teaching-learning experiences. Student-teachers should be helped in acquiring a critical and constructive outlook to use technology for their project work, assessment of students' assignments, and designing teaching-learning experiences for learners.

Communication technology encompasses all forms of electronic communication in both digital and analogue form. The digital electronic devices include computers, CD, optical disc and its players, storage

devices, the Internet, cellular telephony and satellite broadcasting while analogue devices are largely limited to conventional radio broadcasts and audio tapes and tape recorders. Due to increase in bandwidth and the availability of various types of connectivity, the various technologies are converging into the broad field of Information and Communication Technology (ICT).

ACTIVITY 10.3 

Discuss what are the different digital/electronic resources and how can they help you in teaching-learning of physical science more effectively.

10.4.1 Audio aids

(a) Broadcast talks

Radio broadcast and audio recordings are the sources of audio learning experiences for the children. In order to provide learning experience beyond the school syllabus and to relate it to the real life outside the classroom, school broadcast programmes could be one of the best medium. It may not always be possible for a science teacher to invite eminent persons of science for the lecture or talk. In such cases the lectures or speeches can be pre-recorded and can be played in the classrooms. There are various types of programmes, such as discussion forums, question-answers, debates, quizzes, speeches, dramas, which can be either played live or can be pre-recorded, to be used in teaching-learning of science.

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

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

A secondary school science teacher wanted to transact the topic on *Nuclear* energy. She searched various resources of ICT and found that soon there was going to be a radio broadcast on the same topic by an expert in the field. But since the broadcasting time was in the afternoon, she asked her

students to listen to the broadcast at home. She asked the students to note down the important points of the talk as well as the questions which came up to their mind. Next day, she clarified those important points and then she organised a discussion on the same topic in the class. This is how radio broadcast was used successfully by a teacher to give extra and useful information to her students. The discussion in the class also enabled the teacher to assess the level of comprehension and understanding of the students of this topic.

(b) Audio tapes

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

ACTIVITY 10.4 

If your institute library has audio tapes, or if you know other sources where audio tapes are available, make a list of sources of useful audio tapes. Also visit NCERT website and make a list of various audio and video programmes. Procure and observe some of them from the point of using them in teaching-learning.

Advantages

- Audio media are inexpensive. Once the audio tapes and equipments 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 outside the classroom because they can be run on battery.
- Cassette recorders are ideal for home study as students can afford to have their own cassette players. Audio tapes can be easily duplicated in required quantities.
- They can be used in all phases of teaching-learning from introduction of a topic to assessing students' learning. The audio media could be very well used for the purpose of self-paced learning. If required, learner can go back and repeat desired

segments of teaching-learning as often as necessary because the recorder/playback machine can serve as a very patient tutor. On the other hand, learners can skip ahead or increase the pace of their learning as and when desired.

- Pre-recorded audio media can be used as 'talking books' for the visually impaired students. Audio tapes can easily be prepared by teachers for students with special educational needs.

Note: These days recording, storage and reproduction of audio and audio visual materials can be handled easily with a computer system. Development of this technology has made audio and video tape based system obsolete. Therefore, the above description about tapes based systems has only historical importance.

In a programme implemented by Homi Bhabha Centre for Science Education, Mumbai in Ashram schools, audio tapes were used effectively for enhancing peer interaction among the students. Stories from the lives of the scientists were audio taped. These tapes, along with an ordinary record player were made available to the students to be used in their leisure time. Since students lived on campus itself, even after school hours they had ample opportunities to start the record player, whenever they wanted to listen to the recorded story and discuss the topic.

This effort apart from enhancing the students interaction motivated them towards the study of science and understand various concepts of science well.

Limitations

The biggest drawback of the audio media is the lack of visual support. Moreover, audio media is not interactive. There is no possibility for any input from the listener, or of a hyperlink to any material elsewhere on the tape. The presentation can only be in a fixed predetermined sequence, though there is the possibility of rewinding the tape and hearing a recorded segment again or advancing the tape to an upcoming portion. As an example, suppose a student is listening to material on Kepler's laws where the examples being cited are of planets. If she gets curious to know whether artificial satellites also obey Kepler's laws, it will be difficult for her to jump to the material on artificial satellites. In short, there is no equivalent of a 'click' of a computer mouse on the audio tape.

ACTIVITY 10.5

(i) Identify a few topics in a science textbook where audio tapes can be used for enriching learning experiences in spite of its limitations.

(ii) Identify the topics in the textbook where the limitations of audio media become apparent.

10.4.2 Visual aids

The primary function of a visual as a teaching-learning aid is to serve as a more concrete referent to the object being discussed in the class. When the object being discussed is not at hand, then the best referent is a visual representation of it. Even when it is at hand, visuals of its various aspects and its structure are useful referents. For example, when telescope or compound microscope is being discussed, visuals of its structure are extremely useful aids. Similarly, during the teaching-learning of human eye, Van-De-Graff generator, nuclear reactor, electric generator and motor, etc., visuals of its appearance from various angles and its internal structure are very effective for learning. Obviously, for most effective communication, one must use the most realistic visuals available.

Visuals are used very often as iconic representations of objects. Railway stations, roads, bus terminals and airports cater to people of all strata, from totally illiterate to highly literate people, and people of all nationalities. Universal icons representing various objects have been developed, so that no language is necessary to explain them. Similarly in science, we use various symbols of different electric and electronic devices and symbols for various elements in chemistry.

(a) Charts

Charts of different types can be prepared by the learners with a little help from teacher depending on the teaching-learning objectives to be achieved and the need of the subject matter. Charts help in effective representation of the subject matter which is in the form of data, diagram, etc. Those charts which cannot be prepared locally may be procured from various educational centres.

Charts depicting pictures of great scientists, instruments, equipment used in industry, industrial processes, etc. could be used as teaching aids. But the pictures used should be of reasonable size, so that it is visible to the whole class. They should not be overloaded with information to avoid distraction of the learners to unnecessary parts. Pictures or portraits of great scientists displayed in science laboratories not only give proper scientific atmosphere to laboratory, but also inspire learners.

(b) Posters

Printed posters on various science concepts and life history of scientists are available from science publishers. These can be used as a resource in teaching scientific concepts covered in the school syllabus. If a

desired poster is not available, teacher should endeavour to make one for her with the help of students. For example, a good large-size poster of Periodic Table and Electromagnetic Spectrum will be of good help in teaching-learning of physical science.

ACTIVITY 10.6 

(i) Take any textbooks and discuss the concepts on which posters can be made. Make a list of them.

(ii) Make a poster on any scientific concept of your choice as a group work and exhibit in your class. Critically evaluate each other's poster.

10.4.3 Audio-visual aids

Audio-visual aids are the most important teaching-learning aids as they involve both auditory and visual senses. They help in giving concrete and realistic experience. The various types of audio-visual aids are discussed below.

(a) Educational television

The television in the present day society can be used as one of the important teaching-learning aids. It combines the advantages of a radio (broadcast) and of a film, and could be used for mass education. Topics of discussion can be announced in advance and teacher can easily carry on teaching-learning process around the telecast time to incorporate them in the on-going lesson so that students can watch and discuss the concepts in the class. Such teaching-learning helps students to develop their interest in the subject. UGC programmes are telecast on Doordarshan. NCERT telecasts its educational programme on Gyan Darshan channel.

Whenever Rohit, a teacher at higher secondary stage, watches a good educational programme on the TV he informs two of his students on telephone about it. Those two students inform two other students and through this chain of information, the whole class watches the educational programme in the late evening or early morning or on holidays. Later the topic is discussed in the class. Learning is appreciated as participatory approach.

There is a tremendous potential to increase television based education as we have a dedicated satellite in the geostationary orbit named EDUSAT. A large number of educational television programmes can be made and telecast. EDUSAT also offers a facility for two-way interaction where the viewers can raise their doubts and make comments also. 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 a better, more vivid watching experiences which are of educational value.

ACTIVITY 10.7

Watch some of the programmes telecast on Gyan Darshan , UGC, Discovery, Discovery Science, National Geographic channel and discuss how can you use these programmes effectively in teaching-learning of physical science.

Disc records

CDs

The disc recording has a number of attributes that makes it an attractive medium of teaching-learning. It can reproduce the audio spectrum even beyond the limits of human hearing. A major advantage of audio CDs (and other optical discs) is that the user can quickly access any part of the disc. Data from the disc can be retrieved in any desired sequence.

DVDs and Blu-ray Discs

Similar to audio CDs these are the other forms of optical discs. DVDs and Blu-ray Discs offer all the advantages of audio CDs.These are used for video rather than audio due to their higher capacity. Blu-ray Discs supersedes the DVD formats and are used for High definition video and audio.

Other storage devices

USB (Universal Serial Bus) flash drives and external hard discs can also be used for carrying data and teaching-learning materials for students. Documents, pictures, audio and video can be carried in these devices. These are cheap, rewritable and removable devices. Very small in size pen drives can easily be carried in pockets and offer a huge storage capacity of data.

(b) Multimedia

The Multimedia concept involves using multiple media for transaction of a concept. It involves integrating different media into a structured

and systematic presentation. Each medium in a multimedia system is designed to complement the other, so that ideally the whole multimedia system becomes greater than the sum of its parts. Multimedia systems are multi-sensory and stimulate learning. The multimedia kit may include films, videos and audio tapes, records, still pictures, overhead transparencies, maps, worksheets, charts, graphs, booklets, real objects and models.

Commercially multimedia kits are available for various subjects. Multimedia kits can even be prepared by teachers. It is important that the components of the kit be integrated, that is, each component contributes to the attainment of the lesson objective. **Multimedia activities should also be correlated with other relevant learning activities in the classroom. Multimedia kits should be designed to transact particular topics and develop various skills. The teachers should involve students in handling and manipulating the materials in order to maximise their learning potential.**

Since they cater to many senses, multimedia kits make learning enjoyable. They are versatile in their content, range of media, and variety of applications, and thus contribute to learning for a wide variety of learners in many subject areas. In addition, multimedia kits provide scope for individualised attention to students.

(c) Uses of computer

Today, everybody knows about computer. Computer is a power driven machine equipped with keyboard, electronic circuits, storage compartments and recording devices. It can perform mathematical operations at a high speed. It can store large amounts of data which can be retrieved on demand. A computer can do what a whole set of multimedia systems can do. So, whatever has been said above about audio, visual and audio-visual devices, computer alone can do all that. That is why, this single device has made all other devices obsolete. In fact, computer with an Internet connection is an all-in-one device for all kinds of educational aids.

As we use computer in teaching-learning, an important factor to keep in mind is that large numbers of educational systems already use computers for a variety of administrative purposes, such as purchasing,

managing payroll, inventory and personnel, and auditing. These include the processing of information for students' admissions, the continuous updating of students' records and evaluation report and the scheduling of classes, etc. There are a variety of legitimate teaching-learning uses of computers. Teacher can prepare, with the help of computer expert, self learning materials to transact various topics. For example, if teacher finds that there are certain topics where students need practice (for example, solving problems based on certain formulae), the material can be prepared by the teacher and later can be programmed with the help of a computer expert. Using such computer-developed materials, students can learn the various concepts of the topic taking their own time without much help from the teacher. Thus, different topics can be transacted by different ways.

Computer systems can deliver instruction directly to students by allowing them to interact with lessons programmed into the system. This is referred to as Computer Assisted Instruction (CAI). CAI can also facilitate students with Special Educational Needs (SEN) in various ways. Computer can facilitate most effectively for simulation practices, tutorial, educational gaming, discovery and problem solving.

(d) Simulation

A simulation is a simplified version of reality in which essential physical or social elements are represented without hazards, cost or time constraint normally associated with them. The purpose of simulations is to enable us to understand and function in real situation. Simulations are representation of real situations with the element of safety, because some real equipments cannot be used in the class as they may be too costly or too delicate or may be length of time involved in a real exercise would be too great. Simulation and games can give students practice in decision-making and allow them to test a hypothesis in abstract situations. One familiar example is the prediction of effect of increase in temperature on the pressure of a system. The variables can be manipulated on computers and it is possible for students to test out various hypothesis. One of the marked advantages of effective simulation is increase in students' motivation and participation. Students respond with unusual enthusiasm and interest to simulation/ gaming, because of its relevance to how things get done in real life.

(e) Internet

It is a major tool for gathering, accessing, analysing, sharing and disseminating information. With the help of networking your computer

is connected with remote computers for accessing the information. This web of computers has certain specific locations called websites which store information on specified subjects. This information can be accessed by any internet user through the website's address. Alternately, one can also upload one's own information on the web to make it available to any user. The user depending on her/his requirement, then navigates through the web to access desired information.

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

The teachers can use computer and the internet to design their lessons using huge reservoir of information and knowledge available online. The information includes film/video/audio clips, animations, drawings of complicated pieces of apparatus and a host of data of all kinds. One of the advantages of using computer and the internet is that one can explore quickly the information available online and use it judiciously to make lessons more relevant and interesting. In addition to designing lessons and teaching strategies, teachers can write their reports, prepare question papers for assessment and evaluation of students. Electronic portfolio of all students of a class can also be maintained on the computer.

The teachers can form networking groups where they can exchange ideas, innovative experiences, joys and excitements of teaching-learning processes with their peers. They can get help from them and give help to them. They can use computers and internet as a tool for lifelong learning to enhance their professional and social stature. The teachers can also direct their students to educational sites already reviewed by them, so that students can improve on their understanding of various concepts of science by themselves and encourage them to become independent learners. It would take off some tasks from the teachers, giving them much needed time for their other duties. In addition, teachers can set various tasks to students, such as writing reports, term papers, etc., which students can do using the computer.

(f) Some of the open learning resources in physical science

Many open learning resources are available on the website free of cost. These sources can be located by a teacher in specified topics to make learning enjoyable. Such sources of websites can be recommended to

students for self-study and self exploration in order to develop interest in science.

- http://ocw.mit.edu/courses/physics/8-02-electricity-and-magnetism-spring-2002/index.htm
- http://ocw.mit.edu/courses/physics/8-02-electricity-and-magnetism-spring-2002/video-lectures/embed02/
- http://ocw.mit.edu/courses/physics/8-02-electricity-and-magnetism-spring-2002/video-lectures/embed29/
- http://ocw.mit.edu/courses/chemistry/
- http://www.chm.davidson.edu/vce/Equilibria/index.html
- http://www.chm.davidson.edu/vce/index.html
- http://www.chem1.com/chemed/
- http://www.nclark.net/ChemMenus
- http://www.grc.nasa.gov/
- A Charles' Law Calculator: http://www.1728.com/charles.html
- http://www.1728.com/combined.html
- http://www.chem.iastate.edu/group/Greenbowe/
- http://legacyweb.chemistry.ohio-state.edu/betha/nealGasLaw/index.html
- Animation of the way air pressure affects a baloon as it rises:
- http://http://kids.earth.nasa.gov/archive/air_pressure/balloon.html
- http://antoine.frostburg.edu/chem/senese/101/gases/index.html
- http://www.aquaholic.com/gasses/laws.html

For teaching-learning resources –

- http://www.enc.org
- http://www.nasa.gov
- http://dlcenter.larc.nasa.gov
- http://edspace.nasa.gov/index.html
- http://www.learner.org/jnorth/

ACTIVITY 10.8

You have to interact with students of Class X for teaching-learning Periodic Table in the class in the next few days. Use the internet search engines to prepare the lesson for your students.

A possible outline of your first lesson could be :

- A brief introduction to atomic structure;
- History of evolution of the modern Periodic Table;
- The importance of Periodic Table in learning Chemistry; and
- Example of an element from the Periodic Table to explain its properties.

Project 10.1
Surf the Internet for searching meaningful information for various concepts of physical science for primary/secondary/higher secondary stages. Review them and make a list of relevant websites that you would recommend to your students. Share and discuss about the websites with your friends and teacher.

10.5 USING AND SELECTING APPROPRIATE MEDIA

In general, we use media whenever, in our best judgement, it can facilitate learning or enrich understanding of the teaching-learning materials. Communicating to facilitate learning can sometimes be a challenging process, often requiring creative efforts to achieve a variety of implicit teaching-learning goals. Among the implicit goals that media can help achieve are the following:

- attracting attention
- developing interest
- adjusting the learning environment
- promoting acceptance of an idea

10.5.1 Factors affecting media selection

Teacher needs to consider some factors for media selection which centrally depend on the learning objectives. These are shown in Fig. 10.2.

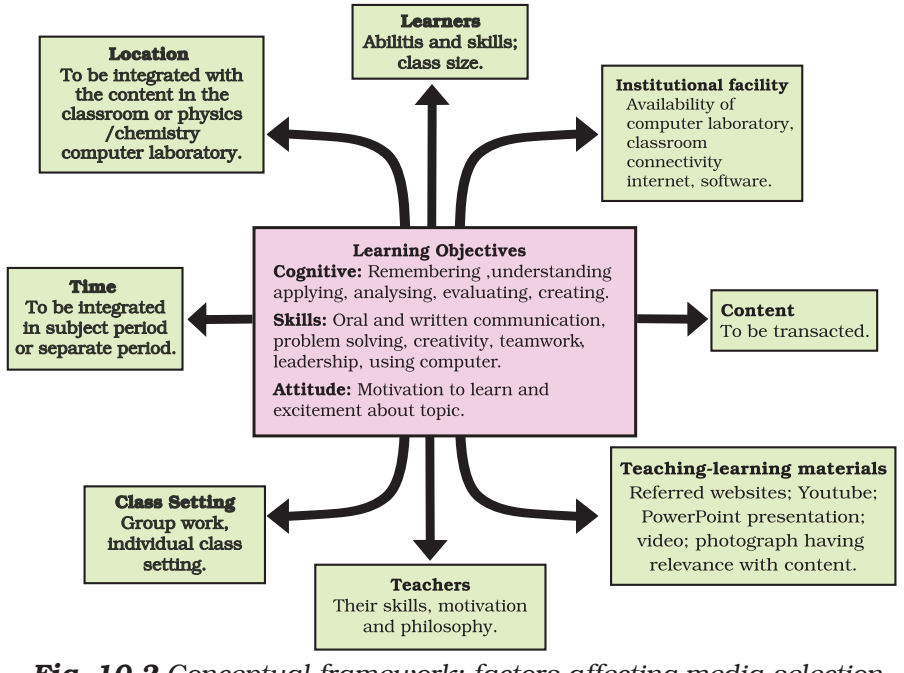


Fig. 10.2 *Conceptual framework: factors affecting media selection*

In addition to the above, following points should also be considered for incorporating multimedia in classroom transactions:

- What is the number of students in the group or class that can be accommodated on a single occasion?
- Is media within viewing and hearing range of all learners?
- Can media be interrupted easily for giving or receiving the explanations and for providing feedback to the learners?
- Can learners make any change in the material? For example, can students change the variable quantity of an experiment to observe its effect on the result of an experiment?
- Is the presentation 'adaptive' to the learner's responses?
- Is sequence fixed or flexible in the medium?
- It there scope for incorporating most of the requirements of learning objectives?
- Does it cater to the needs of all learners including learners with special educational needs?
- Does it enrich the teaching-learning process?
- Is it cost effective?

Teacher may proceed by considering what she knows about the media available and then begin asking herself a series of questions that eliminate what is not feasible. Some typical questions that can help a teacher to take decision about the selection of appropriate media include the following:

- What are the learning objectives to be achieved?
- What are the most suitable media that I can use?
- How can content of the media enrich teaching-learning experiences?
- Are there any other media already available to achieve these learning objectives that I can use?
- Where will I be using the media? What are environmental factors?
- Do I have the skills needed to produce effective media? Can I do it with the help of computer teacher and other teachers of my school/different school?
- Is the production, maintainance and operation cost affordable?

Gagné, Briggs, and Wager (1992) recommend that teachers can apply the following exclusion and inclusion criteria in selecting media for the various common learning areas (Table 10.2).

Table 10.2 Exclusion and inclusion criteria in selecting media

Learning areas	Exclusions	Selections
Intellectual skills and cognitive strategies	Exclude media having no interactive feature.	Select media providing feedback to learners' responses.
Verbal information	Exclude the media simulator with no verbal accompaniment.	Select media able to present verbal messages and elaboration.
Attitudes	Exclude the simulator with no verbal accompaniment.	Select media able to present realistic picture of human model and the model's message.
Motor Skills	Exclude media having no provision for learners' practice of skill.	Select media making possible direct practice of skill, with informative feedback.

10.6 HOW CAN ICT CATER TO DIFFERENT LEARNING NEEDS OF LEARNERS?

10.6.1 ICT for inclusive education

Inclusive education is the need of the day. We have to ensure that everyone in the classroom is able to understand the concept being transacted. A teacher usually faces situations where the learners need additional inputs to facilitate acquisition of concepts. Teacher also comes across students with special educational needs. She has to ensure their learning of science by making special efforts. In all these cases, ICT comes very handy.

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

10.6.2 Students learning with different pace

This is a group of students who are unable to cope with the pace of teaching-learning in the class. For a small group of students, teacher cannot change her pace as she has many other constraints, like completing the syllabus in time. In such a case ICT facility can be made available for the learners learning with different pace, so that they can learn at their own convenience. Digital resources with relevant learning materials can be made available to them. Many of these materials could be used as out of school activities, so that the students come adequately prepared to the classroom. In case of learners learning with slow pace there should be opportunities to repeat the things. It can be provided through ICT by using special software.

ACTIVITY 10.9 

Visit the following websites to know more about applications of ICT for learners of science having special educational needs:

- http://www.closingthegap.com
- http://www.brainpop.com
- http://atto.buffalo.edu
- http://www.iping.com

10.7 SKILLS TO BE DEVELOPED IN STUDENTS IN INTERCONNECTED WORLD

As a teacher one has to bring the changes in the practices followed, help students to think independently, take informed decisions and make effective use of technology. It is important to make teaching-learning relevant to their immediate experiences and relate it to their day-to-day experiences. Teacher needs to adopt innovative approaches and strategies of teaching-learning like inquiry approach, collaborative approach, etc. and make students conversant with problem solving and information processing strategies. **Emphasis should be given to develop following skills and facititate students in learning content of physical science along with inquiry and process skills.** Teacher should help them to evaluate their own work and decisions.

- **Information processing skills:** The information age helps to develop literacy and thinking skills using technology appropriately and ethically, and working as part of a team as well as independently.
- **Problem solving and critical thinking skills:** These skills need to be practised in the context of day-to-day experiences. **Each student must know problem solving, i.e. defining a problem, designing,**

developing, and determining the solution. Technology can help the teachers to make students work on their own, think on their own and resolve issues on their own. We have to move them from a culture of dependency to a culture of independency.

- **Communication skills:** are very important in the age of technology where people have to communicate their message to others at distant places. Over and above technological reading and writing are different processes from literary reading and writing. It is the difference between reading a novel and reading information on a screen; writing an essay versus designing teaching-learning experiences or drawing a graph. These skills need to be developed by bringing their relevance to the various concepts of physical science. These skills should be integrated into the curriculum to deal with increasingly technical and iconic world both online and offline.
- **Technology as a tool and not as a subject:** While developing teaching-learning experiences one has to be cautious that contextualised use of these experiences is for learning rather than focusing on hardware and software. The technology needs to be exploited based on learning needs rather than technology being the driver.
- **Developing information literacy:** Facilitating all students to know how to become judicious users of information in an era of information age by empowering them with the skills such as asking, accessing, analysing, authenticating and assessing.
- **Helping students to make informed decisions:** Students should be helped to explore and gather information from various sources, analyse the given information and select the required data to make informed decisions based on the problem to be solved.
- **Learning to understand interpersonal and intrapersonal skills:** Opportunities should be provided to students for learning goal setting, self-assessment, entrepreneurship, team spirt and collaborative work.

Thus, proper use of information and communication technology can shift the role of a teacher from providing information passively to creating and generating learning environment for individual student as per her requirement and learning style. This can help a student to construct her own knowledge. Students can conceptualise the situation and arrive at the solution of a problem. However, learning is definitely affected by the learning environment and context, attitude and 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 her peer groups.

10.8 SOCIAL NETWORKING SITES AND THEIR USE IN EDUCATION

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

10.8.1 Facebook (www.facebook.com)

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

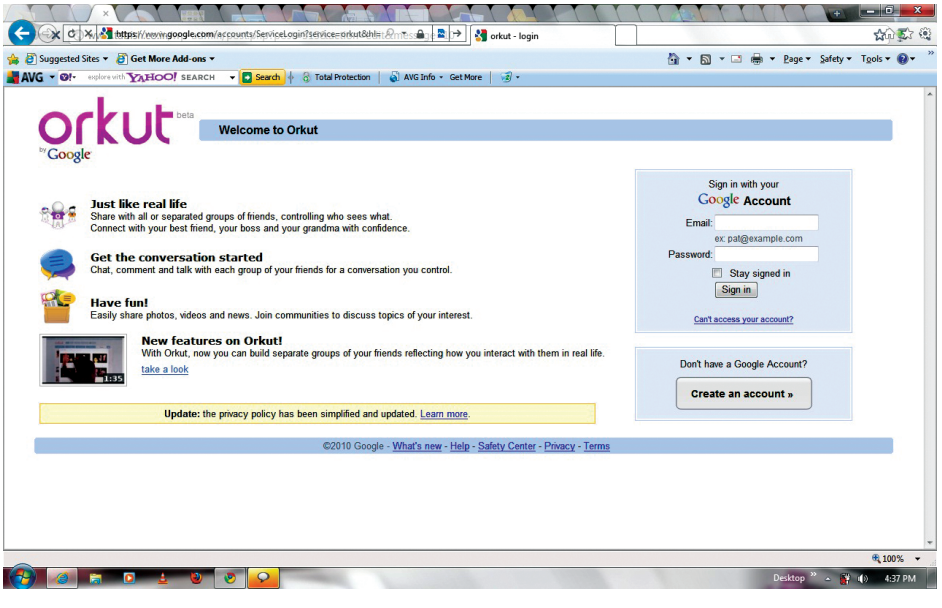
10.8.2 Twitter (www.twitter.com)

There is a value in networking and real time interaction that we can get using twitter. Many educators and academicians find this to be an effective strategy for dealing with the isolation that can come from working in the classroom or office. Imagine encountering technical difficulties during our lesson and having a means of receiving assistance within minutes. Twitter is an effective communication tool for concise messages and news items, or links to longer messages and news items. Twitter is fun to

use and may, therefore, be effective in engaging students in discussions who do not need to write longer essays. Consider the ability to receive assistance from others during a teaching-learning situation where we don't know the answer to a student's query. We can share events at work and this helps us to know our friends a bit more and adds an additional layer of community within our online network. One can customise and use it to meet ones' specific needs and interests.

10.8.3 Orkut (www.orkut.com)

Orkut communities can be used productively by teachers for effective teaching-learning. One can get enormous benefits through Orkut, provided that we use it in a productive way. Discussion or scientific issues can be generated and idea can be exchanged on this site. Through Orkut communities, like-minded people can come together for better understanding of their subjects of interest. We can create communities on Orkut in the name of our school to share our memories and stay in touch with our childhood friends. Orkut can be used to get news updates, find a suitable job, get good career ideas, and know about institutions and certification, and so on.



10.8.4 Virtual field trips

A virtual field trip is a guided exploration through the web that organises a collection of pre-screened, thematically-based web pages into a

structured online learning experience. It is an interrelated collection of images, supporting text and/or other media, delivered electronically via the *World Wide Web*, in a format that can be professionally presented to relate the essence of a visit to a time or place. The virtual experience becomes a unique part of the participants' life experience.

A virtual field trip is a real time guided field trip that is supported by interactive pages on the web. The live links with experts on site in real time is a key aspect in creating a 'real' experience for students. Real time virtual field trips involve the use of video-conferencing and audio-conferencing technologies to permit students in one location to virtually visit and learn about people and places in another location. You may visit following websites to have an idia about virtual field trips.

- http://campus.fortunecity.com/newton/40/field.html
- *www.middleschool.net/curlink/virtual.html*

10.8.5 YouTube

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

10.8.6 Podcast

A podcast is an audio or video file created and placed on the web for individuals to download and view or listen on their computers or digital media players. Podcasting is a means of one-to-many audio distribution via the Internet. The term was coined from 'iPod' and or video 'broadcast'. A podcasting is a useful educational tool for two very different activities— receiving content from experts, and as a means of student media production. Podcasting is the generally accepted term for both audio and video files, but video file distribution is sometimes referred to as 'vodcasting,' This provides a convenient, subscription-based model for distributing educational materials. A list of educational podcasts to get an idea of what is available and how do they work, you can visit the site– www.enpweb.org. This site also describes simple steps on how to create a podcast by clicking on 'cast'.

www.cobb.k12.ga.us/instructionaltechnology/mac/PC/podcasting.htm

10.8.7 Flickr

Flickr is an online photo management and sharing application. The basic service is free, which allows you an access of about 300MB per month. You can upload your pictures from your desktop or your camera phone. Then you can organise your photos by categorising them. These photographs related to activities, experiments, projects, model, chart, poster, etc. can be later used in teaching-learning process.

Flickr allows you to share your photos online, create groups that are public or entirely private. So, if you are participating in a collaborative activity with another class somewhere in the world, you can share your photos 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 can have its own discussion board. The class can ask questions about the photos and have meaningful discussions regarding the photos, and work with international students to generate discussions with them. Visit the website www.flickr.com to have an idea about it.

10.8.8 Wikis

A wiki can be thought of as a combination of a website and a word document. At its simplest, it can be read just like any other website, but its real power lies in the fact that groups can collaboratively (and privately, 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 track of the history of a document as it is revised. Since people come to one place to edit, the need to keep track of word files is eliminated. Each time a person makes changes to a wiki page, that revision of the content becomes the current version, and an older version is stored. Versions of the document can be compared side-by-side, and edits can be 'rolled back' if necessary.

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

Next, the student can draft the paper in the wiki, taking advantage of the wiki's automatic revision history that saves a version of the document each time she makes changes. This allows the teacher and peers to see the evolution of the paper over time, and continually

comment on it, rather than offering comments only on the final draft. It helps in making assessment continuous. When the student completes the final draft, the teacher and peers can read it on the wiki, and offer feedback. You may visit the website www.wikispaces.com to get an idea about it.

10.8.9 RSS

This web tool allows you to gather information from certain websites and display this information on your own site. RSS has great potential of providing teachers and students with a wealth of current information about various topics that are covered in the curriculum. One simple way to take advantage of this tool is to use it to collect information from the sites you visit often and then share the information with your students. The information could be used as research sources for your students as they explore various topics within the curriculum. You may visit the website www.rssfeedreader.com to get an idea about it.

10.8.10 Blogs

Blogs allow you to post homework and other discussion prompts. It keeps record of threaded discussions and arranges items by date. Attachments can be added to blogs too. Students can interact with the teacher online. A blog is a type of website or part of a website. Blogs are usually 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 a sketchbook, a diary, a dictionary or portfolio— it depends on the content that we put into the book.

The commenting feature of blogs allows for immediate feedback on a posting and active participation. The content that can be posted to a blog can be text, images, files, hyperlinks, audio and video. Blogs can 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 classroom teaching-learning process, by the students to post their assessment tasks 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 who moderates the discussion process to keep it on the right track. She can invite absent students, provide necessary teaching-learning materials and communicate with parents, link her class with another class

somewhere else in the world, write comments, opinions, or questions on daily news items or issues of interests and showcase students' best writing pieces. Teacher can also post teaching-learning notes for students, resources, and important links. In many countries students use mostly blogs instead of paper journals for writing assignments.

Services like http://www.blogger.com; www.learnerblogs.org and http://epnweb.org/blogmeister/are free blogging services that students can join. Some are open to the public, others are password protected.

ACTIVITY 10.10 

Discuss with examples how you will make use of various social networking sites for the purpose of enrichment of teaching-learning of physical science.

How did I use a blog?

I created a blog 'Physics is everywhere' to make my students realise the importance of this subject in their daily lives, because most of them considered it as a fearful subject. I posted a number of wonderful videos which could really make them wonder at the wonders of this wonderful subject. I also posted pictures of some famous people with their inspirational quotes along with a forum for frequently asked questions.

I as a teacher, personally feel that blogging can foster a community of motivated learners in our society, because interactive discussion, instant audience, contests, games and various other fun activities can really add new dimensions to the field of science education.

–Experience of a teacher

Classroom of the Future NASA (National Aeronautics and Space Administration) of USA has taken initiative to start Classroom Of The Future (COTF). Taking into account the technological progress COTF attempts to encourage the practising teachers to make use of digital resources in school education. More information about COTF can be found on its website *www.cotf.edu*

ACTIVITY 10.11 

Conduct discussion in the class on Nature of Future Science Classroom' in India.

ACTIVITY 10.12 

Log on to some of the social websites mentioned above to register yourself. Interact with your classmates on the topic being discussed in the classroom by inviting them to visit the sites.

ACTIVITY 10.13

Develop a PowerPoint presentation for one of the topics that you have to transact in the classroom during your school experience programme.

10.9 INTEGRATING ICT IN TEACHING-LEARNING PROCESS: AN EXAMPLE

Topic: Acids, bases and pH scale Class XII

Concepts to be transacted on the topic

- Acids are known to turn blue litmus paper into red. Acids are substances that dissociate in water to give hydrogen ions H+(aq). Bases are known to turn red litmus paper blue, taste bitter and feel soapy. Bases are substances that produce hydroxyl ions OH-(aq) and are capable of accepting a hydrogen ion H+.
- In chemistry, pH is a measure of the acidity or basicity of a solution. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline. The pH measurements are important in medicine, biology, chemistry, food science, environmental science, oceanography, civil engineering and many other applications.
- The pH-dependent plant pigments that can be used as pH indicators occur in many plants, including hibiscus, marigold, red cabbage and red wine.
- The pH of sea water plays an important role in the ocean's carbon cycle and there is evidence of ongoing ocean acidification caused by carbon dioxide emissions.
- The pH of different cellular compartments, body fluids, and organs is usually tightly regulated in a process called acid base homeostasis. The pH of blood is usually slightly basic with a value of pH 7.4. This value is often referred to as physiological pH in biology and medicine.
- A pH indicator is a chemical compound that is added in small amounts to a solution, so that the pH (acidity or basicity) of the solution can be determined visually. Hence, a pH indicator is a chemical detector for hydronium ions, the indicator causes the colour of the solution to change depending on the pH. The pH indicators find many applications in biology and analytical chemistry.

Objectives

Learning objectives

- Distinguishing between acids and bases.
- If given a number of solutions, then based on their characteristics differentiating them into acids and bases.
- Explaining consequences if the precisions in acidity and basicity are not maintained.
- Explaining the importance of a pH scale.
- Finding the pH of various aqueous solutions around their immediate environment using pH paper.
- Describing usefulness of pH scale in measuring the acidity and basicity of various aqueous solutions and its wide ranged applications.
- Summarising the effects of solutions with different pH on our health.

Teacher's Presentation

Teacher can generate discussion around questions, like

- What do you understand by acid and base?
- If you are given two solutions without labels, how would you identify them as acid or base?
- What are the common acids and bases that you come across daily in your life right from the start of the day?

Students may ask questions like:

- How can we discriminate between a lemon juice and concentrated sulphuric acid, though both are acids, one is edible and the other is not?
- What can we do if we have to measure acidicity or basicity of a solution?

Teacher can help them to know how to distinguish between various degrees of acidity and basicity of the broad range of solutions used in their daily life and their importance. These questions can then be followed by the teacher's PowerPoint presentation. Teacher can prepare it involving students.

Teacher's presentation

Lesson design: PowerPoint presentation

Teacher's presentation can address the following questions:

- What are acids? What are the definitions of acids according to different theories?
- What are bases? What are the definitions of bases according to different theories?
- What is a pH scale?
- How to calculate pH of a given solution, given its concentration and vice versa?

- Why are we so much bothered about knowing H^+ concentration? What is the importance of H^+ ion concentration in our life.
- What are the applications of pH measurement of a given solution?

Students' activities

Implementation of plan

Day 1

- On the first day, teacher will create learning environment by posing thought-provoking questions to students as indicated above. She will encourage them to ask questions. It will be followed by PowerPoint presentation by the teacher. Her presentation will generate a discussion among the students and the teacher. It will help the teacher to know existing ideas of the students on the topic. Among the students, it will help in generating curiosity for the importance of knowing acidity and basicity of various solutions around them.

Day 2

- The previous day's discussion will now be carried out as an activity by the teacher.
- The teacher will help the class to form 3–4 groups.
- Each group will prepare a set of solutions from the commodities they use in their daily life, like soaps, shampoos, body lotions, beverages, etc. and determine their pH value using pH paper provided by the teacher.
  - ➲ **Group A:** at least 5 brands of beverages.
  - ➲ **Group B:** at least 5 brands of body lotions.
  - ➲ **Group C:** at least 5 brands of shampoos.
- Once they have tested at least 5 brands they will conclude upon a pH range (from their observations) and will gather information on the effects of that particular pH range on their health in the long run.
- Students will explain their observations supporting with evidences.

Day 3

- The students will present their work.
- Each group of students will discuss their observations, gather information and finally arive at their conclusion. They can also compare and validate their observation and findings with that of their friends.

***Guidelines :* teacher would facilitate each group to**

- find out the pH of at least five brands of the allotted commodity;
- indicate the colour obtained on the pH paper;
- calculate the corresponding H^+ ion concentration and gather information regarding the corrosive effects of high acidity and basicity on our health;
- find the pH of a solution (as in the presentation) with pH strip; and
- present work and to search for the important issues.

Students' presentation

1) Group A - PowerPoint presentation
2) Group B - PowerPoint presentation
3) Group C - PowerPoint presentation

Conclusion

- By carrying out this project students got the understanding about how easy it is to find the pH of a given solution.
- They were enriched with hands-on experiences of how important it is to know the acidity and basicity of the various solutions that we use in our day-to-day life.
- The group testing various shampoos found that a shampoo expired 2 years back had a pH = 10 unlike the usual pH of shampoo that should be near 7.
- Students concluded from their own experimentation and information search that solutions with pH range of 6 to 9 are best suited to our bodies. Solutions with pH higher or lower than this range can have adverse effects on our health in the long run.

Assessment CRITERIA FOR the CONTENT AND use of computer	
Grades	***Criteria***
A	Students demonstrate attainment of learning objectives and answer essential questions. Students show curiosity by asking many questions. Students use technology to present interpretation. Students use computer as research tool and communication device.
B	Students interpret information from various sites, but do not directly answer targeted questions. Students ask few questions. Students do not use computer as research tool to gather information.
C	Students collect all information, but irrelevant to the topic. Students do not submit their work in time and do not present information as PowerPoint presentation.

Learning Indicators (LI) for assessing Power Point presentation

Power Point Presentation
1. Information presented is accurate, complete, useful and meaningful.
2. There are no mistakes in spelling or grammar.

3. The presentation layout and slide order are logical and aesthetically pleasing.
4. Graphics are of proper size and relevant.
5. Graphics are placed properly in a meaningful way.
6. Chart and tables are presented appropriately.
7. The text is easy to read.
8. Proper background coordinates with text colours and graphics.
9. Language used in oral presentation is simple, to the point and clearly describes the different ideas.
10. Answers the questions of the class correctly.

8–10 Learning indicators and above criteria: grade A

5–7 Learning indicators and above criteria: grade B

3–4 Learning indicators and above criteria: grade C

Teacher can work on various criteria and Learning Indicators (LI) of assessment by inviting students' ideas and arriving at a consensus.

Project 10.2

Select a few concepts/topics to be taken up in Classes VI–XII during your practice teaching and prepare a PowerPoint presentation to transact them to the students. Present it in the classroom for critical evaluation by your peers and teachers.

ACTIVITY 10.14

Download some animation files for teaching-learning of certain concepts such as Elastic collisions; Dual nature of radiation and matter and Radioactivity.

ACTIVITY 10.15

Make use of the graphical representation feature of the Microsoft Excel to transact the topic on simple pendulum.

ACTIVITY 10.16

Make use of Microsoft Excel to keep students' records.

ACTIVITY 10.17

Select any one of the social networking tools discussed above and use it as a component of teaching-learning of any topic of your choice.

10.10 SUMMARY

Various print and electronic sources of information are important tools in the hands of science educators for dealing with various issues on science education like access to quality materials, quality of education, active interaction among students and teachers and providing opportunities for lifelong learning. Though text and print materials were popularly used earlier and even in the age of technology they are important documented source of knowledge, the potential of computer has been recognised as an effective tool for obtaining knowledge and information through multimedia, via internal databases (CD-Rom), external databases (Internet) or by communication with others via e-mail, chat, blog, conferences, etc. The teacher should keep some time reserved for daily updating her knowledge and skills using various learning resources regardless of how much knowledge and experience she has already got. Only then she can help learners to locate, select, obtain and use information to support inquiry in physical science and augment communication of the result of inquiry. Thus, judicious use of technology supports and enhances learning of physical science. It helps to address specific learning needs of learners and requirements. However, use of ICT should be integrated with teaching-learning process of physical science and should not be viewed in isolation. Activities, experiments and projects are core of science. ICT can not be substitute to them. It is important for the teacher to have access to various sources of information, evaluate them and integrate them in the teaching-learning process. Learners should be enabled to access various sources of knowledge and interpret them to create knowledge rather than be passive users.

EXERCISES

10.1 What are the various resources for learning physical science? Discuss importance of science journals in keeping the teacher abreast with the latest developments in science and science education.

10.2 Enlist various forms of ICT. How would you use computer effectively in teaching-learning process of physical science? Explain any three uses with the help of examples.

10.3 What criteria will you keep in mind if you have to select a textbook of science/physics/chemistry?

10.4 How can you use audio, video and audio-video aids to make teaching-learning more effective? Explain with examples.

10.5 Explain how Dale's Cone of Experience can help teachers to select teaching-learning resources? Explain it taking an example from physical science.

10.6 What factors and criteria would you keep in mind in the selection of media for teaching-learning of physical science in schools?

10.7 Explain what do you understand by the term 'Multimedia' giving examples.

10.8 Describe how can ICT be used for improving science education in Indian schools.

10.9 What are the different ways in which the computer can be used to improve teacher and learners interaction in science classroom?

10.10 Explain how electronic resources can help you in teaching-learning of physical science effectively. Discuss any three resources with the help of examples.

10.11 Comment on the following statements.
(a) ICT in education leads to equity.
(b) ICT is a great socialising tool.
(c) Direct exposure to the material on the Internet is a real learning experience.

10.12 'Electronic resources of learning can support teaching-learning of science, but it can not be a substitute of a teacher.' Comment on this statement.

10.13 What are the various resources in print form that can be used as a resource in teaching-learning of physical science in schools? Collect a list of print material for the upper primary/secondary/higher secondary stages for science. Share your list with your friends.

10.14 Describe how can you use properly various social networking sites on the internet in the teaching-learning of physical science with examples.

Chapter 11

Tools and Techniques of Assessment for Learning Physical Science

11.1 INTRODUCTION

Education is an activity which is undertaken to fulfil 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

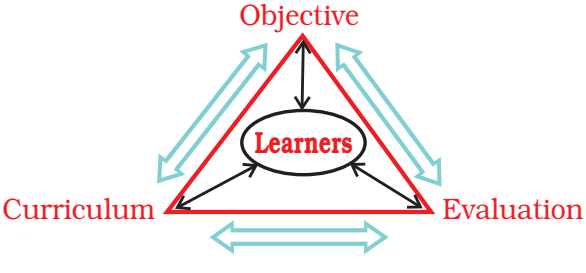


Fig. 11.1 *The three components of teaching-learning process have a two-way relationship*

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. Thus, it becomes imperative for us to appreciate this interrelationship and take a holistic view of evaluation, where it is not considered as a 'necessary evil' to be taken up, but an

entity interwoven in the very process of teaching-learning. We shall discuss this in the section of continuous and comprehensive evaluation (Section 11.3). We shall also see the meaning of test, examination, measurement, assessment and evaluation separately.

The chapter discusses in detail various elements of an assessment framework including details of various tools and techniques of assessment along with examples. The chapter concludes with some suggestions for the assessment of the learning of students with special needs.

11.2 TEST, EXAMINATION, MEASUREMENT, ASSESSMENT AND EVALUATION

Some of these words are often used more or less synonymously (for example, test, examination) and all of them seem related to the process of judgement. Let us consider each of them separately.

Test and examination are used many a times interchangeably, or test is considered a mini examination, for example, monthly test and annual examination. But then 'TET' (Teacher Eligibility Test), that you will take after completing your B.Ed. programme or 'Admission Test,' you successfully cleared for getting into the programme, are also tests, which by any stretch of imagination cannot be called mini examinations. Let us take another example from our day-to-day life.

Suppose, you go to a doctor. Will she examine you or test you? Certainly, here the two words cannot be used interchangeably, and we say that doctor examines a patient and may prescribe certain tests. Thus, **test** is basically a tool (for example, intelligence test, aptitude test, achievement test, etc.) and **examination** is the process. **Measurement** as we are familiar, is depicted by a numeral and the unit (if need be) in which a quantity is measured, i.e. 5 cm, 10 kg or 15g, etc. Let us now go back to our earlier example to understand the other two words, 'Assessment' and 'Evaluation'. After you get the tests conducted in a laboratory, you get a report which contains measurement(s) (numerals + units) of tested parameters. For example, your haemoglobin value is 16 gm/dl (deciliter). Along with these, there is another column in the report, which assigns certain meaning to these measurements, i.e. below normal, normal, above normal, etc. **Thus, assigning meaning to a measurement is called assessment, which may be quantitative as well as qualitative, and final conclusion drawn on the basis of several assessments along with value judgement is called evaluation.**

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 their is any learning gap between students' concept and scientific explanations of the concept. She 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) **At 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.

> The belief that assessment lead to finding learning difficulties and then those difficulties can be remediated, is often very impractical and not founded on a sound pedagogic practice. Problems regarding conceptual development cannot and do not wait for formal tests in order to be detected. A teacher can in the course of teaching-learning itself come to know of such problems by asking questions that make children think or by giving them small assignments. She can then attend to them in the process of teaching-learning by ensuring that her planning is flexible and responsive to the learners and their learning.
>
> *–NCF 2005*

Thus, we see that assessment and evaluation are ongoing processes. These are seamlessly integrated with teaching-learning process. Teacher has to make herself aware of the learners' learning process and

learning product (their performance) both, and evaluate the students holistically.

Let us now perform a small activity before discussing continuous and comprehensive evaluation.

ACTIVITY 11.1

During teaching-learning process of the concept, 'Image formation by spherical mirrors' in Class X, a teacher observed that a student has drawn the following ray diagram:

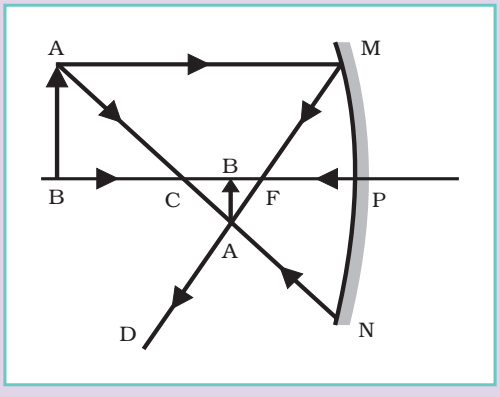


Fig. 11.2 *A ray diagram indicating naive concept of a student*

How can this figure help the teacher to observe students' naive concept? Suppose teacher assess this naive concept at the end of unit, then how can it hinder further development of student's concept on ray optics? Discuss in the class.

11.3 CONTINUOUS AND COMPREHENSIVE EVALUATION (CCE)

We have learnt that evaluation is the final judgement which expresses our opinion about object being evaluated and that final judgement is made in the light of some objectives. Let us take an example— When you go to buy a shirt piece or dress material for yourself, keeping in mind the purpose/occasion for which you are buying the piece, you look into several factors; colour, design, quality, price, etc. of the piece. You do not select a piece, just because you like only one of these parameters (say colour), but make a choice based on overall assessment of all such factors and select the one which is a best fit of all the parameters. Similarly, when you are supposed to make a judgement about how good a particular student is in science, you have to consider all the parameters/attributes which contribute towards making her a good

student of science. It may include her understanding of principles of science, ability to solve problems, skills in handling scientific equipment and experimentation, ability to think logically and rationally and may be her attitude of inquiry and interest in science. As there is little chance of making a correct choice regarding the piece of cloth just on the basis of a single parameter (say colour), similarly we cannot judge a student accurately unless we take all the needed parameters (depending on objectives) into account. Such an evaluation is called **comprehensive evaluation.**

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 assesment is an intergral 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.

ACTIVITY 11.2 

'An evaluation system which is not continuous and comprehensive, needs to be discarded.' Comment.

11.3.1 Educational assessment and educational evaluation

As we have learnt in the beginning of this section that on the basis of several assessments, we make final judgement/evaluation. Looking in this manner, assessments are part of evaluation. But suppose we assess a learner in English and Science and find her good in English and excellent in Science, Can we combine these two assessments to make any judgement? Certainly not, as only similar entries could be combined. Moreover, if we are making a comprehensive assessment for her performance in English, we would like to assess her reading ability, her vocabulary, her spellings, her command over grammar, her speaking ability and so on. We can assign grades for each of these abilities, but can we combine all of them to assign grade for her performance in English, i.e. evaluate her for her performance in English? Again, it is desirable that we do not make such a judgement and instead of saying that she is good in English, we only say that she has excellent vocabulary, has good command over grammar and possesses average reading ability and so on. This procedure will provide a better feedback to the learner as she will come to know the areas she has to improve in. Providing an overall grade is very cumbersome on one hand, because two students may get 2As, 3Bs, 1C, but in different areas and assigning them the same grade will signify that both have

performed to the same level and does not provide the proper feedback to the student on the other hand. Thus, it is better to limit ourselves to comprehensive assessment and follow the procedure:

- Identify the various aspects of a performance in a given area, that is task-specfic to learning indicators.
- Assess each aspect/task continuously and assign grade for each of them.

The various aspects of a performance are called performance parameters or learning indicators. We shall discuss in detail on it in section 11.4(B).

11.3.2 Performance-Based Assessment (PBA): A flexible way of school-based assessment

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. **Hence, there is a need to shift in the process of assessment.** Table 11.1 shows a major shift required in the assessment process.

Table 11.1 Major shift required in the assessment process

	From	To
	Teacher-centred	**Learner-centred**
1	Learner as passive recipients	Learner is viewed as active participant
2	Focus is on learning product and outcome	Focus is on learning process and experiences
3	Focus is on knowing learning deficit of the learner	Focus is on strength, ability and needs of the learner
4	One slot/intermittent approach	Continuous and comprehensive approach
5	Assessment of single attribute	Continuous and comprehensive assessment
6	Assessment **of** learning	Assessment **for** learning

For a learner-centred 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.

Tasks that are challenging and allow independent thinking, and multiple ways of being solved, encourages independence, creativity and self-discipline in learners. Instead of a culture of quizzing of answers quickly and always knowing the right answer, we need to allow learners to spend time on deeper and meaningful learning. For this purpose, performance-based assessment (PBA) can be one of the modes of school-based assessment. Teacher can devise a number of ways to make such internal assessment more credible. Performance-based assessment provides learners to:

- get actively engaged in teaching-learning process;
- develop their critical thinking and problem solving skills; and
- get encouraged to learn and excel in their performance of task as they are free to originate and apply their own ideas.

Performance-based assessment consists of two parts—a task that is open-ended and a set of learning indicators (LI) for assessment. These two parts of assessment demonstrate product of performance and process of performance, examples of which are depicted in Fig. 11.3. The task may be a product, performance or extended written response to a question that requires students to apply critical thinking skills. A well designed performance-based programme focuses on students' ability to integrate what they have learnt creatively; ability to work collaboratively and their written and oral expression skills. Existing classroom teaching-learning activities may be transformed into a performance-based assessment with the addition of suitable learning indicators. Since an element of subjectivity is likely to creep in the assessment, a set of precisely defined criteria in the form of

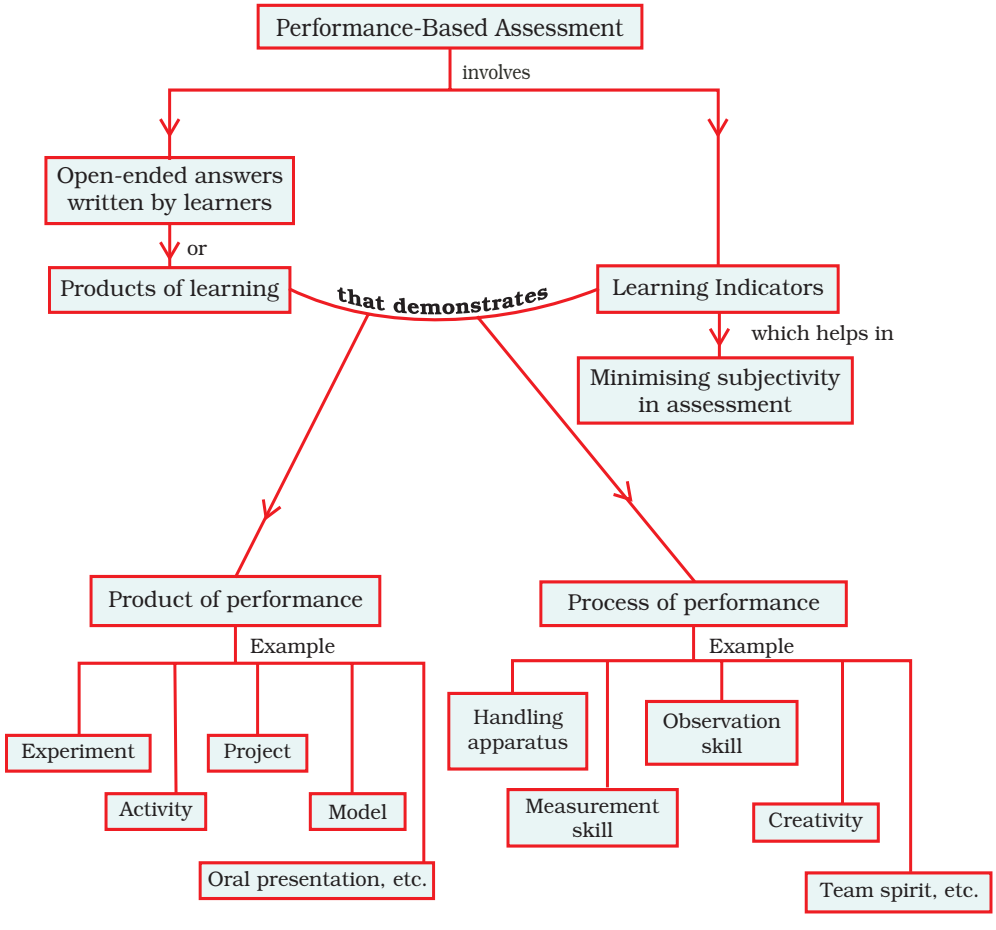


Fig. 11.3 *Concept map of performance-based assessment*

various learning indicators may be developed by the teacher for a given teaching-learning situation. This criteria should be content specific. It should also respond to the particular needs and characteristics of the students, teacher, discipline, topic and context, i.e. what works in a given topic and class may not necessarily work in another context. Tasks specific to these indicators help teacher communicate to students what constitutes understanding of scientific concepts and how to evaluate their own work, define excellence and plan how to help students achieve it.

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.

ACTIVITY 11.3 

Discuss how performance-based assessment can facilitate students in the construction of their knowledge in science. Think–pair–share with your friends.

11.4 ASSESSMENT FRAMEWORK

A teacher is required to make several decisions during teaching-learning process about the (i) learners' abilities, aptitude, attitude, existing ideas, etc., (ii) learning objectives, approaches and strategies to be adopted, (iii) teaching-learning materials, (iv) learning process, (v) collecting learning evidences, (vi) tools and techniques of assessment, (vii) recording and reporting of the assessment, etc. Teacher is also sometimes required to select students for a particular purpose like representing the school in state level science exhibition. She is always interested in knowing how her students are progressing. Are they facing any difficulty in learning? If yes, what is that difficulty? Does a particular learner face any particular problem in learning? If so, what measures should she take to facilitate her learning? How effective was the transaction of teaching-learning materials? What is the degree of achievement of the learning objectives? What modification she has to make in teaching-learning materials and the approaches and strategies adopted? In order to take any decision regarding the issues mentioned above, the teacher has to make some kinds of assessment and evaluation. Thus, it becomes important for her to plan classroom assessment, so that the decisions taken on the basis of assessment are correct and result in meaningful learning of students.

We now understand that **assessment is an integral part of teaching-learning process spread out to entire teaching-learning process and throughout the year.** Therefore, making a broad plan is required on what is the purpose of assessment, what can be learning indicators, how assessment is to be done, how evidences of students' learning can be collected, how feedback can be provided at the suitable juncture of concept formation of learners, how evidences of their learning can be reported and how we can reflect on the overall assessment process. **This broad planning can be done by an assessment framework.**

Developing an assessment framework helps in making decision about proper tools and techniques for the assessment of the teaching-learning activity or task and the process of assessment. An assessment framework covers following main areas:

A. Purpose of assessment
B. Learning Indicators (LI)
C. Tools and techniques of assessment
D. Recording and reporting
E. Reflecting process

This is represented in Fig. 11.4. Notice that learner is at the centre of the assessment throughout the process. After reflecting on the feedback received from the learners and the learning evidences, teacher can revisit the learning indicators.

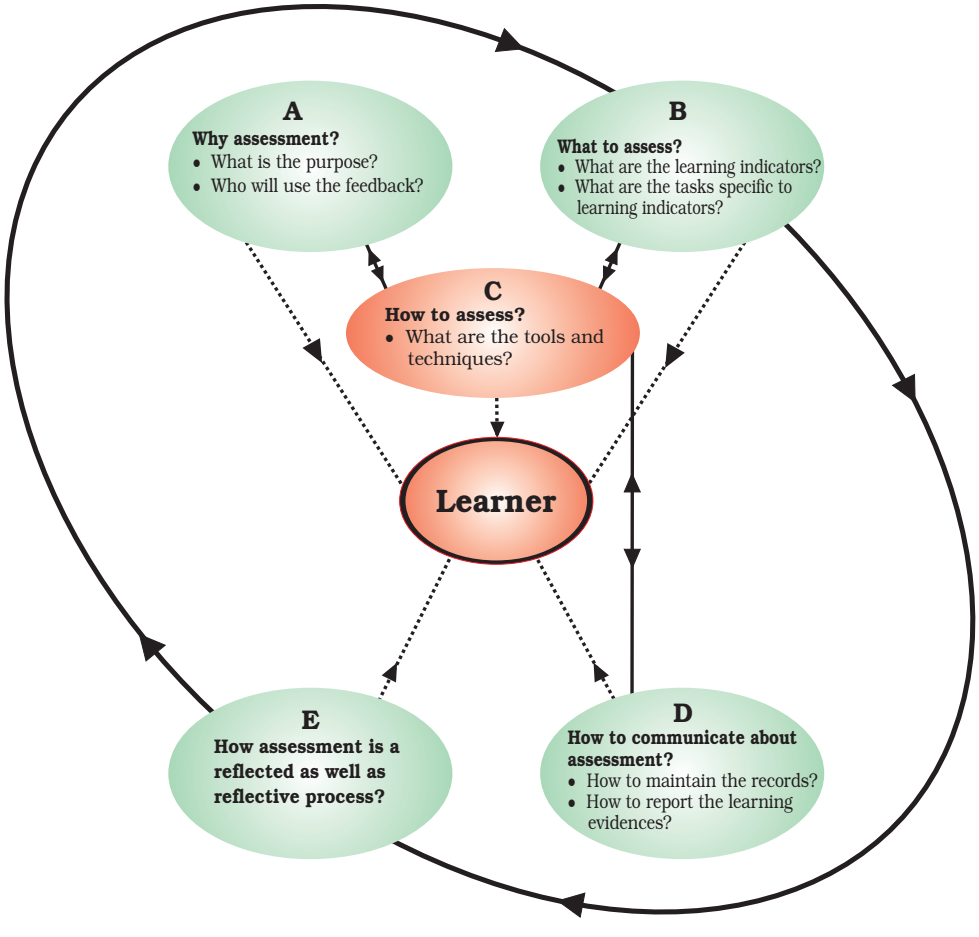


Fig. 11.4 *Assessment framework*

11.4(A) Purpose of assessment

- 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.

The purpose of evaluation is not

– to motivate children to study under threat;

– to identify or label children as 'slow learners', or 'bright students', or 'problem children'. Such categories segregate children, placing the onus for learning solely on them, and detract from the role and purpose of pedagogy;

– to identify children who need remediation (this need not wait for formal assessment. It can be detected by teacher in the course of teaching-learning and attended to as a part of pedagogic planning, through individualised attention);

– to diagnose learning difficulties and problem areas— while broad indications about conceptual difficulties can be identified via evaluation and formal testing.

Diagnosis requires special testing instruments and training. It is also specific to foundational areas of literacy and numeracy, and is not meant for subject areas.

–NCF 2005

Who will use the feedback of assessment? We have to keep in mind the purpose of assessment before discussing, and selecting learning indicators, tools and techniques, recording and getting engaged with reflected and reflecting process of assessment.

11.4 (B) Learning indicators (LI)

In the previous section, we have studied that comprehensive assessment involves an all round assessment of performance and personality of the learner, which in turn may depend on several factors. There could be a number of performance parameters to be assessed separately and continuously. These are called learning indicators and make the process of assessment easier. Assessment of the indicators can throw light on the extent and quality of performance of the learner at a given point of time. A wide range of learning evidences can be pre-defined with suitably designed learning indicators.

In this section, we shall discuss about learning indicators with the help of examples.

Learning indicators help us in following ways:

- knowing various parameters of learning evidences of the learner as she progresses through the process of learning and acquisition of process skills of science;
- monitoring formation of concepts of the learner and her progress in different areas of learning;
- providing feedback for teaching-learning process; and
- enhancing learner's understanding of science as well as teacher's understanding about learner's understanding.

11.4(B).(1) Types of indicators

In this section, a number of sets of learning indicators of science have been suggested to facilitate the teachers in continuous and comprehensive assessment in day-to-day teaching. These indicators are only a broad framework. **Teacher may select various learning indicators depending on the learner's performance and teaching-learning experiences provided to them.** In doing so, a teacher may observe 4–5 students everyday and make a note of observations regularly. Some of the indicators are coupled in order to make assessment teacher-friendly as well as student friendly. Learning experiences and processes should be assessed and not only learning products.

a. ***Observation and inquiry***

- Observing an object, an event or a phenomenon
- Using all senses to collect information.
- Identifying similarity and differences between objects or events.
- Recognising the order/sequence that takes place in an event.
- Observing details of an object for event.
- Asking questions to get information about objects, events or phenomenon.
- Identifying questions which can be answered by their own investigations.
- Raising critical questions that help deeper analysis.
- Thinking critically about one's own reasoning.

Let us take an example.

Starting the topic of the moon, Mahesh, a teacher assigns a class project to record observations of the moon in the form of sketches with detailed

descriptions regarding size, shape and position of the moon with respect to some tree or building (Fig. 11.5).

The teacher initiates the topic of the moon by comparing the sketches made by the students. He finds some discrepancies regarding the curve and position of the moon. The discussion is carried out to point out these discrepancies of the students. During this discussion, a number of questions are raised by the students, such as:

- Why does the moon change its shape?
- Does the moon look different at different places?
- Why does it move?

Fig. 11.5 *Observing phases of the moon*

b. *Classification and experimentation*

- Classifying a group of objects on the basis of observable characteristics.
- Identifying similarities in groups of objects.
- Identifying differences in groups of objects.
- Grouping the objects on the basis of one characteristic at a time.
- Interacting with teacher for safety instructions.
- Following safety measures while working in the laboratory to avoid any accident.
- Handling things, equipments with care— individually and in a group.
- Performing activities individually or in a group in a systematic manner.
- Using standard and non-standard measures in making comparisons and taking readings.
- Improving and creating new things on their own.

- David, a teacher at secondary stage wishes to perform an activity on the classification of materials as metals and non-metals. He helps students to collect various materials made of metals and non-metals from their surroundings. Next day, he collects those materials from the students and puts them for observation and classification in the classroom.

  Students observe the materials, discuss among themselves and write some characteristics on the basis of which metals and non-metals can be classified. They identify characteristics such as malleable, ductile, sonorous, etc. With the help of the students, David consolidates the general classification.

- In order to classify substances on the basis of their solubility in water through experimentation, Simran suggests her students to collect a variety of substances like sand, coal powder, salt, sugar, saw dust, chalk powder, washing soda, etc. Students are then asked to perform the experiment in groups to check solubility of the given substances in water. They write their observations in tabular form and classify substances as soluble and insoluble in water.

c. Collection and presentation of data/recording and reporting of data

- Discussing with others to get information.
- Manipulating laboratory equipments and setting up experiments.
- Reading Tables, graphs, pictures, maps with gradually increasing complexity.
- Reporting and narrating an event or process in oral or written form.

The students are asked to measure the body temperature of some of their friends (at least of 10) with a clinical thermometer. At the end, children present this information in tabular form on charts which can be displayed in the classroom.

d. Communication skill

- Distinguishing between opinion, facts and hypothesis.
- Expressing her ideas in her own words.
- Listening and responding to others' ideas in a group.
- Accepting feedback from others and appreciating that others' may have a different point of view.
- Reviewing one's ideas according to feedback given by others.
- Defining the situation/event in her own language.
- Expressing herself through various channels (quick test/ worksheet/quiz/poster/debate/drama).

The emphasis of assessment in this indicator is to check whether a learner can explicitly communicate her ideas orally, or in written or in any other form. It enables the teacher to find out whether a child has understood the concept transacted.

e. Providing explanation

- Making simple hypothesis to explain observations or relationships.
- Recognising the need to test explanations by gathering more evidences.
- Explaining logical consistency of hypothesis with relevant laws, theory and experiment.
- Proposing, validating procedure for both experiments and activities.
- Explaining scientific phenomena with reason on the basis of observation and experiment.

Sunanda, a teacher brings the following samples to the classroom:

Tap water, detergent solution, aerated drink, soap solution, milk of magnesia, washing soda solution and limewater solution.

She provides pieces of blue and red litmus paper and suggests them to test which solution is acidic and which one is alkaline in nature. Students then tabulate their observations and put forward an explanation for the same.

f. Drawing conclusions/inference

- Making inferences based on evidence gained by experiences/ experiments.
- Changing ideas when a different one makes better sense of evidence.
- Treating every conclusion as being open to challenge by new evidence.
- Identifying or predicting possible causes of any event/ phenomenon.
- Making logical connections, using evidences or patterns to make prediction.

Gurpreet suggests her students to collect the soil from various places and perform the activity given below:

For 2 g of soil in a test tube, add 5 mL water to it. Shake the contents of the test tube. Filter the contents and collect the filtrate in a test tube. Check the pH of this filtrate with the help of universal indicator paper. Also, you can note down the name of the plants growing in the region where you have collected the soil.

On the basis of their observations, students can draw conclusion about the relationship between growth of plants in a particular reason and pH of the soil.

g. Application to daily life/life experiences

- Observing the surrounding environment keenly.
- Raising questions based on daily life experiences.
- Recognising relevance of the learnt material to her daily life.
- Applying the scientific concepts in novel situation to find explanation.
- Solving problems in novel situation.
- Describing how technology makes our work easier.

h. Value/attitude/concern

- Taking initiatives/responsibility in conducting collective work.
- Sharing and working with others; being considerate and helpful towards others.
- Being aware of one's strength and challenges.
- Having a strong sense of justice and being ready to act for a just cause.
- Concern for the environment including plants and animals.
- Avoiding wastage of material, trying to reuse and recycle.
- Being sensitive towards others who may be disadvantaged or differently-abled.
- Being conscious of inequality in the family and society; being able to reflect and question.
- Endeavouring to become independent learner.

These indicators reflect the personality of the learner and can be assessed by observing the day-to-day action and behaviour of the student. These indicators should not be assessed on point scale but should be treated qualitatively. **All students in the same classroom may not learn in the same manner and show same learning evidences.** However, efforts can be made to consider specific instances and provide positive feedback to each learner and her parents. For example, when a learner uses equipment, apparatus, chemicals carefully and asks thought-provoking questions, then such a student should be appreciated for these qualities.

Various indicators of learning are linked to each other. One task can assess many indicators**.** Also, there may be overlapping of the indicators. Students observe, discuss, express, explain, analyse and classify. They also question, analyse and perform experiment. They

take initiative, share their ideas and help each other. Many processes may take place together, though learners are engaged with one kind of process more deeply at sometime. Teacher can assess the learners in a holistic manner so as to assess more than one indicators at the same time.

Example of performance-based assessment for an activity, oral presentation and group work each, specifying their various parameters have been given below.

11.4 (B).(2) Illustrations: Learning Indicators (LI)

(i) Assessment of activity

Name of the activity: Measurement of body temperature

How to perform:

Measure the body temperature of some of your friends (at least 5) with a clinical thermometer and enter the data in Table 11.2.

Table 11.2 Measurement of body temperature

Name	Body temperature ^{0}C

Table 11.3 Assessment of activity

S. No.	Learning Indicator	Tasks specific to Indicator (What can be assessed)	Checklist to assess the learner
1.	Experimenting/ Collecting data	Washes and wipes thermometer before use.	Yes/No
		Jerks the thermometer to bring the level of mercury below 35°C.	• Jerks the thermometer carefully, so that it does not break. • Brings mercury level below 35°C
		Places the bulb of thermometer at appropriate place of the body.	Yes/No

		Keeps there for about one minute.	Uses clock to monitor time.
		Reads the mercury level in the thermometer.	Holds thermometer parallel to her eyes and the point to be read is in front of her eyes.
		Measures temperature of 5 students.	Follows correct procedure while measuring temperature of each student.
		Washes and wipes the thermometer before next use.	Yes/No Yes/No
		Washes and wipes the thermometer and puts it back in its case.	Yes/No Yes/No
2.	Presenting data	Enters name of students and temperatures in the Table.	• Enters data in correct columns. • Fills data for all 5 students. • Speaks out temperature with unit.
3.	Analysing data and drawing conclusions	Realises that the body temperature of every person is not the same.	Yes/No
		Realises that the temperature of human bodies is in the range 35–42°C.	Yes/No
		For a healthy person, temperature is around 37°C.	Yes/No

4.	Providing explanations	Answers questions related to the procedure.	• Why should we wash thermometer before and after use? • Why should we bring mercury level below 35°C? • Why do we place it under the tongue for one minute? • Is the temperature of all students the same?
5.	Asking questions	Shows interest/ curiosity in getting related knowledge.	• Why thermometer is brought in contact with a particular part of the body ? • Why mercury is used in thermometer ? • Why Celsius scale is used ? • What are the other scales of measurement of temperature ?
6.	Values/attitudes /concerns	• Shows concern so that no accident takes place. • Takes care to wash and wipe the thermo-meter before and after each use. • Takes and records temperature of 5 students honestly.	Yes/No Yes/No Yes/No

(ii) Assessment of presentation

Table 11.4 Assessment of presentation

(Tick mark ☑ may be put on the relevant tasks)

Learning Indicator	**Tasks specific to indicator**			
Grade	**A**	**B**	**C**	**D**
Content	Correct/ concise/ complete/ coherent.	Correct/ concise/ complete/ coherent to some extent.	Correct/ concise/ complete/ coherent to a very little extent incoherent.	Correct partially/ concise to some extent/ incomplete/ mostly incoherent.
Understanding of the subject	Describes all principles involved with details /clearly explains all relevant concepts/ conveys depth in understanding.	Describes all principles involved with some details/ explains most of the relevant concepts/ conveys understanding.	Describes most of the principles involved with little details/ explains a few relevant concepts/ conveys a little understanding.	Describes principles involved with some errors/ describes a few concepts/ conveys very little understanding.
Presenting	Speaks clearly with confidence/ speaks knowledgeably/ makes eye contact/ involves classmates /modulates voice.	Speaks with confidence/ speaks knowledgeably/ makes frequent eye contact/ involves classmates/ modulates a little.	Speaks with little confidence and knowledge/ rarely makes eye contact/ involves classmates/ speaks in monotone.	Speaks vaguely/avoids making eye contact/ no involvement of classmates.
Using visual aids	Aids support the presentation	Aids support presentation	Aids support presentation	Aids support presentation to a little extent/

	/organised / relevant/ neat.	/organised to some extent/neat.	/organised to a little extent/neat.	organised to some extent/ messy.
Organisation	Speaks in logical way /smooth transition from one concept to other/ shows connection of concepts.	Speaks in logical way/ smooth transition from one concept to other/ shows little connection of concepts.	Speaks in logical way/ jerky transition from one concept to other.	Speaks mostly in logical way/ jerky transition from one concept to other.
Creativity	Shows innovative-ness/ explores novel ways /generates and sustain interest of the class.	Shows some innovative-ness/ generates and mostly sustain interest of the class.	Shows a little innovative-ness/ generates and sustains interest of the class to some extent.	Performs the task in repetitive way/ generate a little interest of the class.

(iii) **Assessment of group work**

Table 11.5 Assessment of group work

(Tick mark ☑ may be put on the relevant task)

Learning Indicator	**Tasks specific to Indicator**			
Grade	**A**	**B**	**C**	**D**
Participation	Actively participates /contributes significantly /volunteers work/shows positive attitude/ shows initiatives.	Actively participates/ contributes a lot/ volunteers work/mostly shows positive attitude/ shows initiatives occasionally.	Actively participates/ contributes a little/ volunteers work sometimes/ mostly shows positive attitude/ rarely shows initiatives.	Actively participates/ contributes very little/ rarely volunteers work/ rarely shows positive attitude.

Team spirit	Shows team spirit/works collaborativ-ely/respects other's ideas /involves others in work.	Shows team spirit/ works mostly collaborativ-ely/respects other's ideas /involves others in work occasionally.	Shows little team spirit/ works collaboratively /respects other's ideas/ rarely involves others in work.	Shows very little team spirit/ interacts a little/ respects other's ideas /hardly involves others in work.
Democratic attitude	Allows others to speak/ work/ gets involved in healthy discussion/ listens/ interacts to others/gives weightage to other's work /appreciates other's contribution/ demonstrates social values.	Allows others to speak/ work/gets involved in healthy discussion/ listens/ interacts to others/gives weightage to other's work most of the time / appreciates other's contribution most of the time/ demonstrates social values most of the time.	Allows others to speak/ work/gets involved in healthy discussion most of the time/listens/ interacts to others/gives weightage to other's work sometimes/ appreciates other's contribution sometimes / demonstrates little social values.	Sometimes allows others to speak/ work/rarely gets involved in healthy discussion/ listens/ interacts to others sometimes/ rarely gives weightage to other's work / hardly appreciates other's contribution/ demonstrates very little social values.
Reflection on collective experiences	Facilitates collective decision/ gets involved in open discussion/ encourages and recognises multiple views/	Facilitates collective decision/gets involved in open discussion most of the time/ encourages and recognises	Facilitates collective decision/gets involved in open discussion most of the time/ encourages and recognises	Facilitates collective decision/gets involved in open discussion occassionally /encourages and recognises multiple

	speaks without fear /unbiased/ constructs meaning of concept socially/ questions/ inquires/ debates to arrive at a concept/ provides support to the group.	multiple views occasionally/ speaks without fear /unbiased/ constructs meaning of concept socially most of the time/ questions/ inquires/ debates to arrive at a concept/ most of the time provids support to the group.	multiple views sometimes / speaks with little fear/ unbiased/ constructs meaning of concept socially/ sometimes questions/ inquires/ debates to arrive at a concept/ provides support to the group. occasionally.	views rarely/ speaks with fear/biased/ constructs meaning of concept socially/ rarely questions/ inquires/ debates to arrive at concept/ provides little support to the group.
Multiple manifestation	Works with effective planning/ planning relates to project/ experiment/ activity at hand with contextual background /provides explanations /always defends her hypothesis with analysis/ evidences /suggests alternatives /various ways to interpretating	Works with effective planning/ planning relates to project/ experiment/ activity at hand with contextual background /provides little explanations /defends her hypothesis with analysis/ evidences most of the time/suggests alternatives /various ways to	Works with mostly effective planning/ planning relates to project/ experiment/ activity at hand with contextual background vaguely/ provides a little explanation/ defends her hypothesis with analysis /evidence sometimes/ suggests alternatives/ various	Works with mostly effective planning/ planning relates project/ experiment/ activity at hand with contextual background vaguely/ provides very little explanation/ rarely defends her hypothesis with analysis/ evidence/ rarely suggests

	experiments /projects/ data/works at a cognitive level above her own.	interpretating experiments /projects/ data/ sometimes works at a cognitive level above her own.	ways to interpretating experiments /projects/ data sometimes /rarely works at a cognitive level above her own.	alternative ways to interpretating experiments /projects/ data/hardly works at a cognitive level above her own.

(iv) Assessment of collaborative learning

Activities, experimental work, projects, field trips and various other learning experiences provide an opportunity to work in groups and help in developing a positive attitude towards group work, sharing and learning from each other. Let us see in the following example how assessment of participation in collaborative learning was done by Geeta, a teacher.

After completing the Chapter *Metals and non-metals*, Geeta, Class VIII teacher suggested her students to work on a common project given below. "Prepare index cards for any four metals and four non-metals. The card should have information such as name of the metal/non-metal; their physical properties, chemical properties and their uses."

Geeta facilitated the class to form nine heterogeneous groups comprising five students each.

Each group was having a leader with whom other group members were cooperating. They all first discussed among themselves, recalled what teacher discussed in the class and started their work. One student, wrote name of metals and non-metals on the index cards. The second student wrote physical properties of metals and non-metals. Third student wrote chemical properties of metals and non-metals and the fourth one wrote about their uses on the same index card.

After completing the task, each group leader presented the work in the class. Geeta had kept herself free to give attention to the student, who was not able to tackle the problems.

While evaluating the collaborative work, Geeta kept in her mind that groups of students worked collaboratively and each group of students contributed in one way or the other. She randomly asked questions to each member of the group.

Geeta assessed the students on the basis of following learning indicators:

- Content knowledge of the activity/project.
- Putting forth her views with reasoning.

- Proper communication skills, i.e. speaking/writing
- Respect for other members of the group.
- Proper body language while interacting.

It is reiterated that **these learning indicators are suggestive, not prescriptive**. Tick mark(s) can be put on the grade or on the observed tasks specific to the indicator of an individual learner. These can be used for the assessment of learners' proficiency in various activities of learning processes. These assessment Tables help in reviewing and revisiting the concepts. It also helps to remain focused on the task in refining teaching-learning experiences. **The indicators can be varied, modified or altered according to the need of the situation.** It saves time spent by a teacher on assessment. Assessment is authentic with much scope of flexibility and consideration for a heterogeneous classroom. Performance of the learner can be shown qualitatively or in terms of grades in each area of learning. It also helps learners to know their strengths and challenges. Different indicators of learning for various learning experiences may be developed with the help of students for providing a sense of ownership of learning to them and giving them opportunity of self-assessment. A file with one paper sheet for each learner can be maintained for recording the performance of students. With proper planning and little investment of time, it can be one of the effective tools of ongoing assessment and meaningful learning.

ACTIVITY 11.4

(i) Discuss your ideas with your classmates about the learning indicators for the assessment of the assignments given to the students. You may design tasks specific to the following indicators:
Understanding, reasoning, data collection, creativity, completeness, etc.

(ii) What indicators will you use to assess your students on their ability to perform an experiment in the group? Identify the tasks specific to indicators as a group work and give presentation in the class.

(iii) Select any two activities from the textbook of science of Class IX/X. Write down learning indicators and tasks specific to indicators in tabular form for the activities.

11.4 (C) 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 their own work and performance.
- **Peer assessment:** refers to one student assessing other students. This can be conducted in pairs or in groups.

11.4.(C).(1) Written test

(i) Preparing design of the test

Before constructing the test paper, several decisions have to be made by the teacher/paper setter. For example, what content is to be included in the test? What weightage is to be given to different components of the content (units and sub units)? If major categories of the objectives to be tested are remembring, understanding, applying and analysing, then what weightage should be given to each of these categories? What form of questions—essay, short answer and/or objective type should be given? If it is decided to use all three or more than one type, then what should be their respective weightage? As a balanced test paper should contain easy, average and difficult questions, what should be the weightage of each of these? Should there be any choice in the paper or not?

All these decisions, which have to be taken before actual construction of the test paper, are parts of the design of a test paper.

(ii) Construction of blue prints

The next step is to prepare the blue prints. The policy decisions as reflected in the design of the question paper are translated into action through the blue prints. Blue print is a table which facilitates the teacher/paper setter to decide as to how many questions are to be set, marks assigned for different objectives and also that under which unit a particular question is to be set. It also depicts marks assigned for

each question, form of each question and their difficulty level. A sample form of the blue print is given below.

Subject _____ Total Marks _____
Class _____ Time _____

1. Weightage to constituent units

Generally, all the units/sub units, selected for the test are neither of equal length nor equally important from teaching-learning or subject point of view. Some are more difficult compared to others. Thus, all units may not be given equal weightage. In order to decide the weightage, the paper setter has to use his/her own wisdom, unless the examination body (board, etc.) has already provided the weightage. One guiding principle to decide the weightage could be the time spent on teaching a particular unit/sub unit. For example, if 10 periods have been spent on unit A and 5 on unit B, the weightage to A may be double to that of B.

2. Weightage to learning objectives

Again the weightage to each objective has to be decided in relation to content area selected for the test. Generally, if we have selected a representative area of the total content, weightage to remembering, understanding, applying and analysing can be assigned depending upon the nature of the content. Higher order abilities can also be included and given due weightage.

Now we can prepare the blue print depicting weightage to constituent units and weightage to learning objectivies as shown in Table 11.6.

Table 11.6 Weightage to constituent units and learning objectives

S.No.	(Unit/ Sub Unit)	Marks 50 (say)	Percentage of marks	Objective				
				Remembering	Understanding	Applying	Analysing	Total
1.	A	10	20	2 (say)	3	3	2	10
2.	B	15	30					
3.	C	15	30					
4.	D	10	20					
	Total	50 (say)	100					

3. Weightage to types/forms of questions

Types/forms of questions can be of long answer, short answer, very short answer or objective (selection type). However, long answer, short answer and very short answers are relative terms and could be

determined only in relation to the content area and standard of the class. Number of each type of questions is decided and marks assigned for each question is written as shown in Table 11.7.

Table 11.7 Weightage to types/forms of questions

S.No.	Type/Form of question	Marks for each	No. of questions	Total marks
1.	Long Answer (LA)	5(say)	3	15
2.	Short Answer (SA)	3	5	15
3.	Very Short Answer (VSA)	2	6	12
4.	Objective (Selection Type)	1	8	8
			Total - 22	50

4. Weightage to time and length of the questions

Actual length of a particular type of question and number of questions of that type have to be decided by keeping the total time in mind. It would therefore be advisable to budget time properly.

Table 11.8 Weightage to time and length of the questions

S.No.	Type / Form of question	Marks for each question	Expected time for each question (Minutes)	Expected length of each question (No. of words/ sentences)
1.	Long Answer (LA)	5	15	2-3 pages
2.	Short Answer (SA)			
3.	Very Short Answer (VSA)			
4.	Objective (Selection type)			

5. Weightage to difficulty level

Table 11.9 Weightage to difficulty level

S. No.	Difficulty level	Marks	Percentage of marks
1.	Difficult	15	30
2.	Moderately difficult		
3.	Easy		

The terms used above (difficult, moderately difficult, easy) are in fact relative. No question can be called easy, only it may be easier compared

to other questions. However, as a guiding principle, following criteria could be used:

- An easy question is the one, which could be answered correctly by a student who has gone through the content once or twice, although not in a systematic manner.
- A moderately difficult question is the one, which could be answered correctly by those students only who have gone through the content in a very systematic manner.
- A difficult question is the one, which could be answered correctly by those students only who have gone through the content in a systematic manner and their learning is well organised. Questions testing deeper understanding and novel applications generally fall in this category.

6. Scheme of options

Generally, one should refrain from providing options in a question paper. If an option has to be provided, one should make sure that among the options provided they should be equivalent as far as possible. It should be ensured that the questions are from the same content area, have same objective, have same difficulty level and are of the same form, otherwise the weightage allotted to each of these will be disturbed.

Table 11.10 Scheme of options

S.No.	Type /Form of Questions	Total Number		Marks allotted	
		In question paper	To be answered	In question paper	To be answered
1.	Long Answer	4 (say)	3	20	15
2.	Short Answer				
3.	Very Short Answer				
4.	Objective (Selection type)				

Now a comprehensive blue print can be prepared by combining all the blue prints, that have been given above.

BLUE PRINT

Examination _____ Subject/Unit _____

Class _____ Time _____

Maximum Marks _____

Table 11.11 A blue print

Subject	Remembering				Understanding				Applying				Analysing				Total			
Forms of QS Unit/ Sub Unit	LA TM (No. of Qs)	SA TM (No. of Qs)	VSA TM (No. of Qs)	ST TM (No. of Qs)	LA TM (No. of Qs)	SA TM (No. of Qs)	VSA TM (No. of Qs)	ST TM (No. of Qs)	LA TM (No. of Qs)	SA TM (No. of Qs)	VSA TM (No. of Qs)	ST TM (No. of Qs)	LA TM (No. of Qs)	SA TM (No. of Qs)	VSA TM (No. of Qs)	ST TM (No. of Qs)	LA TM (No. of Qs)	SA TM (No. of Qs)	VSA TM (No. of Qs)	ST TM No. of Qs)
A																	5(1)	—	2(1)	2(2)
B																				
C																				
D																				
Total																				
																Total	50(22), say.			

All columns can be filled up with total marks and number of questions under each heading. 5(1), 2(1) and 2(2) indicate one LA type question of 5 marks; 1 VSA question of 2 marks and two ST question of 1 mark each respectively. 50(22) indicates that there are twenty two questions in all for maximum marks 50.

Abbreviations

LA: Long answer **SA:** Short answer **VSA:** Very short answer
ST: Selection type **TM:** Total marks
No. of Qs: Number of questions.

Summary

Long answer Qs ..... Marks
Short Answer Qs ..... Marks
Very Short Answer Qs ..... Marks
Supply type Qs ..... Marks
Difficult Qs ..... Marks
Moderately difficult Qs ..... Marks
Easy Qs ..... Marks

Scheme of options ..... questions e.g. Internal choice in two long answer type.

Scheme of section ..... questions e.g. Section A and Section B.

This blue print is merely suggestive. The individual teacher is free to design it according to needs of the learners.

ACTIVITY 11.5

Analyse a question paper of physics/chemistry of final examination and make a blue print of the question paper.

ACTIVITY 11.6

Fill up the Table 11.11 and based on this blue print set up a question paper of 100 marks in physics/chemistry of three hours duration at higher secondary stage.

(iii) Writing questions

After preparing the blue print, we start writing questions according to the blue prints. For example, if we know from the blue print that from Unit 1, we have to prepare four objective type questions, one each for testing remembering, understanding, applying and analysing and two of them should be easy and two moderately difficult, then we proceed accordingly.

After writing the questions in this manner, questions of one type should be clubbed together, preceeded by specific instruction, e.g., if they are short answer type questions, then indicate the length of expected answer in instruction. If there is any option provided, indicate that also.

Above we have just outlined one possible way of constructing questions according to the blue prints prepared. You can follow any order.

We have named various types of questions as long answer type (which is also called essay type), short answer type, very short answer type, etc. These are supply type questions as students have to supply the answers. A different form of objective type question is selection type, as students have to select the correct answer from the choices provided. It can have different forms. Let us now briefly discuss about them.

1. Long answer type

There are certain outcomes of learning (e.g. organising, summarising, integrating ideas and expressing in one's own words) which can be best measured by long answer type questions alone.

Long answer type questions could be divided into following categories:

Restricted response type: In this form of long answer questions, limit is imposed by restricting the content and length of expected answer in the statement of the question. Restricted response type items are quite useful for testing learning outcomes which require interpretation and application that are specific and clearly defined in nature.

Extended response type: In this form of long answer questions, no limit is imposed and student is given full freedom to write any number

of pages and organise the material according to her choice. There is enough freedom to select, integrate, evaluate and express in any way one likes. Such questions are also useful for measuring broad abilities of learners.

Long answer type questions are deceptively easy to construct, but are difficult to score.

Open-ended type: Open-ended questions can be very useful in evaluating the creativity and innovativeness in students. These type of questions also help students to be imaginative and think divergently and can provide scope to apply their knowledge, which varies from individual to individual. They provide space to generate and express individual thoughts and ideas in a variety of ways.

Example: Suggest some ways of managing/recycling waste plastics.

Open-ended type questions could be even fictitious, as long as it serves the purpose for which it is used. For example, in order to underline the importance of nitrogen in air, we could set question like, *what are the various consequences if air had only oxygen, but no nitrogen?* Open-ended questions often bring out surprising answers from students. We can also ask the way an experiment could be designed, an apparatus to be fabricated, etc.

ACTIVITY 11.7 

Select any chapter of your choice from the textbook of science/physics/chemistry. Make two questions on each of the following long answer type:
(i) Restricted response type (ii) Extended response type
(iii) Open-ended type
Exchange the questions with your classmates and discuss and justify how these questions can be classified as restricted response, extended response and open-ended response types.

2. Short answer type

Short answer type questions, if skilfully prepared, can test with reasonable accuracy many aspects of learning in terms of subject matter, abilities and skills. Answers to these questions are rather specific. Thus, they can easily provide the feedback to the teacher essential for observation of students' misconceptions and naive concepts for effective teaching-learning.

Although there are many forms of short answer type questions, their common features are:

- They usually take a short time (1-5 minutes) to read and answer.
- They include some guidance on the extent of the answer required,

e.g. specific instruction such as 'answer in not more than 10 words' regarding length of answer sentences or required space in the answersheet are provided.

3. Objective type questions

Constructing a good quality objective type question requires skills and practice. Objective type questions can be of supply type or selection type. Some of the points to be taken into consideration for the construction of such question are discussed below.

3(a) *Supply type objective questions*

Following points are worth consideration in constructing these types of questions:

- While using any form (short answer or completion) of supply type one has to be 100% certain that one and only one word (or group of words) can fill the blank correctly or is the correct answer. This is most distinguishing characteristic of an objective type test item that ensures its objectivity in scoring. If a blank can be correctly filled by two different words, such an item should never be constructed.

For example, *What type of wave is light?* (short answer)
Light is…. wave. (Completion type question)
Now the answer to the above question could be *transverse* as well as *electromagnetic*. Both are correct. This is, therefore, not an approprite example.

- Who is the discoverer of *Theory of relativity?* Or, *Theory of Relativity was given by….* The correct response is *Albert Einstein* and the item has been constructed to test the knowledge of the name of the discoverer of Theory of Relativity.

What would you do with these answers to the same question?
(a) Einstein (b) A. Einstein (c) E.A.
The subjectivity in deciding which response of the above should be given full marks could be eliminated by providing two blank spaces in a single item. One mark should be allotted for filling each blank separately.

- While using fill in the blank type, care should also be taken that clue to the answer is not provided by the construction of the sentence.

Example - *An …. is used to measure current.*
Use of the word 'An', automatically gives a clue the word begins with a vowel. This type of error in constructing question may occur in selection type objective questions also, but chances increase in fill up the blank type.

Thus, it is advisable that supply type questions should only be used in places where the learning evidence cannot be obtained by selection

type items and even there, care must be taken that the student is required to supply an answer as brief as possible.

ACTIVITY 11.8 

Do you think supply type questions are suitable for assessment of students at higher secondary stage? Think-pair share your ideas in the class.

3(b) *Selection type objective questions*

Clear/unambiguous instruction

Items of each of true/false, multiple choice and matching type should be separately clubbed in an objective type test paper and preceded by a clear cut unambiguous instruction to the student, so that they know, how they are expected to indicate their preference. This becomes even more important if computer is to be used for scoring.

In order that they mark their answers at the right place, it is necessary that space be provided for putting a ☑ (right) or ☒ (wrong) and properly explained in the instruction.

Oxygen helps in burning. ☑
Water is an element. ☒

Illutrating with an example to clarify the instructions for answering the questions will be helpful to the student.

Some important points which should be kept in mind while constructing a true/false type item are:

- Avoid broad general statements.

Broad general statements are generally false unless qualified and the use of qualifiers provide clue to the answer.

Poor example: *All substances expand on heating*

Poor example: *All solids usually change into liquids on heating to a certain temperature.*

The first one is false, because water is an exception and second is although true, but the word 'usually' provides a clue. Words like generally, usually, commonly, often, etc. are likely to appear in true statement.

- Avoid long complex sentences and use of words which are not likely to be a part of students' vocabulary.
- Avoid including two ideas in one statement.

Poor example: A worm cannot see, because it has simple eyes. ☒

The item has been marked ☒, because worm does not have simple eyes. But a student can mark it ☒, because he feels a worm can see.

- The number of true statements and false statements should be approximately equal.

Some students have a tendency to mark tick ☑ when in doubt, whereas some students have a tendency to mark cross ☒ when in doubt. Neither response set should be favoured by overloading the test with items of one type.

Multiple choice questions (MCQ)

Instruction and examples for MCQ can be given as illustrated below.

For each of the questions given below, 4 possible answers A, B, C, D are given. Only one of them is correct. Put the letter of the answer you consider correct in the box given at the end.

Example: Which is the element having maximum hardness?

A. Diamond ☐
B. Steel ☐
C. Calcium ☐
D. Manganese ☐

We know that a multiple choice item has a stem, a few (2-5) distractors and one key (can be more than 1 to increase the difficulty level). Key (s) is the correct answer.

All selection type items are basically multiple choice items. In case of T/F multiplicity is just 2 whereas the multiplicity increases in a multiple choice item. In the above example, as there are four choices, multiplicity is 4 and becomes maximum in matching the column type questions. For example, if column A has 5 entries and column B has 7 entries, then for each entry in column A, there are seven choices with which it can be matched. Here the multiplicity is 7. Therefore, the form in which the question is constructed also has an impact on its difficulty level.

A question when asked in a T/F form is the simplest and a matching type format is the most difficult form for the same question. **Thus, by changing its form we can make a question more or less difficult.**

Constructing multiple choice questions

Let us now discuss in detail the form of a good MCQ.

- The most crucial element in a multiple choice item is its distractors. As the name signifies, distractors are included to distract the student who is not sure of the correct response (key) and is trying to guess the correct response. Answer to some questions which the constructor of MCQ has to find are:

(i) How many distractors should be used?
(ii) How should they be placed in a particular multiple choice item,

i.e. A, B, C should be distractors and D the key or any other permutation?

(iii) How permutation should be used for deciding percentage of the key in a particular place, i.e. how many questions will have A, B, C or D as the key and in what sequence?

- Same number of distractors should be used in all the items in a given test paper.
- The key to the quality of a multiple choice item is the quality of distractors used in the question. In an ideal MCQ, each distractor should have equal power to distract the students.

Let us consider the following example:

Which of the following has lowest liquification temperature?

(A) Helium
(B) Nitrogen
(C) Carbon dioxide
(D) Ice

In this item distractor 'D' will be opted only by those students who do not know that substances found in liquid state at room temperature have higher liquification temperature than those found in gaseous state.

Chances are that none or very few students will be distracted by this alternative and though apparently there are three distractors, effectively there are only two distractors. Moreover the student who is opting for B or C and the student who is opting for D are not at the same level of ignorance, although both are incorrect. Thus, it is imperative that all distractors have the same distracting power.

- The stem of the item should be meaningful by itself and should present a definite problem.

A poor example

Latent heat

A. is a form of heat transfer.
B. does not depend on the nature of substance.
C. is so called, because it is hidden in the substance.
D. is the quantity of heat required to change one gram of substance at its transition point.

A better example

Latent heat of a substance is the amount of heat required to change

A. total mass of substance from one state to another.
B. total mass of substance from one state to another at its transition point
C. unit mass of substance from one state to another at room temperature.
D. unit mass of substance from one state to another at its transition point.

- All of the alternatives should be grammatically consistent with the stem of the item.

A poor example

An electric transformer can be used

A. for storing up electricity
B. to increase or decrease the AC voltage
C. to convert electrical energy to mechanical energy
D. to change AC to DC

A better example

An electric transformer can be used to

A. store electricity
B. increase or decrease voltage of AC
C. convert electrical energy into mechanical energy
D. change AC to DC

- The relative length of the alternative should not provide a clue to the answer.
- In order to avoid guessing, alternatives should be arranged according to some criteria. For example, if alternatives are numbers, arrange them in descending or ascending order.

Constructing matching type items

As it has been stated above that in a matching type item for each entry in column A, all entries in column B should be plausible alternatives. There should be an unequal number of entries in column A and B. Further, there should not be a clue in the alternatives for a particular entry in column A.

Poor example

Column A		Column B	
1.	Formula for hydrochloric acid	(a)	ampere
2.	Unit of electric current	(b)	Ammeter
3.	Instrument which measures current	(c)	Voltmeter
4.	Formula for sulphuric acid	(d)	HCl
5.	Unit of potential difference	(e)	H2 SO4
		(f)	volt

As there are only two formulae in column B, there are only two alternatives for entries 1 and 4 in column A. Similar is the case for other entries in column A.

Drawing

Assessment of drawing may be part of any type of written questions or it may be assessed as a separate question. Students may be asked to :

- draw the diagram
- correct the diagram
- complete the diagram
- label the diagram

so that their knowledge can be assessed, even if the students are poor in language or communication. Diagrams can effectively test their skills in drawing, labelling and practical knowledge. Drawing clear and labelled diagrams facilitate understanding of many concepts. For example, drawing ray diagrams, electric circuit diagrams help in understanding a number of concepts of ray optics and current electricity, respectively. Drawings can effectively handle various social problems like environmental problems and gender issues in an informal way and reinforce such values without making any hue and cry.

ACTIVITY 11.9

Construct one poor example and one good example both for the following types of questions (for any stage of learning, i.e. upper primary, secondary or higher secondary stage):

- Supply type question.
- Selection type question (with two choices).
- Selection type question (with four choices).
- Matching type question.

Share your work with your friend and critically review each other's work.

ACTIVITY 11.10

(i) Prepare blue prints for a chapter of your choice from Class X Science textbook.

(ii) Construct test items according to the blue prints prepared in the above activity (i).

We know that in order to achieve all the learning objectives of science that we have discussed in Chapter–4, classroom teaching-learning is not enough. Paper-pencil test that we learnt to construct in this section cannot be the only tool.

In the following sections, we describe some of the learning experiences, which a science teacher can plan along with the classroom activities for achieving those objectives. Further, the methods to assess these learning experiences are also explained in some detail. Before that, let us perform an activity.

ACTIVITY 11.11

Critically examine the exercise questions given in a textbook of Science/ Physics/Chemistry in the light of discussion we had above. Do you think

all questions are well constructed? If not, refine them and present a report of your analysis.

11.4(C).(2) Project work

What is a project work?

Mr. Atul was discussing *Rusting of iron* in Class VII. He said, "Moist air is necessary for rusting of an iron nail." One of the students asked him, "Would iron nail rust, if kept in boiled water?"

How should Mr. Atul respond to the student's question? Should the teacher tell the answer to the question immediately or he should provide the student the opportunity to investigate the answer to his question on his own? The obvious solution to this situation is the science project. Mr. Atul assisted the student in the design and use of apparatus for this investigation at a convenient time of regular period.

They took three bottles with wide mouth and labelled them as A, B and C. They filled bottle A with ordinary tap water, bottle B with water which they have boiled for several minutes and bottle C with the same boiled water and a teaspoonful of cooking oil added to it. In each bottle they put a few similar iron nails, so that they were completely dipped in the water. All the three bottles contained equal amount of liquid. They placed these bottles away for a few days. After a few days they took out nails from each bottle and observed them. At the end, the teacher however, planned a special period during which the student could present his findings in the class.

If we analyse the above given example, we find that:

- the teacher has been able to provide a learning experience to a student's individual interest.
- The student was given an opportunity to present his findings to the class.
- The student's search for knowledge has not been cut short due to time restrictions.

Usually children of this age hesitate or feel shy while giving oral presentation of their project reports. Science teacher can provide extensive practice in oral presentations. Teacher can set aside time at the beginning or end of periods for oral presentations. Students should always be ready to answer questions asked by teachers and other members of the class. By facing their audience, students can develop self-confidence and communication skills. Teacher should also encourage students to use as much visual materials as possible while presenting orally. Visual materials give a sense of confidence to the speaker and also hold attention of the class.

After going through the above example, we can say, **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.

Students can do project work individually or in group

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.

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.

ACTIVITY 11.12 

Give example of each of the above approach of taking up a project using a textbook at upper primary/secondary/higher secondary stage.

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 has 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.

Example: Project Work At Upper Primary Stage

Collect weather reports of seven successive days in the winter months (preferably December). Collect similar reports for the summer months (preferably June). Now, collect the data for sunrise and sunset time as shown in Table 11.12.

Table 11.12 Observation of sunrise and sunset time

December			**June**		
Date	Sunrise time	Sunset time	Date	Sunrise time	Sunset time
....					

Example : A Project at Secondary Stage

Objective

To identify biodegradable and non-biodegradable materials (wastes) in the environment.

Theory

It is important to recognise that the terms like biodegradable and non-biodegradable materials referred herein pertain to 'wastes' produced by human activities. These 'wastes' if not disposed of efficiently will cause excessive accumulation and pollute water, land and soil. The wastes range from human and farm excreta, industrial sewage, pesticides and herbicides, empty cans, bottles and jars, metal and plastic cups, polyethyene bags and jars, paper, discarded machinery parts, etc. Wastes also accumulate in the form of refuse from kitchen and vegetable markets, gardens, agricultural and farmlands, etc. The list is very long, but for the sake of convenience and from ecosystem point of view, wastes are categorised into biodegradable and non-biodegradable. In an ecosystem apart from producers and consumers, there is another group of heterotrophic organism collectively referred to as decomposers that consist chiefly of bacteria and fungi which degrade and digest dead plants and animal material. All such materials which are degraded and decomposed by decomposers are called biodegradable wastes. Such wastes are easily manageable by a natural process or in waste treatment plants and can be turned into useful resources (for example, biogas plants, etc.). A large variety of waste materials produced by man and industry, either, do not degrade (polythene, plastic, glass etc.) or degrade very slowly only by decomposers (for example, DDT). Such wastes are called as non-biodegradable materials. Their constant accumulation especially in highly populated urban areas is proving to be a great health hazard and the biggest obstacle for clean living. This study is aimed to distinguish between the two types of materials.

Materials required

Sample of waste materials available in the garden, kitchen market, cowshed, etc. A spring balance, a pair of hand gloves, two plastic bags (10" x 6") and nylon thread.

Procedure

1. Collect a handful of following samples from your nearby surroundings. Use a pair of gloves while handling the samples to prevent injury or infection. The samples could be vegetable matter, animal and fish remnants, bamboo pieces, cardboard pieces, straw, paper, leaves, pieces of glass, cowdung, pieces of cloth, food leftovers, twigs, bark, thermoplastic wastes, fruit peelings, pieces of plastic plates, rubber and plastic tubing, small pieces of ceramic pot, DDT powder, etc.

2. Sort out small samples (5g each) of waste from plant and animal sources (for example, vegetable matter, leaves, twigs, cardboard pieces, paper, cowdung, etc.).
3. Likewise sort out small samples (5g each) of waste materials from other than plant and animal sources (for example, plastic caps, pieces of plastic tubes, polythene, glass, metal can, ceramic pieces, etc).
4. With the help of a sharp knife, cut all the samples into very small fragments and mix them thoroughly into separate heaps 'A' (of samples in step 2) and 'B' (of samples in step 3).
5. Mark the polythene bags 'A' and 'B' with waterproof ink.
6. With the help of a nail, pierce several small holes in each polythene bag. Fill the two samples 'A' and 'B' in their respective bags marked 'A' and 'B'. Tie their mouths firmly with nylon thread.
7. Using a spring balance, weigh each bag separately and note their initial weight.
8. Now bury the two sample bags in a shallow pit of appropriate size dug out in the corner of a garden. Fill the pit with soil.
9. After three or four weeks, remove the bags intact from the pit, clean them thoroughly to remove any soil from the surface of the bags (don't use water for cleaning).
10. Dry the bags in open sunlight.
11. Weigh the two bags again and find the difference between their initial and final weight. Record your observations in the Table 11.13.

Table 11.13 Weights of the Samples

	Initial weight	**Final weight**	**Loss of weight**
Sample A Sample B			

12. Open the bags and transfer the contents separately on two sheets of paper and observe the physical changes in the samples that have occurred during the period of their burial in the pit.

Observations

At the end of the study determine

1. Which sample has substantial loss of weight?
2. Can various components in bags containing samples 'A' and 'B' be easily identified?
3. Has the colour and texture of the components of samples 'A' and 'B' changed?

Discussion

Sample 'A' contained waste materials of plant and animal origin. When buried they were subjected to decomposition by soil microorganisms.

The complex organic matter was decomposed to simpler compounds some of which leaked out through the pores into the soil. Some material were partially decomposed (like twigs, bark, petioles and veins) while the soft tissues of leaves and dead animals were completely decomposed. It is because of this reason that a substantial loss of weight had occurred in sample 'A.' The weight of sample 'B' remains unchanged, because no component in the sample could be decomposed by the microorganisms.

Conclusion

It is concluded that all the different types of material in bag 'A' were bio-degradable while in bag 'B' the samples were non biodegradable.

Example : A Project at Higher Secondary Stage

Objective

To estimate the concentration of acids present in different tea samples and the effect of addition of acids or bases on the colour of tea extract.

PROCEDURE

1. **Estimation of concentration of acids present in tea**
   Weigh 10 g of the sample tea leaves (say 8 samples) and prepare the extract of each sample separately in 200 mL of distilled water. For this, boil different samples of tea leaves with distilled water for a fixed time period.

   Take 5mL of tea extract in a conical flask and dilute it with 20mL of distilled water. Shake the solution well for homogeneous mixing and then titrate it against M/50 NaOH solution using phenolphthalein as an indicator. Similarly titrate other tea extracts with M/50 NaOH solution. Calculate the concentration of acids present in different samples of tea leaves in terms of molarity. If colour of the extract causes problem, then tea extract can be taken in the burette and sodium hydroxide solution in the conical flask. Phenolphthalein may be used as an indicator if sodium hydroxide solution is taken in flask. The colour change will be from pink to colourless.

2. **Effect of acids and bases on the colour of tea extract**
   Take five filter paper strips and mark them as A,B,C,D and E. Dip all the strips in any sample of tea extract and then take them out. Now put two drops of dilute HCl, acetic acid solution, NaOH solution and NH_4OH solution on the strips A, B, C and D, respectively. Compare the change in colour of these strips with reference to the colour of the strip E. Repeat the experiment with other samples of tea extract.

   Discussion: The extracts of different tea samples contain different amount of acids. The quantity of NaOH solution required for neutralisation will depend upon the acid present in the tea extract. The

tritration of various extract samples with standard solution NaOH gives the amount of acids present in the given sample in terms of molarity.

It may be noted that sample reports given above serve merely as a guidelines while writing the projects. By no means, it is exhaustive and is open to further improvements.

Recognition of the projects

After completing the project, usually students want a few words of praise from the teacher. Recognition means enhanced status in the eyes of classmates, parents, other teachers and society.

Report of this project can be displayed in the class using a chart. Projects which are of general interest can be displayed during school assembly where parents can also be invited. Sometimes radio and television reporters visit schools to record the activities of the students. They also invite students to bring their projects to the stations for interviews.

Superior or outstanding or innovative projects should get a chance to enter regional, state and national competitions, where they talk to experts who point out strengths and weaknesses of their work. Students should be encouraged to publish the write-up of their project in school newspaper/newsletter/journal.

Assessing the project work

Generally, following set of learning indicators is used to assess a science project (see Table 11.14).

Table 11.14 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 display	• 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.

ACTIVITY 11.13 

What criteria would you keep in mind in the identification of a project? Identify the concepts from the textbook of science/physics/chemistry that you would like to transact through project work. Make a list of those

projects. Discuss in a group how will you assess those project works on the basis of tasks specific to learning indicators?

11.4(C).(3) Field trips and field diary

This was my first experience when I told my students of Class VII that "Today weather is pleasant and we can plan an outdoor class". I took them to a nearby farmland in Gurgaon and told them to collect the soil samples. I also told them to collect the flowers such as China rose, Petunia, Hydrangea, etc. from the nearby garden. I gave them an opportunity to talk to the farmers, regarding the issues related with treatment of the soil in any manner. They noted down all the information in their field diary, which they had taken along with them. On coming back to school, they tested the nature of the soil samples by using different natural and manmade indicators and noted down their observations in the field dairy. Later on, there was discussion in the classroom about the observations recorded by the students.

Same kind of field trip I planned with Class X students. They also collected soil samples and they found the pH of these soil samples by using universal indicator.

I raised following questions to evaluate the students:

1. Which natural indicators did you use to test the nature of soil samples?
2. Was the nature of soil acidic/basic/neutral?
3. Was the pH of the soil above 7 or below 7?
4. What can you conclude about the ideal soil pH for the growth of the plants in that region?

I observed that students were actively involved in learning.

– Experience of a teacher

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 as we have discussed in Chapter 9 *Community Resources and Laboratory* (section 9.3.2). 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.

Mr. Rampal showed Class VIII students *operation of fire extinguisher* in the school ground because the activity was too messy a to be performed in the classroom.

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.

ACTIVITY 11.14 

(i) Take any textbook of science/physics/chemistry. Identify the concept for the transaction of which you would like to take your students to field visit. **(ii)** Do you think you need to make a plan to keep their observation focused only on the relevant learning concepts? Discuss in the class.

ACTIVITY 11.15 

Identify the learning indicators for the assessment of field diary of your students. Think–pair–share it with your classmates.

11.4.(C).(4) Laboratory work

What is 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. You may revisit Chapter 9, (section 9.8.1) for various approaches to laboratory work.

Deductive laboratory work

Ms Rita began her discussion on *corrosion* by raising some questions related to the daily life experiences of the students in the class.
The questions were:

- Why do silver articles when exposed to air become black after sometime?
- Why does copper lose shiny brown surface slowly and gains a green coat when exposed to moist air?
- Why do iron articles when exposed to moist air for a long time acquire a coating of a brown flabby substance?

She discussed the concept of *corrosion* thoroughly in the class. She then involved students in the laboratory to work on this topic. Students worked in groups to check that iron articles when exposed to moist air get rusted. The students had a pretty good idea of what to expect as a result of their classroom discussions. Students were excited on confirming their results.

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 reinforce the concepts transacted.

Inductive laboratory work

Shyam, a teacher at higher secondary stage facilitated students to perform following activity:

- Collect the following samples from the science laboratory– hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3), acetic acid (CH_3COOH), sodium hydroxide (NaOH), calcium hydroxide [$Ca(OH)_2$], potassium hydroxide (KOH), magnesium hydroxide [$Mg(OH)_2$], and ammonium hydroxide (NH_4OH).
- Put a drop of each of the above solutions on a watch glass and test with a drop of the following indicators as shown in Table 11.15.
- What change in colour did you observe with red litmus, blue litmus, phenolphthalein and methyl orange solutions for each of the solutions taken?
- Tabulate your observations in the Table 11.15.

Table 11.15 Acid bases and indicators

Sample Solution	Red Litmus Solution	Blue Litmus Solution	Phenolph--thalein Solution	Methyl Orange Solution

After completing the activity, the discussion of the results began. Shyam placed the data recorded by students on the blackboard and discussed the concepts of acids, bases and indicators.

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 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.

ACTIVITY 11.16

You are given a concept *What happens when metals react with cold and hot water?/Ohm's law* to transact to Class X students. State whether you will follow inductive or deductive approach? Justify your choice. Make outlines of your plan. Also discuss the learning indicators and tasks specific to learning indicators to assess performance of your students in groups.

ACTIVITY 11.17

Talk to a practising science teacher to know the tasks specific to learning indicators which she uses for the assessment of the laboratory work and the record book of experiments. Present your findings in the class.

11.4.(C).5 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.

11.4.(C).6 Journal writing

Journals could be similar to a student's diary where she can record details of her work and learning on a day-to-day basis. This can enable the teacher to assess the extent of her learning and help the students in better learning.

Students can reflect on their thoughts about new concepts without being conscious of assessment. Teacher can use journals as a kind of window to know what students are thinking about what they are learning. Students' journal can be an important source of information about their learning difficulties, misconceptions, and naive concepts, strengths and challenges and self-assessment. The act of transferring thoughts, ideas and feelings into written words also encourages students to examine their own thought process. In order to set clear expectations and procedures for journal writing, teachers must plan how often students will write in their journals; when; for how long and for what purpose. The teacher must provide feedbacks in the form of a written observation, questions or notes in the margin to encourage students.

ACTIVITY 11.18 

Search in the library the research work done on journal writing by school students. Present a review of any one paper in the class.

11.4.(C).7 Concept Mapping

We have discussed concept map in Chapter 8 (section 8.9) in detail. Concept mapping which is used as a strategy of teaching-learning can also be used as an assessment tool. After learning a unit, students may draw a concept map. Students' understanding about hierarchy, relationships, branching and cross-linkages of various concepts may be tested. Alternatively, a partially written concept map may be asked to be completed.

Concept map of the topic *Changes Around Us* has been shown in Fig. 11.6.

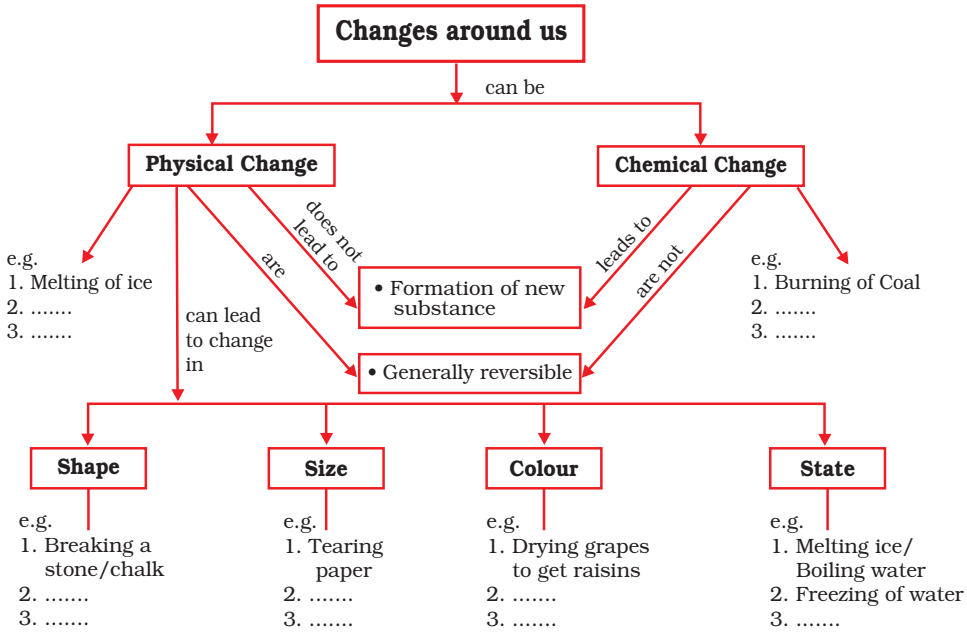


Fig. 11.6 *A partially written concept map can be used for assessment*

Concept maps as assessment devices

Concept maps have proved to serve as useful tools for assessing the attainment of certain learning objectives reliably and objectively. Students may be provided with a set of unlinked concepts with which they have to construct a map or they may be asked to construct a concept map after the teacher has transacted a topic in order to assess their conceptual comprehension. Scoring can be based on several criteria, such as.

- Validity of propositions and relationships connecting the concepts.
- Correctness of the hierarchical level.
- The validity of cross-links.
- Extent of latitudinal and longitudinal branching.
- Appropriateness of general and specific examples.

ACTIVITY 11.19

Recall how you were assessed in physical science at secondary and higher secondary stages. What tools and techniques were used? Share your experiences regarding those tools and techniques with the class.

11.4.(D) 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 achievment; 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 marksheet. 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.

11.4(D).(1) 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.

11.4.(D).(2) What is 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 (75% and 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.

Table 11.16 Absolute Grading

S.No	Letter of Grade	Range of Marks	Description
1.	A	90% and above	Outstanding
2.	B	80% to 89%	Excellent
3.	C	70% to 79%	Very Good
4.	D	60% to 69%	Good
5.	E	50% to 59%	Above Average
6.	F	40% to 49%	Average
7.	G	30% to 39%	Below Average
8.	H	20% to 29%	Marginal
9.	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 categorise the obtained scores into any desired number of grades in a scientific manner. If we decide to use a nine point grade system, we may simply divide the entire measurement scale into nine (5 or 7 or 11) equal parts.

The advantages of relative grading are as follows:

- 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/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.

11.4.(D).(3) Measurement of process skills

For measurement of process skills, checklist or rating scales can be developed. For example, if the following tasks specific to the learning indicators of process skills, are to be assessed; we can mark Yes/No against each task.

Tasks specific to learning indicator

- Assembles the apparatus correctly. (Yes/No)
- Handles apparatus correctly. (Yes/No)
- Measures with precision. (Yes/No)
- Interprets data correctly. (Yes/No)

If rating scale is followed, five point scale 1,2,3,4,5 (Below average, Average, Good, Very good, Excellent) according to the task present, can be used. Tick mark can be put on the relevant point value.

Tasks

- Setting up of the apparatus. 1 2 3 4 5
- Observation of the changes. 1 2 3 4 5
- Measurement of the data. 1 2 3 4 5
- Reporting of the data. 1 2 3 4 5
- Interpretation of the data. 1 2 3 4 5
- Drawing of the conclusion. 1 2 3 4 5

11.4.(D).(4) Measurement of attitudes

A rating scale or practical test can be used for this purpose. Students' honesty, cooperation, objectivity, etc. can be measured on pre-defined rating scale. For example, point values can be assigned to each attitude item as given in Table 11.17.

Table 11.17 Measurement of attitude

Rating scale point indicators	Positive Attitude Items	Negative Attitude Items
Strongly agree	5	1
Mildly agree	4	2
Neutral/Undecided	3	3
Mildly disagree	2	4
Strongly disagree	1	5

It is often argued that the marks and grades carry little meaning and therefore should be substituted by verbal qualitative assessment. Undoubtedly verbal assessments that identify strengths and challenges may be very useful, especially to the students and parents. However, this kind of assessment can be carried out on the basis of learning indicators. Quantification has limitations, but at the same time carries advantages such as brevity and ease of communication.

A summary of measurement of students' achievement is shown in Fig. 11.8 below.

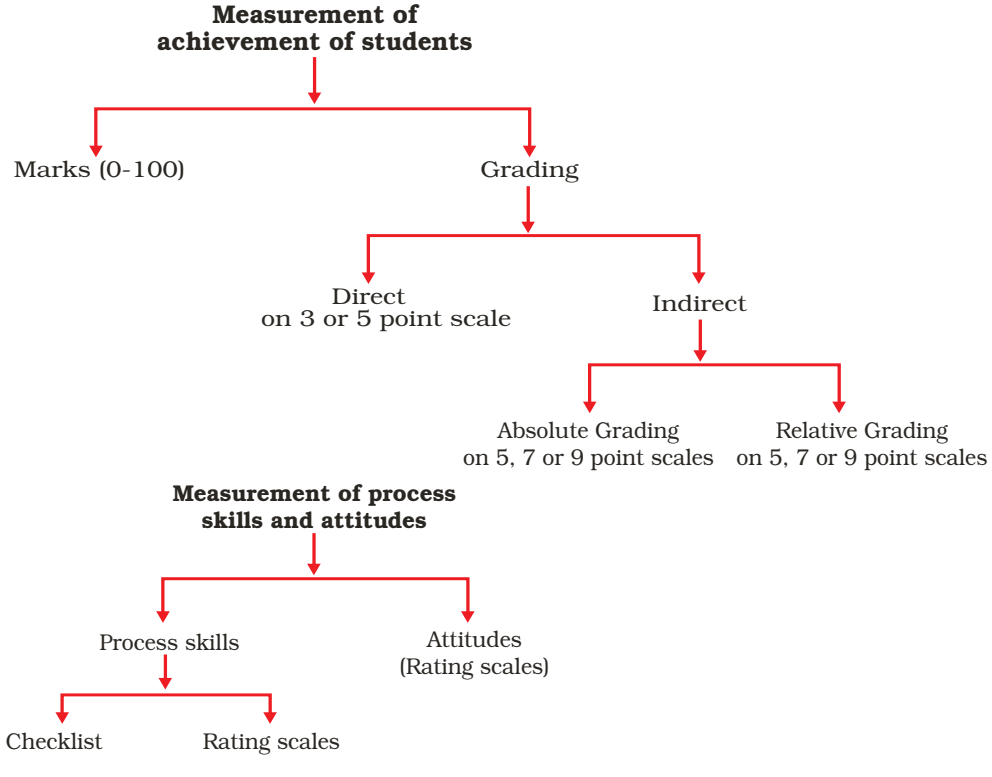


Fig. 11.8 *Summary of measurement of students' achievements*

ACTIVITY 11.20

Lata collected the notebooks of students in which there was a collection of notes copied by students which she wrote on the blackboard. It was not original work produced by the students. She graded the notebooks on the basis of neatness and content accuracy. Do you think that the teacher who carried out this form of activity was imaginative? Discuss.

ACTIVITY 11.21 

Discuss how you can maintain record of assessment of activities, experiments and textbook exercises showing various learning indicators for each student of a class in hard copy form. Think about using computer for this purpose.

ACTIVITY 11.22 

Find out the information about learning evidences of students given on the report card of various schools. Do these cards show quantitative as well as qualitative assessment and evaluation? Collect a few sample of it and discuss on it in the class.

11.4.(D).(5) Portfolio: Its role in evaluating students' performance

Meena, a science teacher suggested students of secondary stage to maintain a science portfolio comprising learning evidences collected throughout the year. She discussed over this issue with her students and together with them arrived at a consensus to include best performances in the following learning experiences in the portfolio:

- Collection of their own science work which included reports of laboratory work done either alone or with a partner or in a group and all the completed home and class assignments.
- Test and weekly quizzes conducted in the classroom.
- Classwork records.
- The report of the article they selected from a newspaper or magazine which they had critically analysed.
- Reports of field trips/visit to any industry.
- Reports of the projects that involved scientific investigations and the projects that were entered in science exhibitions.

Meena also suggested them to write few lines about their learning products, why did they consider that particular item as their best. She also explained that it is expected from the students to organise their portfolios properly so that materials included could easily be found and identified. After four to five months, students volunteered in many different activities that were not associated with regular classwork. They carried out their science project work during and after school hours. A group of students decided to conduct a survey to find out how the sewage in their locality was treated. The report was presented orally in the class and later placed in the students' portfolios. Another group of students designed a series of safety posters illustrating the safety rules to be followed in chemistry and physics laboratories. These posters were placed in the laboratories and classroom. They also maintained

a list of activities that were carried out in the science class to be included in the portfolio.
The students included the quizzes that had already been evaluated. The teacher considered the original work for evaluation during the entire academic year. So, the performance of the student could be judged by the quality of materials present in the portfolio of an individual who developed it.

Portfolio can be used as a way of collecting, recording, monitoring and communicating about learning evidences to the administrators and community. Students can be actively involved in this process. It provides them opportunity of self-assessment, reflection on their work, and setting goals of their learning.

The portfolio should contain the materials that show different aspects of a student's abilities. It shows that the student has learnt about writing reports, performing experiments, conducting discussions, giving presentation on a science topic, designing posters, etc. The portfolios can be evaluated by the teachers as explained below.

Evaluation of Portfolios

It can be done in the following ways:

- *Self evaluation:* Students can evaluate their own portfolios. The diversity of products in different portfolios can be so much that identification of evaluation criteria will not be a simple task. Teachers will have to work cooperatively with students and design a set of criteria by which both teachers and students can judge the quality of their portfolio products. By using the negotiated criteria, students can evaluate their own work. Students can identify their major strengths and challenges of a given product and then reflect on how the product could be improved.
- *Conduct portfolio conferences:* These conferences not only help in evaluating student's learning product but also help them in improving their self-evaluation abilities. Conferences can be planned in advance so that students can start preparing for these conferences well in time. Community can be invited in the conference. Students can also give presentation.
- *Involvement of parents in the process of portfolio evaluation:* In the beginning of the session, students' parents/guardians can be encouraged to keep reviewing their children's learning evidences and products.

Portfolio assessment can provide a way of documenting and evaluating growth of students' work that is happening in the classroom.

Thus, there are various ways of systematic collection of learning evidences of the learners. Teacher can use various modes of Information

and communication (ICT) technology for maintaining record and reporting.

Project 11.1
Find out how recording and reporting of the learning evidences of various curricular activities of students in physical science are done in the school you went for practice teaching. What is your own view regarding this? Prepare a report on it. Share your findings in the class.

11.4(E) Reflecting process

Let us see how did a teacher get feedback from students and used it for the improvement of the assessment process.

Iqbal, a teacher at secondary stage, after completing the Chapters *Chemical Reactions; Acids, Bases and Salts,* and *Metals and Non-metals* gave a test to Class X students. He was disappointed by observing some of his students' performance. During teaching-learning process in the class, students were able to answer his questions which indicated that they have understood the concepts. Confused Iqbal asked children to write on a piece of paper, why they got such poor grades in the test.
Following responses he got from his students.

Rita : You did not ask the question which was asked in the class.
Ali : No question was asked from the topic *Metals and non-Metals*, which I had learnt.
Sophia : I cannot remember so many concepts/topics at a time.
Raja : I was not able to understand some of the questions.
Ritu : Some of the questions confused me because they were too tricky.
Mary : I could not write the answers to all questions because there were too many questions and less time was given.

After reading the responses of his students, Iqbal decided to test his students more frequently, but on fewer concepts during the course of teaching-learning. He also decided to give appropriate number of questions that could be answered in the allotted time.

Assessment is both a reflected process (students' performance) and reflecting process (teacher's performance).

11.4(E).(1) Assessment as a reflected process

(i) During teaching-learning of science, **it is very important to observe and identify misconceptions and naive concepts of students and facilitates them to construct and reconstruct their concepts.** This can be done by interacting with them in various teaching-learning situations as discussed in Chapter 5 *Exploring Learner*.

Teacher should provide them feedback to draw their attention on how their concepts are inconsonant with scientific explanation of the

concepts. Dealing with students' misconceptions and naive concepts at early time is important, as studies show that once they are deep-rooted, it is very difficult to remove them, and such concepts become hindrance to further learning.

(ii) Reflective Prompts

Reflective prompts is a technique in which teacher provides a set of flexible questions to the students that prompt them to reflect on their own learning. In this technique, each student answers some questions such as given below after completion of a lesson/unit by the teacher.

- What did you enjoy about the lesson/unit?
- What was difficult and what was easy in the lesson/unit?
- Can you explore the ideas of the lesson/unit further?
- What help you want from me?

The teacher can use this feedback for improving teaching-learning process.

ACTIVITY 11.23 

Use these questions to reflect on the teaching-learning of this Chapter *Tools and Techniques of Assessment for Learning Physical Science* and discuss with your teacher-educator.

(iii) Self-assessment

Students can be encouraged to get engaged in self-assessment after any process of assessment in the class. They may think on the following (suggested) questions:

- What I liked/did not like about the test?
- How can I improve my performance?
- Did I know the answers to all questions?
- Was time limit less for me?
- Could I share my ideas clearly with the class during discussion?
- Could I demonstrate positive and responsible attitude towards learning?
- How will I do this work (written/oral test, activity/experiment etc.) differently next time?

ACTIVITY 11.24 

As a B.Ed. student of physical science you might have assessed your own performances several times. Share your experiences with your classmates.

11.4(E).(2) Assessment as a reflecting process

Teacher can look back to the lesson/unit and think about overall progress of students. She can investigate the following (suggested) questions:

- What went well?
- What misconceptions and naive concepts students had/still have?
- How can I improve on the content and pedagogy of the lesson/unit?
- What would I change, if I did the lesson again?

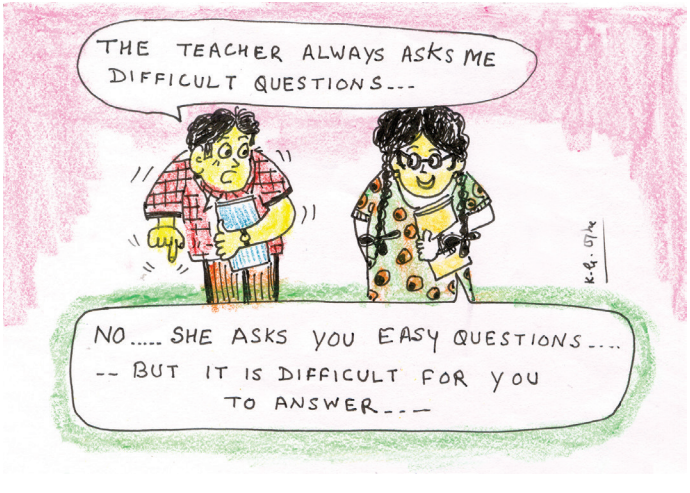
Analysing her own performance helps the teacher to provide additional inputs, look into innovative approaches of teaching-learning, select suitable tools and techniques of assessment and change the direction of work when needed. We shall discuss the teacher as a reflective practitioner in Chapter 14 in detail.

11.5 ASSESSMENT OF LEARNING OF STUDENTS WITH SPECIAL NEEDS

- The assessment criteria should be formulated as a teamwork following a discussion and consent of experts, parents and the students, while conducting assessment of students with Special Educational Needs (SEN, arising from physical, sensory and intellectual disabilities). Individual student's case profile and Individualised Education Programme (IEP) should be incorporated in methodological approach of assessment conducted for SEN.
- **The students' performances should be evaluated against their own previous performances continuously in subsequent evaluations.** The evaluations should be conducted comprehensively by a team of professionals including therapists to cover all areas of development. There should also be components where evaluations should be done by peers, parents, siblings and the student himself. Self assessment of the students with re-evaluation by other may also be included in case of SEN. To ensure that they try to achieve as per standards expected in a class, evaluation may also be quantitative and comparative on some units.
- The specific needs and requirements, the strengths and challenges of these students should be taken care of. When the students are in group activity or individual activity, individualised assessment of the students is recommended for their comprehensive assessment and evaluation,
- There are a number of teaching aids and functional aids required by SEN to carry out their day-to-day school-based activities such as Braille equipments, hearing aids, communication boards, etc.

Prior to assessing these students, it should be ensured that the applicable aids are accessible to the students.

- While conducting assessment, the quality and applicability of the tools and procedures for assessment with respect to the particular SEN should be taken care of. The activities should be selected as per the individualised strengths and needs of the student. The need, use and comfort level of assistive and adaptive devices such as mobility aids, communication devices, technological aids, etc. either in the form of teaching aids and/or functional aids with regard to the students concerned should not be ignored. The SEN should be given the opportunities to improve in different evaluation procedures such as assignment, projects, etc. and may be re-evaluated.
- Curricular areas like Braille reading and writing, orientation and mobility skills, communication skills, daily living activities, social skills, pre-vocational skills, etc. should also be assessed along with other areas of the curriculum. For conducting assessment in these areas experts from the specific disability area should be included in the team.
- Students' anecdotes, class teacher's and science teacher's observations, specialists' reports, parental reports and peers' comments should be consolidated to make the assessment profile of the SEN.
- The suggestive assessment process for students with special educational needs are more objective items; frequent short quizzes in lieu of long examination; provision of extra time, special aids; simplifying the instruction to facilitate students to comprehend; reduction in number of questions and subject papers; alternative



measures like tape recording the answers; etc. Modalities may be negotiated with them by giving extra time to complete the tasks, and assistance of scribes wheres essential. Their evaluation can be done by inviting experts in respective disabilities, shortening assignments, breaking evaluation materials into smaller segments and permitting them to use technology, etc. to give responses that are understandable.

11.6 SUMMARY

The need for assessment and evaluation is to reconstruct naive concepts of the learners and to give

- periodic reports to the guardians, administrator, and community about the quality and level of the learners' progress,
- certificate of completion of a course and,
- a meaningful report for interschool transfer of the learner.

It is not a means to encourage competition among the learners. We have discussed that **assessment and evaluation needs to be learner-centred** and it should be integrated with the process of teaching-learning to enhance the quality of teaching and learning. It should facilitate all-round development of a child. **We should comprehensively assess the performance of the students on a continuous basis by assessing the student's progress with reference to their own self, with reference to the criteria set by the teacher and the learners.** In order to successfully implement the process of comprehensive evaluation, we need to first identify various learning indicators related to the said curricular area of physical science by involving the learners, then construct and implement the tools suitable to measure the indicators. Various tools and techniques can be used for assessing performance of the students and their attitudes, interest and capability of independent learning. There should be flexibility in it. At upper primary and secondary stages, focus can be given on observation, inquiry and description. At the higher secondary stage the focus should be more on reasoning, inquiry and application.

In the modern times, where creativity, innovativeness, and the development of the entire personality are the hallmarks, we need to redefine and search for new ways of assessment and feedback. **There is a need to shift from teacher-centred assessment to learner-centred assessment and from assessment of learning to assessment for learning.** Teacher may choose most suitable approach depending upon learning needs of the learner and teaching-learning process.

EXERCISE

11.1 'Assessment is a process of collecting, analysing, and interpreting evidence to judge the extent of students' learning whereas evaluation is a relative term.' Explain this statement with the help of an example.

11.2 Discuss how assessment and evaluation are integrated with various teaching-learning situations? How can you address students' problems regarding their conceptual development during teaching-learning process itself? Do you need special test for it? Explain taking any topic as an example. Justify your answer.

11.3 Explain the meaning of Continuous and Comprehensive Evaluation (CCE). Discuss its need and importance in making evaluation process more effective. Give suitable example in support of your answer.

11.4 Explain the major shift in assessment that is required for meaningful teaching-learning of science. Suggest some ways to implement these shifts in a crowded classroom.

11.5 Explain why there is a need to shift from assessment of learning to assessment for learning.

11.6 What are the important points which a teacher should keep in mind while evaluating a project work? Name and explain the indicators which a science teacher should consider to evaluate a science project.

11.7 Mention the essential points, you will keep in mind while framing good objective type questions of various forms.

11.8 Prepare a plan for a field trip, you would like to organise for science students of higher secondary classes. Your plan should include (i) Objectives of the visit (ii) Planning of the visit (iii) Assessment of the learning experiences of the visit.

11.9 'Learning at field trips has greater impact than learning gained from books inside a classroom.' Comment on it. Justify your comments with the help of examples.

11.10 (a) Choose science textbook of any class. Analyse the exercises questions given at the end of any five of its chapters. Do you think, any modification is required in the questions? Modify those questions justifying your thinking.

(b) Choose any topic from Class IX/X textbook of Science and construct objective type items to assess various concepts of this topic. Develop various forms of objective type test items.

11.11 List the parameters you will measure to assess your students for these indicators – 'Cooperations,' 'Concern for justice' and 'Equity?' How will you report about these indicators in the progress report of a student?

11.12 Discuss how will you assess students of science with special educational needs?

11.13 'Success and failure in science learning is not responsibility of only one learner or teacher. It is a shared responsibility of both learner and the teacher.' Do you agree with this statement? Justify your claim.

11.14 Discuss, how far the system of assessment and evaluation adopted at your training institute is continuous and comprehensive.

11.15 Make a portfolio consisting items that are best in your opinion and give reasoning why do you consider them the best. Items should be relevant to the topics that have been transacted so far in your class. These might be:

- record(s) of your activities;
- resolution of the discussion conducted;
- interview conducted with practising teachers;
- project work(s);

Chapter 12

Planning for Teaching-Learning of Physical Science

12.1 WHY PLANNING TEACHING-LEARNING?

Many questions may come up to you before entering a classroom, such as how can I facilitate my students to learn science? How can I generate thinking and curiosity in my students? How will I encourage them to ask questions? What if activities do not work? What if I do not answer all the questions of students? How will I assess students' learning? Will students be satisfied by my way of assessment? How will they evaluate me? How will my administrator evaluate me? How can all these concerns be addressed? **Planning of teaching-learning experiences helps you think deeply and focus these experiences to the learners rather than on the delivery of the lesson.**

Planning a lesson before going to the class may also help you in one or more of the following:

- It boosts your self confidence and reduces your strain and anxiety about your teaching.
- Gives time to think on how to engage learners actively, and be creative in designing teaching-learning experiences. In fact, **planning for teaching-learning may also be termed as designing for learning.**
- It saves your time, energy, efforts and resources.
- Activities and experiments may become more effective if you perform and check the functionality of the apparatus and activities beforehand. You can anticipate students' questions and inquiry for which you can plan your teaching-learning strategies.
- You can assess whether your learning objectives have been realised or not. If not, what alternative strategies you need to plan? What modifications in the teaching-learning situation are needed?
- What question will you ask to students? What steps will you take to help them observe, record, discuss, draw conclusion, critically think and communicate during teaching-learning process and carrying out activities?

- How can you organise the class as well as the activities effectively?
- How can you switch over from one concept to another concept without leaving a gap in between?
- What assignment can you give to your students in order to reinforce the concepts learnt in the class?
- It gives you a sense of ownership to the curriculum.

In this chapter, we shall discuss on various aspects of the design of a lesson plan. The chapter also discusses on planning of a unit, laboratory experiences and ICT applications. The need to revise planning of teaching-learning experiences is also highlighted. Few examples of lesson design based on learner-centred approach are also given.

12.2 PLANNING: AN EXAMPLE

Let us take an example. Suppose you wish to organise a party. You draw a plan for it. As a first step of the planning, you first identify and list various issues which need some pre-thinking or in other words planning. Your list may run as:

(1) How many guests to be invited?
(2) Guest list
(3) Menu
(4) Venue
(5) Day and time
(6) Invitation sending process
(7) Decoration and seating plan
(8) Activities to be carried out in the party and so on.

The list may go on or may be shortened for a particular party. But how will you decide, what else to be added or what is not required to be planned? This will certainly depend on the occasion or purpose of the party. It seems on the first look that it is basically the purpose or objective of the party that has its impact on planning of almost all the other factors. Some people may argue that objective(s) of the party becomes the basis for its planning. But the background of the guests, their likes or dislikes of a particular food item and the nature of the programme to be organised are also very important components that can never be neglected.

Similarly we can reflect upon the argument that the planning of a lesson will mainly depend on the 'nature of content and processes of science.' The context in which learning takes place is also very important. For an effective planning, knowledge of the subject matter, the use of teaching-learning materials and apparatus, teaching-learning approaches, tools and techniques of assessment and how students learn science are also important. All these kinds of knowledge, work together to help teacher to plan the lesson well. Certainly, the lesson which deals with a mathematical derivation and a lesson which deals with 'experimentation

by students' cannot be planned in similar manner. The previous experience of the learners is something that has the maximum effect on the way new experiences (that we design in a lesson) are interpreted. You may have to revisit Chapter 5 *Exploring Learners* to understand this aspect. **Different learners in the class have different previous experiences. Therefore, there can be no fixed format or structure for planning a lesson.**

12.3 INQUIRING FOR PLANNING LESSON DESIGN

Teachers need to understand how to plan lesson design, so that learners are challenged to think. Teachers also need to know how learners are constructing their knowledge and what they are learning. **Meaningful learning takes place when teacher is able to involve the students in the process of learning, by taking them beyond the process of listening to that of thinking, reasoning and doing.**

For planning meaningful learning design in physical science through learner-centred approach you may start asking yourself questions like:

- What concepts are relevant to learners' interest?
- What can I expect them to know?
- How will learners interact with the learning materials in particular learning situations? What questions they might ask?
- What misconceptions and naive concepts learners might have? How can I elicit those concepts from them?
- What misconceptions and naive concepts might emerge out of teaching-learning process and how can I deal with them?
- What diverse needs of the learners I need to consider in grouping them and selecting teaching-learning materials?
- What can be the learning indicators? How can I get evidences of their learning of ideas, concepts and process of science?

Frank answers to such questions will help you meet the purpose of teaching-learning, i.e. learners' learning.

12.4 IDENTIFICATION AND ORGANISATION OF CONCEPTS

Identification and organisation of concepts are two basic components and an initial activity for teaching-learning. An efficient science teacher should know how best one can identify, organise, design and assist in the progress of learning experiences under specific conditions and situations to help diverse groups of students. Let us now discuss the factors that need to be considered for organisation of the concepts.

12.4.1 Factors that need to be considered for organisation of concepts

1. **Students'consideration:** Students are constructors of knowledge and teacher is a facilitator of learning. Students are at the focus of your teaching-learning. Each student is an individual with her own interests, abilities and experiences. Each student has special strengths and limitations. Students are constantly in a state of change, i.e. their ways of thinking and their personality change. They come to class with their own concepts and previous experiences. Your role as a teacher is to identify and remove their misconceptions and naive concepts, inculcate habit of argumentation, articulation and make them critical and reflective thinkers. Therefore, before identifying and organising concepts for teaching-learning, you should keep following points in your mind:

   What do you know about your students, individually and as a heterogeneous group? Are they easy or difficult to motivate? What do they already know about the concept you are planning to transact? How might they best learn? What accommodations will be needed for students with special educational needs?
2. **Content and process consideration:** What main ideas and concepts are involved? What teaching-learning materials will you need to transact the concepts? In what order should the teaching-learning activities be arranged? How can you devise a variety of learning activities and experiences to transact the concepts?
3. **Time consideration:** How much time is available for it? Do you need more than one day or one period for a particular topic?
4. **Resource consideration:** What resources are available in the school and community such as laboratory, library, ICT resources, science centre and museum and with people within the community who might contribute to teaching-learning process in the school?
5. **Teacher consideration:** Teacher needs to identify the pre–existing understandings that students bring with them. Inquiring into students' thinking orally or in written form and creating classroom tasks and environment under which students' thinking can be revealed are important in order to:
   - transact same concept in various ways and, thus providing different learning experiences to learners for a firm foundation of factual knowledge;
   - recognise preconceptions of students that make the understanding of particular subject matter challenging;

- work with those preconceptions, so that students build their knowledge on them and challenge them when appropriate, and replace them; and
- integrate teaching-learning of metacognitive skills into the curriculum.

6. **Technical consideration:** What appropriate equipments, hardware and software are available for effective transactions?

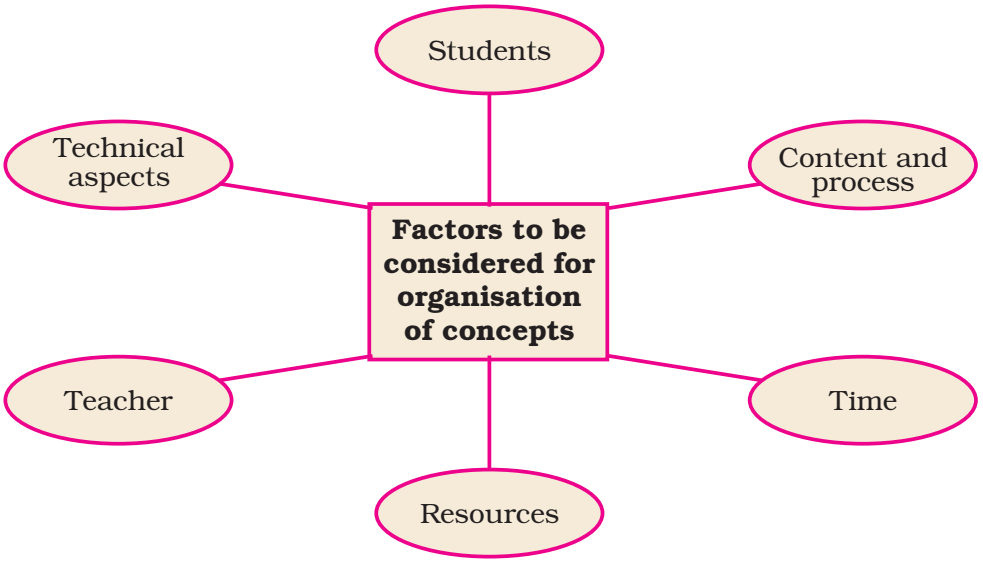


Fig. 12.1 *Factors that need to be considered for organisation of concepts*

12.4.2 Need for identifying and organising concepts for teaching-learning science

Identification and organisation of concepts help a teacher to know :

- What are most relevant concepts to the topic?
- What students need to know about particular topic?
- What are the misconceptions and naive concepts student might have and their way of removal?
- What misconceptions and naive concepts might arise during the teaching-learning and how will these be tackled?
- What will you do to ensure that your students understand the concepts?
- What are the learning indicators that can show that students have meaningfully understood the relevant concepts and processes?

12.4.3 Basic principles: Guiding choice of classroom practices for organisation of concepts

Before we discuss on the essential elements of a lesson plan, let us see the basic principles for organisation of concepts in order to identify and design teaching-learning experiences.

1. **Every learner constructs her own knowledge:** Teacher's responsibility is to enable this process through appropriate means and process and with adequate help and support. There can be several ways of construction of knowledge and there could be several ways of generalising as well as validating the knowledge constructed.
2. **Importance of experience in learning:** Experience is perhaps most important step in the construction of knowledge. All possible opportunities to observe, feel, work with hands, reflect and arrive at ideas should be provided to learners.
3. **Active engagement of learner in construction of knowledge:** It refers to engagement of body as well as mind. Learners can be actively engaged when they feel motivated to learn. They can be involved in inquiry, debate, discussion and reflection. An element of challenge in the context of capabilities of the learner is critical for the process of her active engagement and learning various concepts, skills, and attitude.
4. **Every learner is unique:** Every learner constructs her knowledge in her own way. Some learners might find a particular kind of learning process challenging and enjoyable while others might not enjoy it as much. The level of learners' engagement could vary. Although it is difficult to respond to each learner's preference in everything a teacher does, it would help to have broad understanding of the patterns of their thinking and response process. If the teacher involves learners and remains flexible while planning her work, individual unique abilities of learners will bring tremendous richness to classroom process.
5. **Variety of situations and multiplicity of strategies are important for creating diverse experiences:** Different kinds of situations provide different kinds of learning experiences to students. Exposure to a variety of learning situations such as self work, small group work, and whole class (or a large group) work helps in widening the experiential base. It also helps in developing diverse perspectives of learning. Therefore, it becomes important to have opportunities for self-learning, peer learning, and learning

through interaction with teachers. The experience of working in diverse situations also helps in realising the necessity and developing the skills of interdependence and cooperation. The experience of self learning could help in developing capability for independent action.

Similarly,there could be several ways of inquiry and exploration. If classroom questioning and dialogue could be suitable for transaction of some concepts; collecting information through observation followed by its processing, analysis, and theory building would be more appropriate for some other concept. A place for work with hands would also be important in many cases. Similarly, it is also important for teachers to be familiar with different forms of expressions,verbal and non-verbal, as well as ideas, so that they can create space and opportunities to allow all these to happen.

6. **The implication of aims for classroom practices:** The entire organisation of the classroom and learning experiences need to be such that they promote the same ethos, values,and principles. For instance, **the aim of promoting equity, democracy, freedom and plurality through education has to be reflected in all aspects of the pedagogy including the strategies, the teacher-student relationship, and kind and nature of learning experiences.**

It would be difficult to promote equity and democracy through a classroom where teacher does not allow children to ask questions, where teacher does not make extra effort to make a relatively silent child speak and participate, and where varying opinions are not encouraged to be voiced and debated. In other words, democracy or equity is not taught only by covering these as knowledge areas, but have to be made part of the regular classroom process.

7. **An enabling teacher-learner relationship:** The process of learning requires an uninhibited participation and engagement of learners that can be largely facilitated by teachers. Teachers' expectations from learners have proved to be one of the important factors in determining their motivation to learn, and consequently the pace and level of their learning.

It is important for the teachers to develop an affectionate and equal kind of relationship with learners, irrespective of their background and specificities. They should be responsible for making the learners feel comfortable and acceptable in the class, which is one of the first requirements for learning to happen.

8. **Providing space for parents and community:** While school is a structured space for guided learning, the process of constructing

knowledge is a continuous one, which goes on even outside the school. Providing some space to community in the classroom processes as part of the curricular plan could help in developing mutual appreciation and greater coordination among them. Parents or community members could be seen as resource persons for exposure to certain ideas and concepts and could be requested to share some of their experiences with students.

ACTIVITY 12.1 

Outline and organise the various concepts on the topic *Electrostatic potential* (Higher secondary stage)/*Carbon and its compounds* (Secondary stage)/ *Water* (Upper primary stage).
Discuss and justify the factors you kept in mind in the organisation.

12.5 ELEMENTS OF A PHYSICAL SCIENCE LESSON

A standardised format of a lesson or unit plan cannot capture interest of all learners. A well organised teaching-learning situation can have an appeal to students yet follow curricular guidelines of the school. Therefore, you need to design various learning situations in creative and innovative manner to cater to the learning needs of different learners. There are certain basic elements of a lesson plan. Knowledge of these basic elements of a lesson plan will be a great help to you in planning for lesson design.

1. Title of the lesson/unit
2. Learning objectives and key concepts of the time frame
3. Pre-existing knowledge
4. Materials, equipments, resources
5. Introduction
6. Presentation
7. Assessment
8. Extended learning, assignment

It is important to understand that this is not a rigid picture of a lesson plan. **There are a number of ways to design a lesson and you may think on many innovative designs of it depending on the learning needs of the learners, nature and context of the concepts, learning situations and your own resourcefulness.**

You may need to change, add, omit or delete some elements as you move from one lesson to another and even when the classroom interactions are going on in order to meet different needs of the learners.

Many of these elements are discussed in detail in various chapters of this book. Let us now discuss them in brief again.

12.5.1 Learning objectives and key concepts

Objectives are the first step in the process of planning and thus form the basis of the subsequent steps of the plan. Objectives of the lesson need to be planned by keeping in view the *Nature of Science* (see Chapter 1), *Aims of Learning Physical Science* (see Chapter 3), and context of the learner and her needs. Objectives, if framed properly, provide the direction for planning teaching-learning experiences as well as recapitulation and evaluation. Suppose you are transacting Archimedes' principle to students and frame your objectives as:

- stating the Archimedes' principle; and
- verifying the principle experimentally.

Now it is clear that your lesson will proceed in the direction of statement of the principle, its explanation and demonstration for experimental verification.

The other way of stating the objectives for the same content could be:

- inferring the Archimedes' principle from the activities performed in the class; and
- stating the Archimedes' principle.

Now, your way of presentation of teaching-learning activities will take a different course. Here, you will first facilitate the learners to perform the experiment and try to help them to observe and infer that:

- there is an apparent loss of weight of a solid when immersed in liquid;
- loss of weight is equal to the weight of displaced liquid and then help the students to arrive at the statement of the principle. Your planning will depend on your understanding of the approach you think better in a given teaching-learning situation.

Both the ways are equally acceptable, but they focus on the achievement of different aims of learning physical science. Thus, it is for you to decide that in relation to your content area and the needed experience by the learner, which of the aims you wish to emphasise on.

In the constructivist perspective, learning objectives cannot be predetermined, however, it can be developed on the basis of interaction with the learners and questions asked by them. It can be written in terms of certain broad and integrated **key concepts.** For example, the key concepts on the topic *Force* for Class X can be 'force– a push or pull'; 'forces are due to an interaction'; 'force has magnitude as

well as direction'; force can change state of motion'; 'force can change shape of object'; 'contact force' and 'non-contact force'.

A questionnaire distributed to students before starting a lesson to get acquainted with their existing knowledge and their curious questions can be of great help to teacher for developing learning objectives. Developing deep understanding of the concepts on physical science, the learning process and the learner are important for writing learning objectives. You may need to revisit Chapter 4 *Learning Objectives of Physical Science* for writing learning objectives.

12.5.2 Pre-existing knowledge

By pre-existing knowledge, we mean the knowledge and experiences, which you consider essential for students to possess for learning the lesson being planned. Those earlier experiences and concepts learnt by the students, which are crucial for comprehension of the lesson, should be considered in previous knowledge for their better understanding. Paying attention to previous and existing knowledge helps a teacher to identify misconceptions and naive concepts of students and reconstruct their ideas that are scientifically accepted. You may revisit Chapter 5 *Exploring Learner* for this.

ACTIVITY 12.2 

(i) Think about a learning situation such as an activity and develop a questionnaire comprising five–six questions that can elicit pre-existing knowledge of the learners and their curiosity related to the following topics:
Atomic structure; *Work, Power and energy;* and *Newton's laws of motion.*
You can consider these topics at secondary/higher secondary stage.

(ii) Discuss how can pre-existing knowledge of the learners and their curious questions can help a teacher in developing learning objectives of the topic? On the basis of the Activity [12.2(i)] develop learning objectives of the topic/concepts.

12.5.3 Teaching-learning materials and involving learners in arranging them

Teaching-learning materials aid in learning. These can be equipments, apparatus, model, chart, real objects, video, audio-video aids, etc. Learning can be reinforced with teaching-learning materials of different varieties, because they stimulate, motivate as well as capture learners' attention for a while during the teaching- learning process. While selecting appropriate teaching-learning materials for our classroom,

we need to make sure that they should cater to the needs of learners learning with various learning styles. Every student learns differently, and teaching-learning aids will be more effective if they appeal to everyone. While entering the class, it is important to make sure that all teaching-learning materials are ready for use. It is also important to check that all these materials are in proper functioning order. You should have a clear vision when and how to use these materials. When these are not in use, they should be placed away from the view of students to avoid distractions.

In case, you are using equipment students are not familiar with, it is better to say a few words about the equipment before using it, so that students' curiosity about the new object is taken care of.

Learners should be involved in procuring the materials for the preparation of activities and experiments to be performed. Such involvement can provide learners an opportunity to explore resources available in their surroundings. It can instil a sense of responsibility and ownership to learning. The skills they gain in such a process have their own worth. Students learn to volunteer for various responsibilities. Next day, when the activity is conducted, their motivational level and involvement in the lesson is observed certainly to be of higher order as they have themselves planned and brought materials for it. Students get opportunity to learn something on their own about something they themselves have decided to learn and in the manner they wish to learn. It helps in making teaching-learning process more effective.

- Abida had to transact various concepts of alloys in Class X. She asked students to bring samples of various alloys before starting the topic. She found that students brought different samples with them the next day. The collected materials were taken in the class one by one to study their colour, shine, strength, etc. She observed that uses of these alloys were articulated by the students themselves as while collecting the samples they learnt them on their own. It was a good experience for her as students participated actively and learning was more effective.

- Abdul suggested his students to bring different types of fruit and various other materials like soap and detergent, etc. from their home. They were asked to observe the change in the colour of litmus paper with the use of solutions made by those materials. The term '*Acid and Base* was introduced thereafter.

- Next day students brought turmeric and red cabbage leaves/black carrot and they prepared extracts of turmeric and red cabbage leaves/

black carrot in boiling water. The students used these extracts as indicator for testing the acidic and basic nature of the substance. As students had brought material from home, they were really excited on observing the change in colour of these materials. The concept of 'universal indicator' could be easily transacted after this.

- In order to transact the concept of *Magnetic effects of electric current*, Ashok, a teacher at secondary stage, suggested his students to get an iron nail from home. Some of them brought nuts, some brought very long nails and others brought small ones. He facilitated them to make electromagnets using insulated copper wire, battery and pins. The first Aha! moment for the students was when they saw the electromagnet made by them could attract the pins. He then put the idea of formulating hypotheses to find which electromagnet would be the strongest. Lesson came out very well as students were involved in collecting materials, performing activities, formulating hypothesis and deciding of variables such as length of the nail, number of turns of the coil, strength of current, etc.

- Facilitating formation of a number of groups of students equal to the number of activities in the chapter, Sanjana motivates each group of her students to take charge of one activity of a topic. Each group then volunteers to take responsibility to collect materials and equipments to make arrangement for the activity; to prepare chart and/or work on ICT applications. She does it before the lesson starts. They arrange for the materials and equipments from their surroundings or laboratory. "This way I can easily carry out a large number of activities in Class VII Science. Students do some self-study in the process of preparation for the activity. It makes my work easier and students remain interested in the topic. Of course, I take care of the safety measures" Sanjana says.

Teaching-learning of every topic in science should possibly be supplemented with appropriate activities or practicals, and therefore it is essential to have sophisticated laboratories full of apparatus and equipments. In fact, such facility is not always available. An innovative teacher may prepare many improvised apparatus from the available materials from here and there by involving the students. Improvisation is the term that refers to construction of a teaching aid with simple available materials costing little or nil. Especially, scientists of ancient days basically depended on improvisation in order to show their inventions or results. This practice is helpful in making the teaching-learning, learner- centred, activity-oriented and participatory. **It helps the learners in inculcating scientific temperament and provides scope to develop creativity. Improvised apparatus is repairable,**

replaceable and disposable. These are discussed in detail in Chapter 9, *Community Resources and Laboratory.*

ACTIVITY 12.3 

Select any two topics of your choice in science/physics/chemistry. Make a list of teaching-learning materials that you think are required for the transaction of various concepts of the topic. As a pre-lesson activity what help will you take from your students in the preparation of these materials? What preparation do you require?

12.5.4 Introduction

A good beginning is crucial for the success of any endeavour. Relating learning with everyday life experiences of the learner generates interest for learning new concepts. Main purpose of introduction is to motivate and prepare the students to learn the topic by relating their existing knowledge with the new knowledge. Besides motivation, other purposes of introduction may be to:

- establish continuity of the lesson;
- highlight the importance of the lesson;
- clarify the objectives of the lesson;
- raise curiosity among the students;
- present a brief outline of the lesson;
- create interest among the students; and
- test their previous knowledge, etc.

ACTIVITY 12.4 

Take a textbook of science/physics/chemistry. Select concepts to be introduced for each of the purposes mentioned above. Write down the introduction of those concepts for your lesson.

The various techniques which could be adapted for presenting the introduction may be following:

- presenting a problem to the students;
- carrying out activities and experiments and raising questions;
- involving students in an activity and listening to their questions;
- presenting a challenging idea, situation and/or problem to students;
- narrating an anecdote/historical event/life history of the scientist related to the topic; and
- narrating stories, incidents, etc.

One question which comes to mind while planning the introduction is: how much time should be given to the introduction? Certainly, there

can be no one answer to this question. You have to first decide what technique of introduction you are applying which in turn depends on the nature of the content of your lesson. If it is a new unit, whole period may be devoted to introduction, whereas if it is in continuation of the previous lessons, a brief recapitulation and testing of previous knowledge may do well.

12.5.5 Presentation/Development

Presentation/development of the lesson should be in accordance with the objectives of the lesson. You should also take into account the following:

- nature of the subject matter
- learning context of your students
- classroom environment and infrastructure available and
- your own context.

As presentation will vary, depending on the factors mentioned above, several illustrative plans are being given in upcoming sections of this unit. It involves splitting of the lesson/unit into smaller ones for a given period and including a number of activities to help learners to observe, feel, reflect and arrive at ideas through their own experiences. Learning experience of students can be enriched by:

- discussion and argumentation.
- activities and experiment.
- pre-lab, and post-lab discussion to engage learners in thinking, planning and relating knowledge with their existing ideas.
- computer simulation and other interactive softwares, reviewed webpages
- quiz, project, field visit, etc.
- review and feedback.
- assessement that is intertwined with all stages of the lesson.

12.5.6 Assessment : Acceptable evidences that show learners understand

Purpose of this element of a lesson plan is to get feedback from learners. In fact, assessment should be an integral part of the design of a lesson. Learning is a kind of understanding that emerges from a well-developed and supported theory, an explanation of phenomena, data, feelings, or ideas. Learners' understanding is uncovered through their performances and products that clearly and thoroughly explain how things work, and how do they connect those performances and products with the relevant concepts. Learning evidences acquaint

the teachers about students' understanding of concepts and how they show meaning of facts, concepts and application of knowledge. Evidences of learning come from the assessment of students' work such as experiments, presentation, homework, assignment, explanations, worksheet, test, project, etc.

12.5.6 (i) Determining learning evidences

We can infer that learning evidences are concerned with the assessment. It is obvious that one of the main objectives of science education is development of students' understanding of science concepts. Students reveal their understanding most effectively when they are provided with proper opportunities and environment to express themselves. How can we determine evidences of students' understanding? Learning evidences help us to evaluate their progress. Let us now see how to determine learning evidences.

1. Set objective: This is a learning objective we have discussed earlier.

2. Identify ends: Learning ends should be a part of your vision for the learner, or what you envision about the learner – to know, understand or perform. These may provide a framework for culling content and sifting it into various areas and strands of learning.

3. Expand or recombine: Can specified ends be broken down into smaller pieces (such as knowledge, specific skills and performances, or learning objectives), or compressed and integrated with other subject areas, or combined into a comprehensive problem, simulations, or self-directed investigation?

4. Determine acceptable evidence for collecting indicators of learning:

- What evidence will prove that students have achieved the objectives or completed the problem?
- What will they, or should they, be able to do to give evidence of learning?
- Can these evidences be placed in graded tasks specific to learning indicators with clearly stated parameters for each level of gradation (i.e. unacceptable, acceptable and exemplary; or at introductory, practiced, and advanced levels?

A student who can explain why steam, water, and ice, though superficially different, are the same chemical substance, has a better understanding of water than someone who cannot. A student reveals an understanding of things – perhaps an experience, a concept, or

her own performance – when she can provide reasoning and relevant evidences to support her claims. More thorough understandings involve more thorough and systematic explanations, typically when an event is subsumed under general principles. Merely cramming the matter of the textbook to give back on class tests is not evidence of understanding. Before collecting evidences for understanding, teacher must be clear about the following points:

- What kind of evidences does a teacher need to find learners' understanding? What would be the nature of the task to provide such evidences? For example, would it be performance of an experiment or activity or writing answer to an open-ended question or oral presentation.
- Teacher should know the learners' thought process along with their answers or solutions.
- What specific characteristics in the learners' responses should be examined to determine the extent to which the learning objectives are achieved?
- Their explanations of why they did what they did; their reasoning and justification for the approach or response.
- Can the proposed evidence enable teacher to infer learners' knowledge, skill and/or understanding?
- Reflection on the result, as it gives further insight into the extent of understanding of the concepts.

12.5.6(ii) Planning of the acceptable evidences of learning for assessment

Planning on the acceptable evidences of learning helps the teacher to remain focused on the task at hand and integrate assessment with the teaching-learning of physical science. A summary containing salient features of the lesson can be prepared side-by-side (for the blackboard work) with the presentation. It can help you revisit and reflect on the feedback obtained during teaching-learning process. You may revisit Chapter 11 ***Tools and Techniques of Assessment for Learning Physical Science*** for more details on assessment.

ACTIVITY 12.5

What learning evidences will you plan to get **before**, **during** and **after** teaching-learning of the topic *Motion and measurement of distance/Metals and non metals/ Magnetic effects of electric current?* Think-pair-share with your classmates.

12.5.7 Extended learning/assignment

The most valuable assignment is the one which a student finds interesting and important, and understands why it is important. Assignment may vary from student to student due to their different interests and needs. Providing constructive and positive feedback to them encourages them to work on their assignments. An assignment based on the continuation of the work in the classroom is very helpful for students' understanding. You may revisit Chapter 8 (section 8.14 *Facilitating Learners for Self Study*) for an illustration. As far as possible, assignment should emerge out of the group planning in the class, it should not be dictated by the teachers. There should be scope for critical thinking, creativity, and open-ended responses in the assignment.

Same assignment can be given to the whole class, or it can be given separately to different groups or individually depending on the context, learners and the situation.

Assignment should be planned for extended learning, self-learning and in a forward looking manner rather than only in a backward looking manner, i.e. doing routine type exercises at the end of the lesson. Learners can also be given assignment at the planning stage of the lesson. If a principle has been transacted in the class and students are given an assignment to make a model based on the principle for extended learning, they will not only understand the principle better, their understanding on construction and working and model-making skills will also get enhanced.

The unit, *p-Block Elements* always gave me trouble as I was struggling to make it interesting for my students. Involving them in a prelesson activity in groups to develop this lesson was a good idea. I have a class of 35 students. So I facilitated them to form seven groups of five students each and gave them the assignment of preparing powerpoint presentations on the relevant concepts of their choice in the lesson. One member from each group gave presentation in the class with the help of her team members. I acted only as a facilitator. This was a lesson developed by the students, for the students. They loved being on the other side of the table and explaining concepts to their classmates. I intervened only for extra explanation and some new terms like *inert pair effect*. As students were involved from the beginning they found the topic interesting.

–Experience of a teacher

ACTIVITY 12.6 

Select any topic of your choice and make a tentative list of assignments you plan to give to your students. Will you change or modify these assignments after discussion with your students? Discuss and justify your answer.

ACTIVITY 12.7 

Organise and conduct a debate on 'home work breeds tuition habits in students'.

12.6 MAKING GROUPS

12.6.1 Why group learning?

Group Learning is very important in teaching-learning of physical science. Group learning is a vehicle for nurturing various interpersonal skills in students. Students working in group display their growth in tolerance, their ability to listen to others and respect each other's views. It brings improvement in self-reliability, independence in dealing with others and their ability in making decisions; and in becoming considerate and helpful towards others. They also develop logical and critical thinking, communication skills, and presentational skills. Group work creates situations for students to develop skills of argumentation and tolerance. It can also promote opportunities for confronting different ideas, learning ways to express one's own point of view, the ability of making oneself understandable by others; the capacity of being involved actively in discussions and accepting criticism. In a group, students jointly negotiate understanding, plan tasks, explain things to each other, share ideas and coordinate actions. Therefore, while designing teaching-learning experiences, care should be taken to provide ample group work in various situations such as discussion, activity, experiment, field work, project work, use of ICT, etc. Group set up can be done for various approaches and strategies of teaching-learning of physical science. We have already discussed about it in Chapter 8 (section 8.7 *Collaborative Learning Approach*)

12.6.2 Facilitating formation of groups

Following points can be kept in mind for facilitating formation of groups in the class.

- How can the particular task be performed by group approach?
- What are learning objectives for the concepts to be transacted?
- What abilities are required for performing the task?

- How to help students to select the work of their interest and choice and prepare an outline of the work?
- How to form different heterogeneous groups of students to cater to their varied needs and abilities?
- How to support them to find resources, people, books, library, videos, to collect information and data?
- How to discuss regularly with students of different groups regarding their progress?
- How to help them in writing report and giving presentation?
- How to assess students and provide them feedback?
- How to assess myself while planning group work to make certain that meaningful learning of all students is taking place?

ACTIVITY 12.8

Select any topic from the Upper primary/Secondary/Higher secondary stage. Working on different topics, different groups of student-teachers can perform this activity.

- What activities can be performed to transact the selected topic? Make a list of them.
- What are the materials required to perform all those activities?
- Perform all those activities.
- How much time do you need to conduct these activities in the class? Estimate the time required for it.
- Present and discuss the report of your work in the class.

ACTIVITY 12.9

Select a chapter from a textbook of science/physics/chemistry. Develop a list of group activities that can be organised for effective teaching-learning of physical science.

12.7 PLANNING AND ORGANISING ACTIVITIES IN PHYSICAL SCIENCE

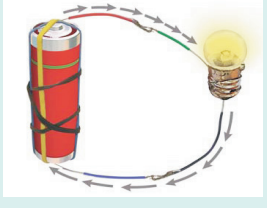
Teaching-learning of science is a process and its three essential components are—to acquire knowledge, to understand the concepts or principles and to apply those in a novel situation in order to solve a problem. As **learning by doing is cardinal principle of science** teaching-learning should be interwoven by activities to facitilate understanding. Therefore, planning an activity is the core of the planning teaching-learning experiences of physical science. For example, it is quite difficult to explain, *Archimedes' principle* only by

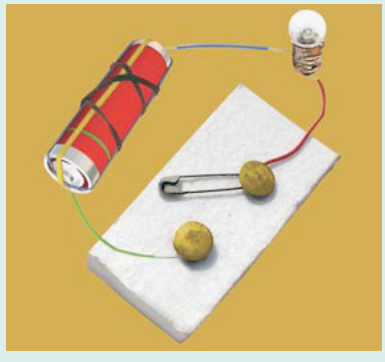
theoretical description. A student's mind may not readily accept the result. If this principle is explained by doing an actual experiment to show that when an object is partically or wholly immersed in water, there is an apparent loss of its weight and this loss is equal to the weight of displaced liquid, it will leave a permanent impression on the mind of the learners.

Let us discuss planning and organising an activity of physical science in some detail.

Tressa, a student-teacher had to take up science of Class VI for the first time. She was anxious about it. She shared her feelings with her classmate Namit. They discussed together the way of preparation for doing activities. They first performed the activity themselves and started thinking on the following lines and noting down their ideas.

Table 12.1 Self questioning of a teacher for facilitating learning of students

Self-questioning	***Facilitating learning***
Which activity am I going to carry out in the class?	**Making an improvised electric switch and observing its function.**
What concept/objective I intend to transact through this activity?	We can make an improvised electric switch. It can be used to keep any circuit open or close.
How much time will it take to perform?	10–15 minutes.
Will the activity be performed individually or in a group or by me with the help of students? How many students will be there in a group?	Students will perform this activity in groups. 4–5 students. I will facilitate formation of groups in the class.
What preparation is required for carrying out this activity in the class?	I need to make arrangement for one cell, one torch bulb, one safety pin, 2 thumb pins, connecting wires and a piece of card board for each group of students.
How shall I relate this activity with their previous knowledge and help them to think about the need of using a switch?  ***Fig. 12.2***	We have already prepared a home-made torch using a cell and a torch bulb in our previous class. Do you see any arrangement for switching on or off this torch (Fig. 12.2)? Can we move the base of the bulb away from the tip of cell to turn the bulb off ? Do you think, it is easy to use?

	Can we make a simple switch to use in our circuit?
At what stage of transaction of concept will I perform the activity— before introducing the concept, after discussing over the concept or in between the process of transaction of concepts?	After performing the activity of preparing a homemade torch and before transacting the concept of function of a switch.
How will I facilitate my students to perform the activity— interacting with them, before and during activity is conducted?  ***Fig. 12.3***	I can facilitate one student from each group to collect materials, viz. a cell, a torch bulb, a piece of soft cardboard, two thumb pins, one safety pin and few pieces of connecting wires, etc, for doing the activity. I shall help them to make a circuit by connecting an electric cell and a bulb with this switch as shown in Fig.12.3 and then making an electric switch using two drawing pins, a safety pin, two connecting wires and a small piece of cardboard. Students will insert a drawing pin into the ring end of the safety pin and fix it on the cardboard sheet making sure that the safety pin can be rotated freely. Students will fix the other drawing pin on the cardboard sheet in a way that the free end of the safety pin can touch it. I will move around in the class to observe whether students are making the switch in proper way. I shall interact with them answering their questions and help them in making the switch.
Are there any safety measures to be taken?	Handle the cell carefully. Do not play with the cell.
What questions will I ask them? How will I encourage them to inquire?	When you rotate the safety pin, does its free end touch the other drawing pin? Does the bulb glow? What do you observe by closing the switch by joining the two drawing pins with a safety pin? Does that work? Now move the safety pin away from one of the pins. Does the bulb continue to glow?

	What is the reason for it? What is the direction of flow of current?
Do I foresee any difficulty or problem in performing the activity by students?	The cell and the torch bulb should be in working order. I have to check them before the class starts. If activity does not work, I will help students in checking whether the cell is exhausted, the bulb is fused or the connections are loose.
How will I prompt them to observe and think? How would I draw attention of students to the expected conclusion of the activity?	Why does the bulb glow when safety pin touches the two drawing pins? Why does the bulb not glow when the safety pin does not connect the two drawing pins?
How will I carry out discussion to encourage and help students to draw conclusion?	Is the circuit complete when the safety pin touches the two drawing pins? Is the circuit complete when there is a gap between two drawing pins? Do you think here safety pin functions as a switch? You observed that the bulb glows when the safety pin touches the two drawing pins. The switch is said to be in ON position. When the safety pin does not touch the drawing pins, the bulb does not glow. It is said to be in OFF position. I will ask, "How does the switch help in making or breaking an electric circuit?"
How will students record their observation?	Students will draw the figure of the electric circuit. They will note down what did they do and what did they observe. Following format may be used: • Activity I performed. • Materials I used. • How did I do it? • What did I observe? • What I wanted to know? • What did I learn?
How will I help them to understand function of a switch?	Do you think switch is a simple device? Can it make or break an electric circuit? Have you observed electric

	switches used in various electric devices at your school and home? Is their design complex compared to the switch that you have prepared? How does a switch help in saving energy?
How will I relate the concept to everyday life experiences?	Let us observe the switch fixed on the switchboard of the classroom. I shall help them observe one electric switch that I shall carry with me. I shall discuss function and working of a switch fixed on an electric torch case.
How will I assess students' understanding?	I shall carry assessment sheet file in the class as given in Chapter 11 *Tools and Techniques of Assessment for Learning Physical Science* [section 11.4(B).2] I have to put tick mark only on the tasks specific to learning indicators. I shall try to do assessment of at least three students on today's activity during teaching-learning period. I shall also observe the way they record their observations while moving around them and check at least three note-books in the class. I think qualitative assessment of 3–4 students for an activity can be done in each period.
How will I wind up the activity? How will I switch over to the next concept?	Students will open the connections. They will place various materials separately. Two students will collect the material and keep it in one small box/tray. I will ask, "Does the material of the safety pin allow the current to pass through it? What do you think, is it a good conductor of electricity?" I shall help students to replace the safety pin with a small plastic string and inquire why does the bulb not glow? Next concept to be transacted will be *Good and poor conductors of electricity.*

This planning helped Tressa a lot in the class as she could sustain interest of the students and all students actively participated in the activity. She assessed her teaching-learning experiences by asking herself a few questions as given below:

Self-reflecting questions

- Could I carry out the activity as per my plan?
- Did I face any problem in carrying out the activity?
- Could I handle all the queries of my students?
- Next time when I will carry out the same activity, do I need to modify the activity?
- What modification/change will I make in the activity?
- Did I feel the need of changing the planning part of the activity?
- What change will I incorporate in planning of activity next time?
- Could I engage all the students of the class in inquiry? Could I sustain the interest of the class throughout the activity?
- Did the task that I gave to my students show a sense of achievement in them? Did they enjoy learning?
- Did the activity lead the class towards another concept/problem to be solved?
- Did I provide enough opportunity to all students to express their ideas?

Different activities need to be planned differently. The example given above is written very elaborately. You may find it cumbersome in the beginning, but do this exercise for a few activites before you enter the classroom to interact with students. Gradually with experience you may need to elaborate on only a few steps of this exercise. One thing is very important here. You need to visualise mentally all the steps (may be with few modifications) in the planning stage of teaching-learning process. After number of years of experience with the students, this visualisation would take only a few minutes.

If the activities are well planned in advance, it leads to discussion instantly and you get an idea about next step in investigation. It generates thinking with reasoning. If performance of activity is supported by well-designed questions, students arrive at conclusion themselves.

ACTIVITY 12.10

Select one activity each from Class VI and from Class X textbook, and plan the activities as discussed above. Student-teacher may need to perform the activities to anticipate any difficulty in carrying out the activity in the class and some of the questions raised by students.

ACTIVITY 12.11 

Suggest any other way of planning activities. Make a detailed worksheet as per your plan by selecting any one activity from a textbook of science/ physics/chemistry.

12.8 PLANNING LABORATORY WORK

Proper planning of laboratory work is required in order to provide opportunities to all students to manipulate equipments and materials, interact and work collaboratively with peers in an environment where they feel free to investigate and find solutions to their inquired problems. You can think on the following lines:

- Sufficient equipments and apparatus should be set up where a group of two–three students can work together. If sufficient number of apparatus required for one experiment or activity is not available in the laboratory, different experimental set-up for different groups of students may be planned.
- Laboratory equipments and experimental set-up should be tried out for their functionality before the start of laboratory period.
- Students should be involved in setting and checking up the equipments and apparatus.
- Pre-laboratory discussion with students becomes necessary in some instances. For example, you may feel that understanding of *Wheatstone bridge principle* is required to perform experiment on a meter bridge; knowledge of the principle of potentiometer is required before performing the experiment, etc. Pre-laboratory session is required for making students aware of the safety measures to be taken in the laboratory. They should be encouraged to identify their own problems and select their own procedure for laboratory activities. Pre-laboratory discussion can be very helpful for this purpose.

We have already studied about Chemistry and Physics laboratory in detail in Chapter 9 *Community Resources and Laboratory*. Wherever appropriate, laboratory activities can be designed using familiar objects, tools and household items, as such objects provide a context that students find interesting. Students can relate applications of scientific concepts and principles in their everyday life by using everyday materials and can get more inclined to acquire inquiry skills. **As laboratory work is an integral part of teaching- learning of science, laboratory activities should be interwoven with the teaching-learning of theoretical aspects of physical science.** Laboratory work includes

activities, experiments, demonstration by students and teachers and project work. A topic should be scanned beforehand to plan what kind of laboratory work can be carried out for its transaction. Students should be involved in the work of identifying, selecting and arranging for the materials required for performing various kinds of laboratory work. Questions and interest of students should also be kept in mind in designing teaching-learning experiences in the laboratory.

After identifying key concepts of the topic *Light– Reflection and Refraction,* Debojit suggested his students of Class X to make a list of equipments and materials required to perform activities and experiments based on the topic. He also suggested them to note down their ideas about the activities they wanted to perform with those equipments and what are they curious about to learn on that topic. Students discussed among themselves and prepared a list of apparatus and materials they wanted to use for performing the activities. Their list included *convex and concave mirrors, glass slab, prism, convex and concave lens and candles.* Facilitating students to perform activities using above materials and based on their questions, he transacted the concepts *of Reflection and refraction of light* easily. An environment of discussion and argumentation was set up in the class as students started sharing their observations. They explained the nature, size and position of images of the candle flame kept at different distances from the mirrors and lenses giving the reason of their explanations. Debojit observed that students enjoyed learning.

Involving students in planning of laboratory work encourages them to be more responsible for their work and conduct in the laboratory and learning physical science.

12.9 PLANNING ICT APPLICATIONS

Present age may be called an age of technology. Technology has had its impact on all walks of life, but perhaps its impact on communication cannot be questioned. Teaching-learning process, which is basically a communication among all those stakeholders taking part in the process, can certainly be enriched substantially by employing Information and Communication Technology (ICT) in the form of recorded audio-video presentations, video conferencing, overhead projecter, science films, computer alongwith its various software and e-mail applications, etc. now available to a teacher. A teacher can surely make use of them to enhance the quality of classroom communication and enrich the teaching-learning process. **Technology and software have the potential to minimise the distance between learner, teacher and resources.** Interactive activities enable the teacher to take her teaching-

learning process beyond the classroom, and enable her to play the role of a true facilitator of learning.

It is desirable that administrative level creates a supportive infrastructure to integrate ICT in the curriculum by allocating resources for preparing teaching-learning materials, and building a comprehensive programme for teaching-learning of physical science.

Principles of planning ICT applications for effective learning are similar to those for classroom general practices. It is depicted in Fig. 12.4.

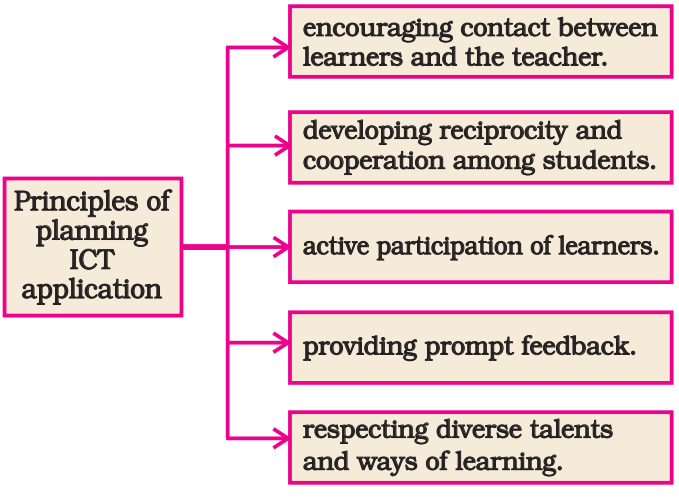


Fig. 12.4 *Principles of planning ICT application*

While the above points can be augmented, these are given as illustration of similar situations in a well-provided teaching-learning experiences with or without the use of ICT.

Teaching-learning of science with emerging technology requires:

- a spirit of experimentation;
- willingness to engage learners in creation of learning resources (co-creation of content);
- willingness to rise above the traditional approaches of teaching-learning of science; and
- Tolerance of failure.

Discussion on various networking systems, web seminars, quizzes and video conferencing can be various forms of ICT applications. Students can be asked to read a text available on a reviewed website or listen to audio and video presentation. Use of ICT provides opportunities for enrichment of the teaching-learning experiences. This enrichment can make the teacher free from the trivial issues and discussion of a classical classroom. In ICT enabled classroom situations, the time saved from

such activities can be devoted to challenging the misconceptions and naive concept of learners, posing and exploring open-ended unresolved questions and problems, etc. **Suitably designed e-material can be a source of self-learning for students and help them to become independent learners.**

Project 12.1

Considering above principles of planning for ICT and based on your understanding of Chapter 10 *Print and ICT Resources in Learning Physical Science* select any one chapter of your choice in physical science and develop a PowerPoint presentation/photo story. Review the websites and collect their addresses and/or collect video clips on the related concepts. Your friend may select some other topic and you may share your ideas. This can be one of your teaching-learning resources to be used during practice teaching.

12.10 REFLECTIVE PLANNING

Reflection on teaching-learning and planning needs to be done continuously. Let us see how frequently we need to plan and revise our planning.

- On a daily basis to organise the learning materials for the next day and to review the day's teaching-learning experiences.
- On a weekly basis to make unit plan and to work out details of activities, experiments and projects.
- On a monthly basis to review the learning progress of the learners and examine critically curricular experiences and organisation of own work. Subject committee meetings can be held at school and cluster level to share ideas and plan for the forthcoming month together.
- At the beginning and end of the year to evolve an annual plan for all curricular activities of physical science. It may include plan for science club activities, field visit, laboratory work and organisation of specific days like science day, environment day, etc.

Teachers should be reflective practitioners. They can improve their teaching-learning through their own feedback. We shall discuss on reflective practices in detail in Chapter 15 *Teacher as a Researcher.*

ACTIVITY 12.12

Give a presentation of 10–15 minutes on any topic of physics/chemistry in the class.
Assess your own performance on the basis of a questionnaire designed by you. Reflect and review how meaningful and effective was the presentation. Share your experiences with your friends.

Project 12.2
Maintain a journal for reflective planning during your practice teaching. Review your own performance in the class and self assess your teaching-learning experiences of each lesson. You may develop a format for this reflective exercise.

12.11 PLANNING A UNIT

Before preparing detailed lesson plans for the day on a given topic, it is always advantageous and helpful to plan for the whole unit, so as to ensure continuity in the teaching-learning process and have a holistic view of the content. Individual lesson plan then can easily be planned on the basis of this holistic plan. While selecting a unit, it should be kept in mind that a teaching-learning unit is not just a collection of unrelated topics or lessons, but such an integrated whole where each lesson is a part of the whole unit and leads to the development of a new lesson in the unit.

A unit of science is concerned with its content and strategies of teaching-learning in an evolving manner. It is neither a block of subject matter nor a series of independent lessons. In fact, it has its own structure. In a unit plan, the subject matter is splitted into smaller sections to have a brief overview of various concepts and interconnectivity among them. While planning teaching-learning of a unit the following points may be taken into consideration:

- Suitable length of the unit, so as to maintain the interest of the learners,
- Learners' needs, capabilities, interests, previous experiences and their social and physical environment.
- Flexibility in approach, which is the hallmark of a good unit and call for variety of experiments, activities, projects, etc. to be incorporated.
- Collaborative planning by teacher and students.

While planning a unit, the unit should be analysed for the purpose of identification and organisation of concepts and sub-concepts. Suitable learning experiences should be planned for each of the concepts. A number of resources for planning a unit can be used. These can be textbook, laboratory manual, library, internet, discussion with peers and experienced teachers, visit to science centre and museum, planetarium, etc. Following proforma will help you in understanding the procedure for planning a unit.

Subject _____ Class _____
Name of the Unit _____ Number of Lessons required _____
Time required (No. of periods) _____

Table 12.2 Example of an unit plan

S.No.	**Concept**	**Scope of the subject matter**	**Teaching learning materials**	**Procedure** (approaches and strategies; activities, laboratory exercise, pre-and post-laboratory discussion; computer simulation; review of lesson, feedback; assignment — whole class, small group, individual; etc.)	**Assessment** (tools and techniques of assessment to be used)	**Unit Test** (using a variety of tools and techniques)
1.						
2.						
3.						
...						

After completing the above proforma, detailed unit plan may be prepared as given below.

Sub-concepts _____
Lesson No. _____

Table 12.3 Example of a detailed unit plan

S.No.	**Sub-concept**	**Learning objective** (Writing condition and criteria	**Teaching-learning materials**	**Procedure**	**Students' argument**	**Assessment**

		can be helpful for beginner teachers)				
1.						
2.						
3.						
..						

As there is no fixed way of planning a lesson, there is no rigidity in planning a unit. You may modify the above proforma as per your need. In fact, there can be an entirely different way of planning a unit, wherein instead of specifying what is to be done and in what order, variety of activities to be undertaken are focussed upon, an example of which is given below.

Subject : Physics

Time required: ..... periods
Topic : Electrostatics

Overview

Table 12.4 Example of a unit plan

Concepts involved in the unit	Rubbing two non conducting objects can produce static electricity; two types of charges— positive and negative; charged bodies may repel or attract each other depending on nature of charge they posses....
Previous experiences of learners	A plastic comb rubbed with dry hair can attract small pieces of paper.
First-hand experiences	1. Rubbing different objects and testing for electric charge. 2. Dancing paper dolls activity. 3. Activity showing attraction and repulsion between two charged balloons. 4. Attraction of unlike charges and repulsion of like charges.
Strategies Activities/projects video/powerpoint presentation	1. Gold leaf electroscope, Lyden Jar. 2. Thunder light.

	3. Making an improvised aluminuim foil electroscope. 4. Making chart/model showing safety in thunderstorm.

Thus, a unit can be planned in different manner and there should be flexibility in the way of its planning.

ACTIVITY 12.13

Complete the unit plan shown in Table 12.2 and 12.3 taking any unit of your choice. You have the freedom of modifying the way of planning.

ACTIVITY 12.14

Concepts for the unit *Work, Energy and Power* for Class XI are given below: *Work Energy theorem, work, kinetic energy, work done by a variable force, potential energy of a spring,potential energy, various forms of energy, conservation of mechanical energy, principle of conservation of energy, and power.*

Develop a unit plan for the transaction of the above unit. Exchange your work with your friend and share your ideas.

ACTIVITY 12.15

Develop a unit plan on the topic Dual Nature of Radiation and Matter/ Hydrocarbons, the way you find convenient for your use in further developing design of the lesson plans.

12.12 LESSON DESIGN: EXAMPLES

EXAMPLE 1

Class : XI **Topic : Redox reactions**

Time : 40 minutes

For the introduction to the topic, the teacher facilitates the class to form groups of two or three students to perform the following activity.

Activity : Teacher helps each group of students to put zinc granules in a test tube and pour some dilute hydrochloric acid over it. Students observe carefully the changes taking place in the contents of the test tube.

The teacher encourages the students to generate an explanation on the basis of their observations, interpretations, conclusions and arguments

that zinc reacts with dilute hydrochloric acid to produce hydrogen gas and zinc chloride. For this she raises questions as per the need of the learners and the learning situations.

Q.1 What do you observe?

Q.2 Which of the chemical has gained positive charge and which of the chemical has lost positive charge?

Q.3 Why has zinc gained positive charge and hydrogen lost its positive charge?

Q.4 Does oxidation and reduction go hand in hand?

Q.5 What is the speciality of displacement reaction?

Q.6 What can be alternatives of classification of these types of reactions?

Assessment is interwoven throughout the teaching-learning process. Based on the learning indicators and the task specific to the learning indicators in the conceptual development framework, questions are developed by the teacher in collaboration with learners in the classrooms for qualitative assessment.

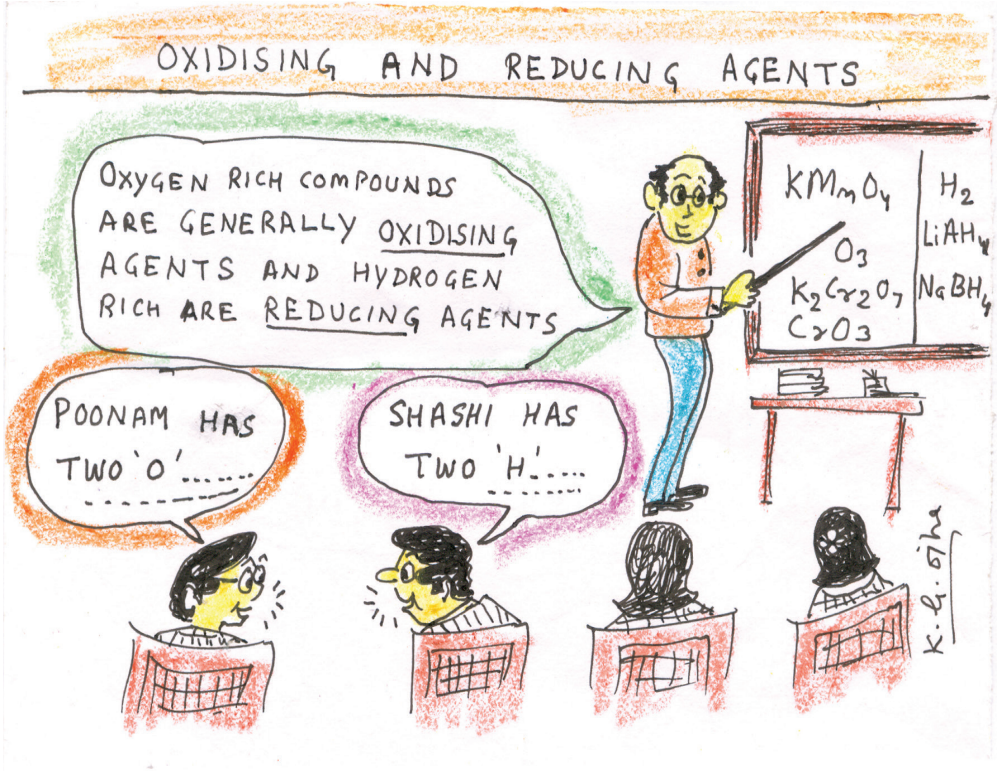
Table 12.5 Developing a lesson design

Conceptual development framework	**Observation and reporting**	**Organisation of activity**	**Students' involvement in negotiating learning**
Concept to be articulated: Competitive electron transfer reaction **Teacher's mediation required in –** **(i) Observation and reporting** Drawing figures of observations made and apparatus used, narrating, presenting data	**(i)** Observing the colour of $CuSO_4$ solution. • Observing the decolourisation of the solution after few minutes of insertion of Zn rod.	**Materials required:** Zinc rod and copper sulphate solution in a beaker. Copper rod and silver nitrate solution in a beaker. Teacher organises the activities involving students. **Task** • Keep the Zinc rod in copper	**Exploration** • Students keep the zinc rod in copper sulphate solution and observe what happens. • Students keep the copper rod in silver nitrate solution and observe. • Students discuss with their group about relative reactivity of two metals. **Discussion/ Elaboration**

Conceptual development framework	Observation and reporting	Organisation of activity	Students' involvement in negotiating learning
as Tables, graphs, etc. **(ii) Classifications** Categorising, grouping, comparing, contrasting **(iii) Asking questions** Expressing curiosity, critical thinking.	• Observaing that the rod has acquired reddish tinge. • Reporting on the basis of observations that Zn is replacing Cu in in the solution of $CuSO_4$. **(ii)** Categorising as oxidising agent and reducing agent. **(iii)** Inquiring what will happen if Cu and Zn rods are kept together in $CuSo_4$ solution. • Inquiring why Cu is replaced by Zn in the $CuSo_4$ solution and not vice-versa. i.e. Zn is not replaced by Cu in $ZnSO_4$ solution. • Inquiring what will be the reaction, if we insert a rod having less reactivity than that of Cu.	sulphate solutions and observe. • Keep copper rod in silver nitrate solution kept in a beaker.	• Students will reflect on the result of experiment; and whether both the metals involved in the reaction have same reactivity or not. **Argumentation** • Students will explain that the reactivity of metal is more than its stronger reducing agent; and • why silver nitrate solution turns blue when copper rod is dipped in it. **Engagement** • Students will work together to list the oxidising and reducing agent by comparing their reactivity as given in the reactivity series in the book.

Conceptual development framework	Observation and reporting	Organisation of activity	Students' involvement in negotiating learning
(iv) Discussion Listening, presenting arguments, expressing opinion, trusting observations of others, concluding.	**(iv)** Discussing if both the metals involved in the reaction have same reactivity then what will be the result.	• Organisation of activities reflects concern for social justice, equity and environment.	**Assessment** • Given the reactivity series, students will write the possible reactions discussing within their group and with the teacher.
(v) Explaining Reasoning and making logical connection.	**(v)** Explaining that if the reactivity of metal is more, then it is stronger reducing agent.		
(vi) Analysis Making hypotheses, predicting and drawing inferences, application to daily life.	**(vi)** Inferring from the electro-chemical series that which metal would replace which other metal in solution.		
(vii) Experimentation Improvisation, fabrication of models, doing experiments.	**(vii)** Repeating same experiment with same metal rod but with different metal salt solutions.		
(viii) Developing an indentity as learner and contributer to science.	**(viii)** Finding applications of the concept of redox reaction in day–to–day life.		**Application** • Generate arguments about burning of coal and putting Na in water

Conceptual development framework	Observation and reporting	Organisation of activity	Students' involvement in negotiating learning
(ix) Collaboration Participating with others using scientific language and tools. **(x) Extended learning**	**(ix)** Working together to list the oxidising agent and reducing agent by comparing their reactivity. **(x)** example • Burning of coal • Putting Na with precautions as it is explosive in water.		considering – Redox reaction; – Oxidation with focus on carbon (C); – Reduction with focus on oxygen; – Oxidation with focus on Na; and – Reduction with focus on hydrogen.



EXAMPLE 2

Chapter : Chemical Reactions **Class :** VIII

Title of Lesson : Physical and Chemical Change

Time Required : 45 minutes

Materials Required: Mg ribbon, spirit lamp, watch glass, litmus paper, lead nitrate solution, KI solution, Na_2SO_4 solution, $BaCl_2$ solution, lead nitrate crystals, NH_4Cl crystals, test tubes.

Key Concepts : Occurrence of a chemical reaction is accompanied by one or more of the following observations:

- Change in state
- Change in colour
- Evolution of a gas
- Change in temperature

Classroom Proceedings

Engage

Have you noticed that butter hardens when kept in cold conditions? What happens to its material? Does it change? Justify your claim. Does its taste remain same? Can it be turned soft again?

Teacher facilitates the class in group formation and encourages them to enlist the changes that they have come across from their daily experiences, for example,

a) Melting of ice
b) Curdling of milk
c) Rusting of iron
d) Tearing of paper
e) Crumpling of paper
f) Burning of paper
g) Growth of a plant
h) Ripening of fruit
i) Melting of wax
j) Freezing of water

Teacher draws their attention towards the following categories and assists them in putting of enlisted changes in the relevant category.

Material remains same and change can be reverted easily	**Material remains same, but change cannot be reverted easily**	**Material changes and change cannot be reverted.**

Learners' inquiry drives the teaching-learning process. Teacher facilitates the inquiry to move towards the concept of physical and chemical changes. The changes in which material remains same are called physical changes and the changes in which composition of elements of the material changes are called chemical changes. Students categorise the above changes as chemical changes and physical changes and write the results in tabular form.

Change	Physical Change	Chemical Change
Melting of ice		

Do you think it is easy to identify physical change and chemical change? Let us perform some activities to explore this problem.

Explore

Activity 1

- Teacher facilitates the group of students to put zinc granules in a test tube and add dilute HCl to it.
- The students observe carefully and answer the following questions. They write the answers in the following Table.

Activity No., What did we do?	What was the observation?	Is something new formed?	Why do you feel so?
1. Add zinc granules to dilute HCl.	Bubbles are formed and the test tube has become warm.	Yes	Zinc granules have changed in colour. A gas is being evolved.
2.			
3.			
.....			

Subsequently following activites are to be performed and students complete the Table given above.

Activity (2) : A Mg ribbon is burnt using a spirit lamp (demonstration by the teacher).

Teacher : What do you observe?

Student : Mg ribbon burns with a dazzling white flame.

Activity (3) : Aquous solution of Na_2SO_4 is taken in a test tube and a few drops of $BaCl_2$ solution are added.

Teacher : What do you observe?
Student : A white solid is formed.
Activity (4) : Aquous solution of lead nitrate is taken in a test tube and a few drops of KI solution are added.
Teacher : What do you observe?
Student : A yellow solid is formed.
Activity (5) : Crystals of $Pb(NO_3)_2$ are taken in a test tube and heated gently over a flame. (demonstration by the teacher).
Teacher : In each of the activities performed above, do you think a new substance is formed?

Teacher assists students in generating arguments about how can they define a chemical change.

Explain

Students explain in their own words, what they learnt from the activities. For example, occurrence of a chemical change may be identified by any of the following observed changes:

- Change in state
- Change in colour
- Change in temperature
- Evolution of a gas

Elaborate (independent practice)

Physical and chemical changes are identified by more than one parameter. Students add some more parameters identifying these changes in the activities performed.

Evaluate

Evaluation is done involving students in identification of Learning Indicators (LI) in the class. Teacher helps students in indentifying the task specific to learning indicators such as:

- contribution in the form of inquiry in performing activities;
- argumentation;
- collaboratives work; and
- recording and reporting the observation, etc.

Group Activity

The class is divided into small groups. Students are taken to the laboratory to perform following activities.

They are asked to find out whether a chemical reaction has occurred or not, giving a reason for their conclusion. They are provided the required chemicals.

a) Mix solution of NaCl with solution of $BaCl_2$.
b) Mix solid sodium carbonate with acetic acid.
c) Mix iron nails with $CuSO_4$ solution.

d) Mix $AgNO_3$ solution with NaCl solution.
e) Mix Zn granules with dilute HCl.

Students are asked to submit their findings in the form of a written report which may be assessed on the basis of following indicators:

Scientific skills : Performing the activity, collecting and analysing data, and drawing conclusions.

Language skills : (i) Writing the report
(ii) Verbal communication (viva)

Fine Arts Skills : Tabular and diagrammatic presentation

EXAMPLE 3

Topic: Referaction through spherical lenses **Class** : X

Key Concept: Focal length of a convex lens **Time** : 45 minutes

Learning Objectives:

1. Describing image formed by a convex lens.
2. Explaining how the rough local length of a convex lens is determined.
3. Discriminating between real and virtual image, magnified and diminished image.

An experienced teacher can think of a lesson design for conducting an activity in the classroom in the following concise form.

Materials: 6–7 convex lenses, metre scales, plane and ruled sheets of paper to be used as screen, class window.

Time schedule for various steps of the activity

8–10 minutes: Written test of five short answer type questions to assess their understanding on refraction of light.

8–10 minutes: Teacher discusses the answers with the class. Learners exchange papers to check the answers.

8–10 minutes: Learners work in small groups to determine rough focal length of the convex lens by observing image of a distant object in front of a window. Teacher facilitates the class to perform the activity.

10–15 minutes: Students discuss on the observation of principal focus, object and image distance; real and inverted image and focal length; **Assessment** on their participation in the activity and discussion.

Extented learning: Search for the uses of convex lens in our everyday life.

Pay attention how the following features are emphasised in this lesson design—consideration of the existing ideas of the learners, group work, experiments, empowering students for self-learning, discussion and argumentation, intertwined assessment in the teaching-learning process and peer evaluation.

EXAMPLE-4

Class : XII **Topic: Faraday's laws of electromagnetic induction**
Time : 40 minutes

1. Situation

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

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

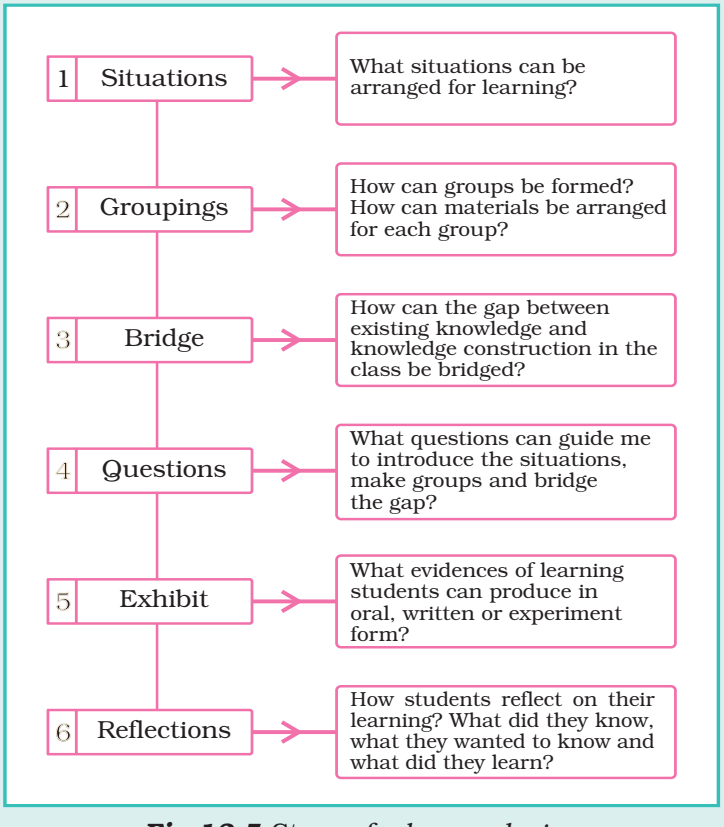


Fig.12.5 *Steps of a lesson design*

2. Groupings

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

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

(Please refer section 12.6 of this chapter for understanding making groups)

3. Bridge

- **It is to bridge the gap between pre-existing knowledge and the knowledge students might construct by teaching-learning experiences. It can be filled by hands-on activities, discussion, questions, etc. This might take place before grouping or after grouping and it can facilitate growth of knowledge over time.**
- **Teaching-learning experiences can continually be changed according to the observed gaps in students' learning.**
  - ➲ Static charge can produce electric field, static magnet and static coil altogether cannot produce electric field.
  - ➲ Comparison of
  - – electric field and magnetic field;
  - – a conservative field and non-conservative field;
  - – electric flux and magnetic flux;
  - ➲ story of Faraday's experimental observation; and
  - ➲ performing activity using a magnet, a coil and a galvanometer.

4. Questions

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

See Fig. 12.6. What do you observe? What do you think is the reason of deflection in the galvanometer? Do you observe deflection in the galvanometer, if magnet is held stationary inside or near the coil?

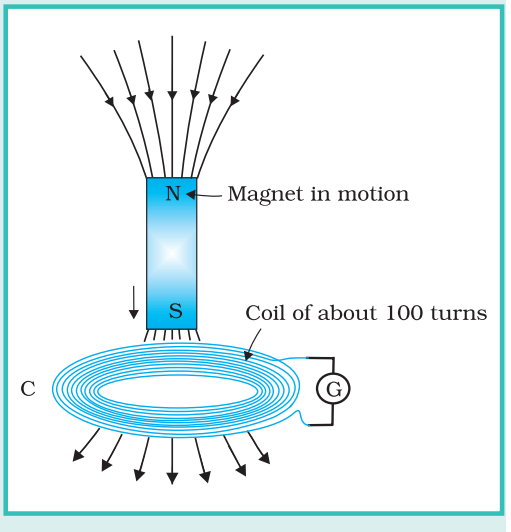


Fig. 12.6 *Magnet in motion produces an induced emf in coil C*

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

5. Exhibit

- **Students produce evidence of learning by writing, oral representation, performing activity/experiment, making models, etc.**
  1. Performing activity to observe;
     - the phenomenon of electromagnetic induction;
     - how speed with which the magnet is brought towards or away from the coil changes the magnitude of induced current; and
     - the effect of number of turns of the coil on the magnitude of induced current.
  2. Writing report of observation.
  3. Explaining Faraday's laws of electromagnetic induction mathematically.
- Some students may make coils of different diameters and number of turns/primary and secondary coils for learning the concept of mutual induction in the upcoming class.

6. Reflections

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

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

Students knew	Students wanted to know	What did they learn
1. Emfs are localised between two terminals of a battery. 2. Magnetic field	• Can magnet/magnetic field produce electric field? • What is magnetic flux?	• Emfs can remain distributed throughout the circuit. • A changing magnetic flux can produce electric field in a coil. • The electric field associated with a changing magnetic fields is non-conservative.
3. Electric field resulted from static charges is conservative.	• How can magnitude of induced current be increased or decreased?	• Magnitude of induced current can be increased or decreased by – changing the speed of the moving magnet; – changing number of turns and area of the coil; and – changing orientation of the coil with respect to the moving magnet.

ACTIVITY 12.16

Develop a lesson design on the topic *Periodic properties of elements/ Moving charges and magnetism* in the format **Situation-Grouping-Bridge-Questions-Exhibit-Reflection** as discussed above.

ACTIVITY 12.17

Observe the above four examples of lesson design critically discussing their various aspects. Develop a lesson design on *Energy* for the students at secondary stage on the basis of any one example.
Why did you select that particular example as a base for your lesson? Justify.

ACTIVITY 12.18 

Read the elements of a lesson given below. Discuss with your friends and the teacher-educator to develop a lesson design based on these elements on the topic of your choice.

Dr. Madeline Hunter's research indicates that effective teachers usually include the following elements in their lessons.

(1) ***Anticipatory set:*** *A short activity, discussion or prompt that focuses the students' attention and ties previous lessons to today's lesson.*
(2) ***Purpose:*** *An explanation of the importance of this lesson and a statement concerning what students will have to do when they have completed it.*
(3) ***Input:*** *The vocabulary, skills, and concepts to be learned.*
(4) ***Modelling:*** *The teachers' discussion what is to be learned.*
(5) ***Guided practice:*** *The teacher leads the students through the steps necessary to perform the skill using multiple modalities.*
(6) ***Checking for understanding :*** *The teacher uses a variety of questioning strategies to determine, if the students are understanding.*
(7) ***Independent practice:*** *The teacher facilitates students to practice on their own.*
(8) ***Closure*** *- A review or wrap-up of the lesson.*

12.13 SUMMARY

Teachers of physical science need to understand how to plan for a lesson, so that learners are challenged to think and try out what they learn. Developing a lesson design helps a teacher to arrange and organise her ideas on how to transact a concept/topic/unit to the learners. In order to design meaningful learning experiences in physical science, a teacher needs to have a sound understanding of many aspects of teaching-learning. For example, the science content and the process; nature of science; the linkages of the concept undertaken with existing ideas of learners and also with previous and next lessons; the psychological, sociological or other relevant theories and researches, and her own understanding of the learners as individuals and as a group. She also needs to make preparation for the activities and experiments as **learning by doing is the cardinal principle of science.** All these considerations involving students and combined with their understanding and her own creativity, innovation and concern for her students' learning can facilitate the teacher to answer the questions, like how can she plan a lesson design and why should she plan in that way?

Planning for lesson design should enable the teachers to give individual attention to the learners and to make alteration in a task depending on their learning needs and interests. Involving learners and older students in planning teaching-learning experiences brings tremendous richness to the classroom processes. It also allows teachers to respond to the special needs of some learners without making them feel as obvious exceptions.

Planning helps a teacher in making choices of teaching-learning experiences and situations depending on the needs of the learner. It facilitates the teacher to know when, what and how to change these experiences and situations. It is important to remind students the task at hand, involving them in inquiry and discussion, monitoring their learning progress, setting extra challenges for the students who finish the task quickly, and bringing the whole class for the start of next activity.

No doubt, planning of teaching-learning situations has a number of advantages. However, it should not be made rigid and mechanical. If some unexpected situations arise, if students ask question beyond teacher's anticipation, if any activity needs to be performed many times to invite attention of students towards a particular concept, if order of performing activities needs to be changed— a teacher has full freedom to take decision considering students' learning needs and variations in the level of their interest. Teacher should keep ample scope for flexibility as per the need of situation and to reflect on the dynamic nature of science and teaching-learning of physical science. **It is important to understand that just as there is no one best approach or strategy to transact a concept, there is no single way of planning a unit or developing a lesson design in physical science.**

EXERCISE

12.1 Discuss the importance of planning teaching-learning experiences. 'Knowing what, how and when to change teaching-learning experiences requires planning'— explain this statement with the help of an example.

12.2 What is the need for identifying and organising concepts for teaching-learning of physical science? Discuss on the factors, a teacher should consider during organisation of concepts.

12.3 Keeping in view learners at the centre of teaching-learning process explain basic principles that guide choice of classroom practices for identification and organisation of concepts. Illustrate with suitable examples.

12.4 What do you mean by learning evidence? What factors will you keep in mind for planning to collect learning evidences of the students? What learning evidences can be collected on the topic *Periodic properties of elements*/*Dual nature of matter and radiation*?

12.5 What factors will you consider in facilitating formation of groups of students for:

- performing an activity/experiment;
- carrying out a project work; and
- class discussion?

Describe each of them illustrating with suitable examples.

12.6 Discuss the principles for use of ICT for effective teaching-learning. Select any topic from science/physics/chemistry textbook and describe how will you plan teaching-learning experiences based on ICT involving students in the planning.

12.7 Discuss how would you involve students in planning and carrying out activities and laboratory work. Illustrate taking an example of any concept/topic.

12.8 Your students of Class VI want to learn the topic *Separation of substances* by performing projects. They also want to develop some ICT backup for understanding the concepts. Explain how will you facilitate them in learning.

12.9 Plan a lesson on any topic in which direct laboratory experience will help learners to know more about the topic.

12.10 Discuss with an example how aims, learning objectives and assessment should be consistent with each other. Explain how will you plan teaching-learning experiences in physical science considering this.

12.11 Develop a unit plan on *Laws of Motion*/*Hydrocarbons* (approximately of 15 periods) at higher secondary stage and work out details of activities and experiments. You may consider any structure of your choice for the unit.

12.12 You have to transact the concept on *Carbon and its compounds*/*Work, energy and power*. Make a list of materials and equipments you would require to perform activities and experiments related to the topic. Describe how will you involve students to:

(i) procure and prepare learning materials for the activities and experiment;
(ii) make a chart to summarise and organise the concepts; and
(iii) make a powerpoint presentation with some video clips on the topic?

12.13 Observe a few lessons on physics/chemistry of a practising teacher. Note:

- How does she introduce the concept/topic to the students?

- How does she involve students in teaching-learning process?
- How does she carry out activities involving students?
- How does she make transition from one activity to other sustaining interest of the students?
- How does she assess students during teaching-learnnig process?

Share and discuss your observation with your friends and teacher-educator.

12.14 Make daywise planning for teaching-learning activities on any topic of physics/chemistry of your choice. You may use the format given in Table E12.1

Date _____ Topic _____
Class _____ Duration of period _____

Table 12.6(E)

Day	Topic/ Concept	Teaching-learning materials required	Apparatus and material required	Preparation required	Approaches /Strategy	Assessment tools to be used
Day 1 Day 2 Day 3 Day 4 Day 5 **Day 6**						

12.15 Develop a lesson plan on a topic of your choice in physics/chemistry in the following format:

Unit _____ Topic _____
Date _____ Class _____
Duration of period _____
Key concepts _____

Pre-lesson activity

(i) Eliciting pre-concepts of students for setting learning objectives.

(ii) Preparation for activities/experiments, PowerPoint presentation (if any) and other teaching-learning materials
- by the student-teacher; and
- by the students of the class

Table 12.7(E)

Learning objective	Teaching-learning activities (creating learning environ -ment)	Teaching-learning materials	Anticipated questions of students	Questions that teacher might ask	Time required	Extended learning/ connecting with next learning objectives	Reflective questions (post lesson activities of the teachers)

Blackboard work _____

References to be suggested to students _____

Chapter 13

Lifelong Learning in Physical Science

13.1 INTRODUCTION

In Chapter 12 on *Planning for Teaching-Learning of Physical Science*, we have understood that learning by doing is the cardinal principle of science. However, the pace at which scientific knowledge (facts, principles, laws, theories, etc.) is growing, it is impossible for any learner to learn all of them and any teacher to transact all of them. Moreover, all these knowledge may not even be required by or useful to a particular individual. So, what is important to learn is the processes through which these products of scientific knowledge are obtained. The processes are far less in number than products and thus, it becomes feasible to learn them. Moreover, if a student has learned the process of science and process of learning, she can always use them to obtain the product. It can enable them 'to do science' as a scientist does and carry on learning beyond the school, and become a lifelong learner. Rapid changes in the technology-based society also necessitate lifelong learning. We shall first see the meaning of lifelong learning and why it is needed.

In this chapter, we shall also discuss about what are the attributes of a *lifelong learner* and various ways of developing those attributes through teaching-learning of physical science. The chapter also discusses a number of activities that can be organised in school to stimulate creativity and inventiveness in students leading them towards lifelong learning. The chapter concludes emphasising on the need of science teacher herself being a lifelong learner to motivate her students.

13.2 LIFELONG LEARNING

Lifelong learning is continuous learning throughout life which satisfies our intellectual, social, physical and emotional needs and helps in refining knowledge in all spheres of our life. It is voluntary and self-motivated pursuit of knowledge. It occurs formally and informally through various resources.

Learning is a natural human instinct. It starts from the cradle and continues throughout life. Learning has no boundary. It is infinite. When one feels, he has learned something, he comes to know he does not know something. Lifelong learning is not teaching or training or providing some course materials. It aims to focus on the needs and demands of the learners and to empower them to use a variety of tools and techniques with which they can learn according to their own styles and needs using all resources of learning. It is related not only with physical science. It has a vast scope. It has scientific, technological, social, economic, personal, cultural and educational meaning in the wider sense. *Learning: The Treasure Within,* the UNESCO report (1996) of the International Commission on Education for the 21st Century feels that education throughout life is based on the following four pillars of learning, given below:

1. **Learning to know:** acquiring proficiency in using learning tools rather than acquisition of structured knowledge.
2. **Learning to live together, and with others:** peacefully resolving conflicts, discovering other people and their cultures, fostering community capability, individual competence and capacity, economic resilience, and social inclusion.
3. **Learning to do:** equipping people for the types of work needed now and in the future including innovation and adaptation of learning to future work environments.
4. **Learning to be:** contributing to a person's complete development: mind and body, intelligence, sensitivity, aesthetic appreciation and spirituality.

These four pillars cannot function alone. For helping students to become lifelong learners, it is important that teaching-learning of physical science contributes to their holistic development. You may visit the website "http://books.google.com/learning: The treasure within" to know the details of the four pillars of learning.

In the context of physical science lifelong learning involves:

- Making learners indulge in inquiry and develop interest for science.
- Applying the basic principles of science in everyday life situations.
- Helping learners to be aware of various scientific issues and performing their role as an informed citizen.
- Opening their minds, so that they can improve their own life giving up their superstitions and prejudices.
- Helping to adapt to changes taking place all around us.
- Enriching life for self–fulfilment enabling learners to identify their talents and enabling them to use them optimally.
- Helping learners to become independent learners.

13.3 WHY LIFELONG LEARNING?

Lifelong learning is essentially important, because of several reasons.

- **A person is expected to continuously adapt to new and changing situations in life.** In a world where career paths are increasingly non-linear and pursuit of knowledge interdisciplinary, an individual has to continuously handle, update, evaluate and apply knowledge to newer contexts. While learning has to be embedded in the social context and knowledge is interdisciplinary, acquisition of new understanding have to be dynamically linked to the changing needs of the society.
- **We are living in knowledge-based society where knowledge is given prime importance.** We know the fact that knowledge is expanding exponentially. A society of knowledge with no bounds also has to be a society of learning without bounds. In this age of knowledge era, updating and expanding knowledge is important to broaden our horizons of thinking. We need to develop skills to continuously upgrade our knowledge in order to function effectively in the increasingly complex technology-driven society. We need to make informed decisions about many specific issues affecting our life to contribute meaningfully for the development of the nation.
- **Democratic citizenship demands of all its citizens, an ability to make wise decisions on basic problems**. Students need to develop thinking in a broader framework to get the solution for the prevailing problems of the society. For this, leading students on the basis of democratic actions and the free play of intelligence is necessary as opposed to methods of coercion and dogmatic belief.
- **The key role of teacher is to facilitate and support learning of students**. Teacher has to recognise that students in schools today, no more need teacher as a source of knowledge. The media explosion challenges their minds with the immense learning choices and possibilities. Facilitating learning from the unprocessed information is a big responsibility of the teacher today.
- We have seen in Chapter 6 *Curriculum of Physical Science* that **everything related to teaching-learning experiences in a school is an active part of the curriculum.** Therefore, function of a physical science teacher is far more than facilitating learning of the contents and process of physical science. She has to help students to learn how to learn, develop scientific attitudes and various

social qualities, and harness their own resources in planning and carrying out learning activities to become independent learners. Teacher has to develop in students adaptability to various situations rather than to establish rigid habits of response through repetition and mechanical performance. She has to observe patterns of concepts that students are learning in order to help them to reject their misconceptions, restructure the naive concepts and construct their knowledge in physical science.

The question now arises, what are the attributes of lifelong learners? How a teacher can develop these attributes in students? We shall discuss them in the following sections. Before that let us perform a small activity.

ACTIVITY 13.1 

Do you think lifelong learning is important for students and teachers of physical science? In addition to the points discussed above, do you see any other reason for lifelong learning? Think-pair-share with your friends.

13.4 ATTRIBUTES OF LIFELONG LEARNERS

It would be helpful for the teacher of physical science to know the attributes of a lifelong learner to facilitate students to become such a learner. Following important attributes can be identified.

- **Deep understanding:** Learners have a good understanding of basic concepts of physical science and can use them in everyday life to know the world around them and generate new knowledge.
- **Critical thinking:** Learners recognise patterns and context of learning, apply reasoning to analyse and synthesise information, judge the accuracy of data resulted from experimentation; justify conclusion on the basis of evidences; seeks solution of a variety of problems; construct new knowledge on the basis of previous knowledge, etc.
- **Creativity:** Learners use a variety of tools and techniques to generate new ways to solve problems; explore options of doing work; create products (models, exhibits, improvised apparatus, etc.); find innovative ways of doing activities and experiments and presentation of ideas, etc.
- **Inquiring attitude:** Learners pose a problem, formulate hypothesis, collect data and information; draw conclusions to support hypothesis and form generalisation; get involved in the process of science; raise questions; etc.

- **Communication skill:** Learners understand symbols and meaning of scientific terms; draw and interpret graph; keep their viewpoint with evidence and conviction; use mathematical process and spatial relationship to support their understanding; explore ideas critically; express ideas and thought through various modes of expression (oral written, using ICT, etc.).
- **Active participation:** Learners participate actively in a group; perform tasks towards a shared goal; identify and challenge unjust and undemocratic activities; appreciate and acknowledge diverse perspectives; show team spirit.
- **Self-motivated:** Learners plan and organise their own thinking; know their strengths and challenges; identify their learning style; strive to improve their learning and performance; look for opportunities to transfer their knowledge and understanding in new situations; monitor their own learning and are motivated to learn further.

ACTIVITY 13.2

Can you think of some other attributes of a lifelong learner? Should a learner have all these attributes to become a lifelong learner? Discuss with your classmates.

13.5 DEVELOPING LIFELONG LEARNING ATTRIBUTES THROUGH TEACHING-LEARNING OF SCIENCE

The processes of science are procedures which scientists employ in the formulation, verification and generalisations of hypotheses in an attempt to understand the nature and natural phenomen. Process skills are scientific processes that facilitate the meaningful understanding of concepts. These skills help to stimulate the development of curiosity and attitude of inquiry, so that students start to understand their environment. **Teaching-learning situations of science should have ample scope for the students to observe, identify, formulate, inquire and investigate important issues in the world around them to help then become lifelong learners.**

Providing following opportunities can make students understand and apply scientific concepts, principles to physical and living environment and facilitate them to develop lifelong learning attributes.

- Manipulating materials with the help of teacher. For this, students should be given opportunity to perform activities and experiments.
- Estimating, finding, and communicating measurements, using

standard unit. Use of scientific notation of quantities, significant figures, graphical representation of the data should be facilitated to them.

- Comparing and contrasting, understanding and developing schemes of classification of objects and events in the physical environments.
- Observing, analysing, and reporting observations of objects and events. For example, students can observe the position of sunrise daily; based on their observations students can note the change in the direction of sunrise over a period of time.
- Leading to inquiry and communicating cause and effect relationships. For example, students note that the leaves of trees on sides of roads with heavy vehicular traffic often appear blackish. They relate this observation to the fact that it is due to deposition of soot near busy streets.
- Raising questions in response to observations, events, and other experiences. For example, why does it take more time to dry clothes during rainy season?
- Recording and analysing appropriately the given data, and accurately interpreting the results.
- Making predictions based on prior experiences and information. For example, students have the knowledge that when the surface is slippery, friction between the surface of the path and the sole of the shoes is less and there are chances of falling down. Based on this earlier experience they would prefer to walk on wet grass walkway rather than on smooth surface during rainy season.
- Identifying and controlling variables and factors. For example, students have conducted an experiment to find the factors affecting rusting of iron; hence, based on their findings they suggest remedies for controlling rusting of iron articles.
- Communicating the findings and experiences through oral and written presentations. It can be done in the class through engagement of students in discussion and argumentation; powerpoint, poster and chart presentation, etc.
- Facilitating interaction with eminent personalities from the field of science and experts from community. They can be invited to share their expertise in their areas of specialisation. This will develop interest among students and motivate them for further learning. Learners will come to know about the latest developments in the field of science.
- Taking students for a visit to university departments of science, science centers, etc. where the world of science is unfolded to them and they get a wider view about utility and prospects in science.

Students get highly excited when they have the opportunity to explore the things in their surroundings. They can create strong and enduring mental representations of what they have experienced in investigating the everyday world. They gradually acquire vocabulary to describe and share these mental representations and the concepts that follow from them. Students then rely on their mental representations as the basis for further learning. It helps in developing higher order intellectual skills such as problem solving, hypothesis testing, and generalising situations.

There are various attributes that get developed during the process of their involvement in the *in class* and *out of class* activities. They should learn to apply them in real life situations. Students must understand that science is not limited to textbooks and classroom teaching-learning situations. They should be engaged in the excitement of science, discovering the value of evidence-based reasoning.

Let us take an example. Students are given project in the class to find the solution to energy crisis. They can use various means of collecting data like visit to various places, conducting survey and interview, internet, library, etc. for doing the project work. It gives them the broad framework to generate solution. It also updates their knowledge since textbooks have limited scope. The project work aims to apply students' knowledge and understanding in daily-life problems. It promotes habit of critical thinking and helps them to adopt the scientific method of working. Students can perform at their own convenience. They also learn to plan and execute their ideas within a given timeframe. Learning science by doing and getting involved in project work widens the mental ability of students. They get an opportunity to learn several skills such as observation, reasoning, interpretation and inference, reporting, etc. A project conducted in a group also promotes social interaction and collaboration among all the members.

Thus, by involving themselves in the process of knowledge generation students develop many attributes of lifelong learner. Students learn their role as participants in this process. They also change their viewpoint or beliefs based on prior experience. This acts as a platform for their smooth transfer from knowledge consumer to knowledge generators.

Lifelong learning attributes can be developed among students in school by exposing them to a variety of learning activities and providing them opportunity to share their ideas with each other. For this, teacher can use a variety of strategies of teaching-learning of physical science incorporating discussion, exploration and collaborative learning. Some of these strategies are depicted in Figure 13.1.

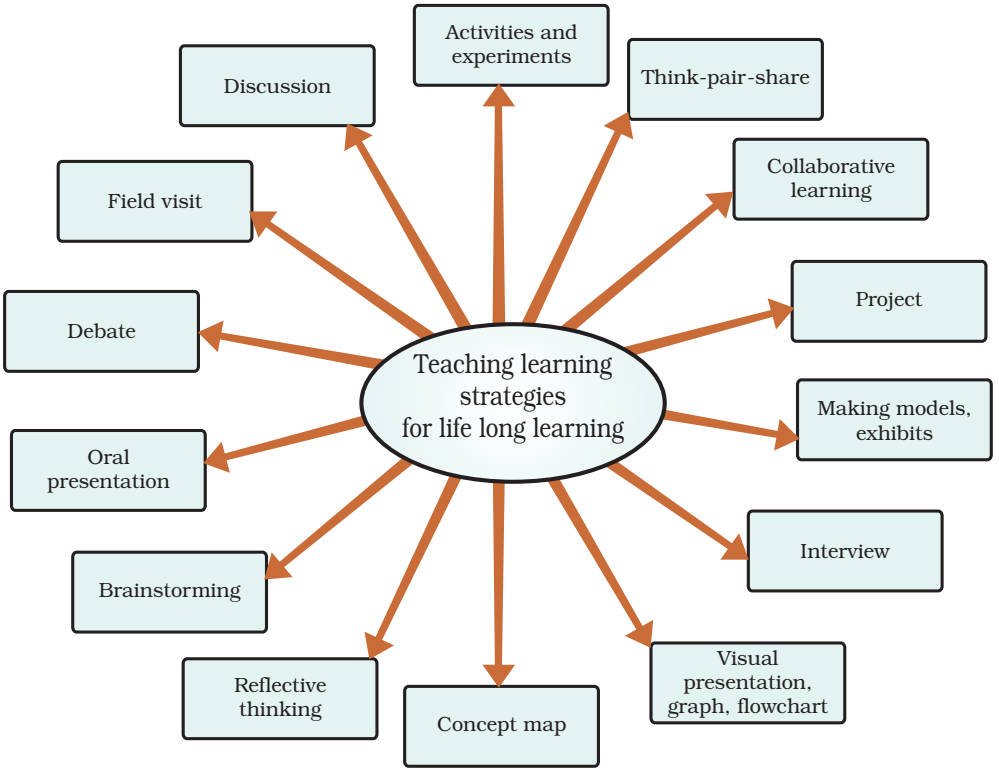


Fig. 13.1 *Teaching-learning strategies for lifelong learning*

ACTIVITY 13.3

Take the concept of *Light/Electricity/Rate of chemical reaction* from the science textbook of the secondary stage. Plan activities giving details of the attributes of a lifelong learner. Which attributes among the students can be developed by each of these activities? Discuss them in your group and present in the class.

13.6 EVERY CHILD HAS NATURAL CURIOSITY OF OBSERVATION AND DRAWING CONCLUSION

Every child has natural curiosity which makes them explore the natural world. Therefore, they should be given opportunities to have direct experience with nature and common objects, materials, and living things around them. It is important to focus on understanding relationships, processes, mechanisms, and applications of concepts. **Students should develop ability to inquire, explain, analyse, and interpret scientific processes and phenomena more than their**

ability to recall specific facts. For example, experimenting with objects to see which objects sink or float, the learners are engaged in finding out how the world around them works. Another example is learners experimenting with light and shadows. They collect many types of materials to see which one creates shadow in the bright light and which one does not form any shadow. From experimentation, they learn that materials through which they cannot see through and create shadows are opaque materials while the materials through which they can see through and allows light to pass through are transparent materials. There are some materials that do not fit in either category. These materials allow some light to pass through them and they cast vary light shadows. In another example, learners observe the changing phases of moon and then wonder how does it happen? They come to know that we see only that part of the moon which reflects sunlight to us. Learning is to be appreciated as occurring in shared social and everyday contexts in order to foster curiosity in children. Learning does not take place only inside an institute designed for this purpose. When learning outside is connected with learning inside the school, it can be hugely valuable.

Children are active, self-motivated learners and learn best from personal experiences. **They learn through observation and interaction with the environment around, nature, things and people both through action and languages.** Therefore a number of opportunities for observation and drawing conclusion on the basis of experimentation should be provided to children.

ACTIVITY 13.4 

Select any one topic from the science textbook of science. How will you create opportunity to develop curiosity of observation through teaching-learning process of this topic? Make a brief plan of it. Work in pairs and share your ideas.

ACTIVITY 13.5 

A few learners of your class show interest in further learning about nuclear energy. Plan activities including visits to science centers, laboratories, university departments in order to develop their interest in this topic.

13.7 STUDENTS WITH SPECIAL EDUCATIONAL NEEDS (SEN)

In a class, different students do not have similar abilities. They differ with respect to their interests, abilities and aptitudes. Teacher should

be sensitive enough to attend the needs of the students and organise learning experiences suitable to their needs. Some suggestions are given which can help the teachers to take certain decisions considering the diverse needs of the students.

There are students with a variety of needs like students with difficulty in reading, writing, speaking, attending, hearing, seeing, retaining and retrieving information, and students with high ability. The various measures suggested for the teachers are discussed below.

Students with reading difficulty: Strategies like peer tutoring; using audio devices along with the text; helping students to read aloud; paraphrasing key points, summarising key points, identifying main ideas; highlighting texts, passages, key words, or concepts; preview units, chapters; pre-reading and post reading drills may be adopted.

Students with writing difficulty: Teacher can incorporate the strategies like repeated short writing assignments; using computer for word processing, spelling and grammar check; visual representation of ideas; providing a structure for writing activity, or model of writing; and using of flowchart for jotting down the ideas before the student starts writing on a topic.

Students with SEN may sometimes need individual attention

Students with speaking difficulty: Teacher can use visuals for description; involve students dynamically in activities and experiments; use cues and prompts to help them know when to speak; encourage them to speak at their own pace; use rhythm or music; give enough scope to practice and opportunities for speaking, etc.

Students experiencing difficulty in paying attention: For such cases teacher should decrease distractions in the class during teaching-

learning; increase opportunities for students to participate; provide opportunities to change tasks or activities frequently; use reminder cues or prompts; etc.

Students experiencing difficulty in hearing: In order to overcome the difficulty faced by such students, teachers are expected to use visual cues, overhead projector, drawings, maps, demonstrations, PowerPoint presentations. They can also use sign language, alternative testing methods, etc; face student directly when speaking and speak slowly; highlight text with coloured chalks, pens; provide notes on classroom presentation in advance to allow hearing impaired student to concentrate on the teacher; show videos; etc. before presenting information to provide a knowledge-base for students.

Students experiencing difficulty with seeing: Teacher can provide intricate verbal details what she is doing; promote interaction among group members; provide materials in large font or Braille print; use *books on tape;* make sure about proper light arrangement, and also try to see that there is no glare of light on blackboard; write in big letters with maximum contrast; stand away from window glare when talking to the student; give student an individual copy of a specifically designed material on the visual information discussed in the class.

Students experiencing difficulty with retaining and retrieving information: Teacher can make use of multimedia (visual, auditory, etc.) to transact the same concept; discuss on vocabulary of science in context by performing activities and experiments; use cues, prompts; use frequent repetition of key points; breakdown teaching-learning units into smaller steps; show relationships among concepts through graphs, outlines, concept map; highlight important information; use rhythm, music, and movement, etc.

Students in the class with high ability: To deal with such students, the teacher needs to give choices and alternatives for the tasks; allow them for making independent plans for independent learning and investigative projects; showing entrepreneurship, facilitate them to study various reference materials; involve them in peer tutoring, etc.

Including students with special educational needs (SEN) in all teaching-learning situations of physical science provide them opportunity to learn to communicate, and to deal effectively with a wide range of students without SEN. This also prepares them to participate in a pluralistic society, when they are adults. At the same time, students without SEN can learn a good deal about individual difference, tolerance, and human exceptionality by interacting with those with SEN. Therefore, all efforts should be taken to make students with or

without SEN lifelong learner considering their varying educational needs and learning styles.

ACTIVITY 13.6 

Identify learners with special educational needs in your class during practice teaching. Make a note of their special needs and the way you can deal with their requirements.

13.8 PREPARING LEARNERS FOR LIFELONG LEARNING: STIMULATING CREATIVITY AND INVENTIVENESS IN SCIENCE

While students are still at school, science teachers can develop their traits, habits, and attitudes so that they would keep learning throughout life. They need to be repeatedly reminded to be creative; to integrate material across subject areas; to question their own assumptions and become creative problem solvers. In order to stimulate creativity and inventiveness in science among students, many **in class** and **out of class activities** such as debate, discussion, drama, poster making, visit to various places, celebration of specific days, field visit/study tour, etc. may be organised in the school. Learning experience with science club and science exhibition can cater interest and abilities of each and every student, Let us now discuss them in detail.

13.8.1 Debate

The goal of education is to have a society of informed, active, vocal citizens who will make a difference in development of the community. Debating is one of the many ways by which teachers can achieve these goals. Debate is very effective in developing critical thinking and argumentation skills among students. The teacher may integrate debate within the classroom teaching-learning situation. **In a debate, topics are discussed on which there are different viewpoints and students have to take a stand on the given viewpoint.** They provide powerful arguments supported by evidence to justify their stand. In debate, pros and cons of each topic are presented by two opposing groups. Each group tries to convince the other through powerful arguments. Each group also tries to strongly defend the stand taken by it.

Students may be organised in small groups and each group can be facilitated to do research and prepare a write-up on a pre-selected topic. They can then exchange their write-ups with other groups and provide constructivist criticism to one another. According to the peer feedback, each group can revise its write-up and then present it in the

class. During the presentation by one group, other groups can cross question. They can speak for or against the motion. One student from each group can be assigned the task of reporting the questions asked and their answers provided. The evaluation of each presentation can be done by the other groups on the basis of certain parameters which can be mutually agreed upon by all groups prior to the start of the debate. Extempore debate on many topics can also be organised such as *Should junk food be banned in school? We as students can do a lot to reduce water pollution, etc.*

The teaching-learning of science should never be confined to chalk-talk method, or a technology dominant approach that renders little scope to stimulate, and foster creativity and inventiveness. The traditional science learning should be transformed into a platform to exchange new ideas. Accepting the seemingly non-workable ideas may also gradually turn into stimulant for creativity and inventiveness for the students. A simple delivery of abstract ideas by lecture, or teacher- dominant methods without ensuring students' participation can not generate creativity and inventiveness in science.

Using debates in the classroom can help students foster many essential skills of critical thinking and presentation such as

- analytical thinking;
- cross examination, questioning;
- distinguishing fact from opinion;
- identifying bias;
- organisation of information;
- public speaking;
- research;
- teamwork, cooperation; and
- responsible citizenship, ethics, etiquette; etc.

Topics of the debate chosen must be appropriate to the grade level of the students. Care should be taken in planning for debate issues that would not offend the beliefs and values of the students.

ACTIVITY 13.7 

Organise a debate in the class on *'A science teacher has an important role in making a student lifelong learner'*.

13.8.2 Discussion

The purpose of discussion is to provide an opportunity to the students to express their ideas. The teacher should encourage students to discuss their observations, findings, conclusions, answers among themselves

and also with the teacher. The students may not agree with each other, but if given enough opportunities to have a discussion, they learn to listen patiently to each other's conflicting ideas. They also learn to resolve their differences in a democratic way and arrive at a consensus. The act of verbalising helps the students to clarify their own thought process. It also helps the teacher to learn about students' ideas. It provides an opportunity to the teacher to find out the misconceptions and naive concepts harboured by the students and thus facilitate them to reconstruct their ideas.

The topics which have wide scope of incorporating the divergent thinking on scientific issues require discussion during teaching-learning of science. The issues connecting physical science with social and cultural lives need to be brought to the students' attention. The discussion can also be preceded by brainstorming.

13.8.3 Drama

Drama in science has tremendous possibilities to tap students' potential. It develops interest in learning science through kinesthetic movements. Therefore, a dedicated science teacher has to analyse the science content to find out the concept where dramatisation can be done. The concepts of molecular arrangement, chemical reactions, life sciences related topics can also be transacted by bodily movements, and dramatisation. In fact, many concepts in science can be developed through drama using innovative ideas. Drama related to science helps to foster imagination among students. It helps to integrate the study of science with music, art and performing arts. It unleashes creativity among students when they experiment with dramatic form as a means of communication. Students may stage a short or long drama, based on a scientific concept or issue. The performers should be encouraged to use special costumes, dance, and music to enhance interest in the drama.

PROJECT 13.1

Review the textbooks of science/physics/chemistry of Classes VI to XII and make a list of topics on which debate, drama and discussion can be organised during teaching-learning process. Select a concept of your choice and organise one activity in the class on each of the three strategies—debate, drama and discussion and seek critical review of your teacher-educator.

13.8.4 Poster making

Poster making activity offers scope to students to translate and express scientific language into the language of pictures, signs and symbols

Poster making offers scope to attach meaning to abstract ideas via visuals

by using minimal words. It is the activity of attaching the meaning to abstract intangible ideas via visuals. The poster making activity can be given to students before, after or during learning. It provides opportunity to teachers to tap creative and imaginative skills and ideas. Science as a subject does have a tremendous scope of imagination that can be exemplified with the Einstein's and Kekule's ideas of beam of light and benzene structure repectively.

13.8.5 Visit to various places

This may be an organised field visit by the teacher as discussed in Chapter 9 (section 9.3.2) and Chapter 11 [section 11.4.(C).3]. Visit of students to various places during vacation period may also be utilised for developing the attributes of the lifelong learner. However, teacher needs to plan for it.

Lifelong learning can be continued through various non-formal education also, in addition to formal education. Therefore, students need to be encouraged to consciously extend their intellectual, individual and social horizons of learning.

They should be encouraged to collect information from the communities and environment relevant to teaching-learning activities in the class. They can also collect sample of soils, plants and other material of their interest. However, students should not be overburdened with the task at the cost of their enjoyment during vacation period. They can be encouraged to opt for any activity of their interest and choice that can lead them to clarity of various scientific concepts. Learning that might take place in their day-to-day activities can be highlighted. A mini exhibition to display their collection of materials and share their experiences can be organised in the class after their return from vacation. This can give students a feeling that learning of physical science can take place continuously and it does not start and end in the classroom.

Rita a secondary school science teacher observed that different students of her class had different interests and abilities. Many stduents had planned to go to different places along with their parents during vacation. In order to cater to their diverse needs, she gave an innovative assignment to students of Class IX. It was to observe their surroundings, collect data relevent to teaching-learning of physical science during their visit to different places and report the same to the class when they come back from vacation. She suggested the students to visit places of scientific interest.

A student went to Jodhpur in Rajasthan. There she visited a place where tying and dying of clothes were carried out. She got interested in details of the work and asked many questions with the worker. She collected a number of data from the workers of the industry regarding dying of clothes, kinds of dyes used, process adopted, effect on environment and measures taken up, etc.

Another student visited one of the cities in Maharashtra where the use of polythene bags was banned. The student tried to find the effect of banning the use of polythene bags on the environment, opinion of vendors and people regarding it, habit development among people for not using polythene bags, etc.

When the vacation was over students were asked to report on their experiences, observation, data collection and findings during their visits in the class by making poster presentation, powerpoint presentation, charts, graphs, etc.

This kind of activity given by the teacher made students' learning interesting and meaningful, since they were able to relate it to what was learnt in the classroom. They also started questioning, thinking critically, gathering data, communicating ideas and developed values like discipline, perseverance, honesty, punctuality, etc.

ACTIVITY 13.8 

Select a topic of your choice from a science textbook. What type of project would you plan keeping in mind the diverse learning needs of the students of your class? Discuss with your friends and give a presentation in the class.

13.8.6 Science club

For all-round development of the students, it is necessary to provide varied learning experiences to them. Students get an opportunity for developing the habit of initiativeness and independent study. There is a scope to provide each and every student an opportunity to carry out activities of her interest and abilities in a science club. The objectives of having science club in schools are as follows:

- To generate interest and awareness in science.
- To inculcate spirit of scientific inquiry.

- To develop habit of reading supplementary materials and self-study.
- To help in developing skills related to certain vocations.
- To help students, to relate classroom learning with the reality outside.

Science club provides a platform to carry out various activities such as organising science exhibition, science fair, science congress, guest lectures, arranging workshops, field trips, etc. The club activities are organised by the students and for the students. It is considered as backbone of all the activities in the area of science.

Broadly, there can be three types of activities of the club.

(a) Workshop activity
(b) Collection activity
(c) Social activity

(a) Workshop activity: In workshop activity, various types of working and non-working models, charts, diagrams and teaching-learning materials of different types could be prepared. There could be activities like working on projects on various issues, working for experiments and technical processes like preparation of soap, making various electronic circuits, etc.

(b) Collection activity: Under this activity, students can be directed to collect various specimens, samples of soils and ores of different elements, various samples of polymers (natural and artificial), various types of fertilisers, drugs of different families, rocks, stones, leaves, seeds, etc. and put them on display in school.

(c) Social Activity: There could be various social activities like arranging field trip to places of scientific interest such as zoo, botanical garden, planetarium, science centre, etc., science fair, exhibitions, discussions, debates, quiz, celebrating birthdays of scientists, and special days such as science day and environment day; arranging popular lectures, special assembly programmes, special film screening symposiums, etc.

Other activities may be contributing for a science column in school magazine, preparing science displays for school bulletin boards, organising science demonstrations by students during interval period; maintaining aquarium; maintaining school garden and preparing manure for it; spreading awareness about energy and water conservation, health and sanitation in local community. Members of science club may also help their science teacher in planning and setting up activities during regular classroom teaching-learning. They may also help the science teacher in repairing and maintaining the science equipment.

Assessment and evaluation should be integral part of science club activities. Evaluation of activities of science club can be done internally as well as externally.

Purpose of organising science club activities in the school

The purpose of a science club is to stimulate the enthusiasm of learners who demonstrate interest in science. It provides them year round opportunities to explore science. A science club helps the members to delve deeper into specific areas of science in an informal environment. They take up tasks according to their interests and abilities. At the same time, it also provides opportunities of collaborative learning and greater interaction with teachers and adults. While handling the various programmes undertaken during club activities, members learn to plan and share responsibilities. This helps them to hone their interpersonal skills.

To establish and run a science club in a school, funding and space are needed. Funding can come from school funds or a sponsor. For space, one or more rooms of the school can be used depending on the number of members. School administration should provide a fixed time within school hours for club meetings and its various activities.

In the beginning of the session itself, the members with the help of teacher incharge, can decide as to what all activities club will undertake during the sesson. They can also decide as to which member will undertake which specific responsibility to ensure smooth functioning of the club. If need be, some sub-committees may be formed. They should also plan out a tentative utilisation of budget allocated to the club.

Science club forms an important school sponsored curricular activity in science. As the most of the activities are performed in non-formal manner, more cooperation and mutual understanding is observed among students. Members of the science club bring increased enthusiasm in the class which motivates non-members to participate in various activities of the science club. Science club can make possible for students to pursue their scientific interest in science and become lifelong learner.

ACTIVITY 13.9 

Visit a nearby school to observe what activities in science club are organised there. Note the varieties of activities.

ACTIVITY 13.10 

What activities in a science club can be carried out during the course of a year in a school? Make a list of them. Think-pair-share with your classmates.

PROJECT 13.2
Organise science club activities in your schools during practice teaching for various classes involving all the learners. Present a report of your work.

13.8.7 Celebration of specific days

In India, National Science Day is celebrated on February 28 every year. It is celebrated in the memory of Nobel Prize winner Indian scientist C.V. Raman who discovered Raman effect. This day is celebrated for the promotion and understanding of science. This day can be celebrated by organising some of the activities such as special film screening, talk by eminent scientist, debate, and quiz, etc.

In the second week of February last year, Rajan was discussing with his students of Class IX on how to celebrate science day in the school. A student came up with an idea of doing role-play of some scientists. The class welcomed this idea. They started preparation of the role-play of a scientist of their choice. On the science day they were wearing a crown of chart paper with name of the scientist written on it. Each of them were given opportunity, to speak in the class for two minutes about that particular scientists' work.

Environment Day is celebrated around the world on June 5 every year. It was founded in June 1972 by United Nations General Assembly. The aim is to increase awareness of environmental issues on global scale and also to promote and encourage action that can be taken to safeguard planet's future. Our planet is facing many dangers due to our actions. Celebration of this day in school provides the students an opportunity to reflect and act upon issues affecting the planet. Events may be organised in school in which students are allowed to participate in various activities for bringing awareness to environmental concerns. Some of the events may be tree plantation, essay writing and poster making competitions; pledge to save electricity and fuel; spreading awareness about local environmental issues in community; special film screening; etc.

ACTIVITY 13.11 

Make a list of various days relevant to science that can be arranged in the school during an academic year. Plan and organise any one of these days in your school during practice teaching involving the students.

13.8.8 Field visit/Study tours

Field visit exposes students to new environment. It can provide challenges that allow more independent learning as students have a

chance to take as much as they want and as they can. It facilitates development of many attributes of lifelong learner in students. It also breaks monotony of a classroom environment. We have already discussed about it in Chaper 9 *Community Resources and Laboratory* (section 9.3.2).

13.8.9 Science exhibition: Nurturing creative talent at local level

Children learn through interactions with the environment around, nature, things and people both through action and languages. They like to interact with their surroundings by exploring, responding, inventing the things and interpreting their observations. We have discussed earlier that they construct knowledge by connecting new ideas to their existing ideas, based on materials and activities presented to them. Organising science exhibition is one of the ways to provide such opportunities to children.

In order to stimulate creativity and inventiveness in science, *National Focus Group on Position Paper on Teaching of Science* recommends encouragement of implementation of a number of curricular components through a massive expansion of existing non-formal children's science congress, etc.

Science is a powerful way of investigating and understanding the world. Therefore, teaching-learning of science must enable children to examine and analyse their everyday experiences. Children need to be aware of various crucial issues related with science and technology that our society is facing, such as *climate change, energy crisis, pollution, health and nutrition, biodiversity,* etc. Concerns and issues pertaining to the environment should be given importance on all possible occasions through a wide range of activities involving outdoor project works. Every resource must be explored to enable children to express themselves and to handle objects through these activities. Well planned children's projects may get a place for display in various science exhibitions. Science exhibition is a long-term project that may span over several months. Let us see what benefits children get from participating in science exhibition.

13.8.9(a) Benefits of a science exhibition

- Children raise questions, form hypothesis and test them, record observation, collect, organise and record data, manipulate materials and examine their innovative ideas.
- They use reading, writing, research, and computer skills and develop communication skills in science.

- They understand that science exists not only in the textbook, but in their immediate environment as well. They also understand that science, technology and society are interdependent.
- They become aware that they can apply their knowledge of science and technology to initiate solution of a number of problems related with food, climate change, pollution, health, nutrition, biodiversity, etc. in order to sustain well-being of all people.
- Children learn to organise their work into manageable chunks, keep to a schedule, and work collaboratively.
- Children are exposed to a variety of ideas and comments from the public of different spheres of society. This broadens their horizon of thinking.

Science exhibition stimulates creativity and inventiveness in students

- Children get opportunity to share their ideas and findings with their peers and adults. They also develop team spirit and healthy competition with peer group.
- Children enjoy working on their novel ideas and deriving satisfaction with a sense of achievement. They love showing others what they have done. They like to interact with the surroundings by exploring, inventing the things and interpreting their observation. Science exhibition provides such opportunities to the children.

13.8.9(b) Objectives of science exhibition

- To provide a forum for children to pursue their natural curiosity and inventiveness to quench their thirst of creativity.
- To make children feel that science is all around us and we can gain knowledge as well as solve many problems also by relating the learning process to the physical and social environment.
- To lay emphasis on the development of science and technology as

a major instrument for achieving goals of self-reliance and socio-economic and socio-ecological development.

- To highlight the role of science and technology for producing good quality and environmental-friendly materials for the use of society.
- To analyse how science and technology have developed and is affected by many diverse individuals, cultures and society.
- To encourage children to participate in the responsible use of science and technology for the benefit of society.
- To develop critical thinking about global issues to maintain healthy and sustainable society.
- To encourage children to visualise future of the nation and help them become sensitive and responsible citizens.

13.8.9(c) Who organises science exhibition

In addition to National Council of Educational Research and Training (NCERT), a number of other agencies are also actively engaged in the promotion of the science activities through organisation of science exhibitions at district/state/national level. The National Council of Science Museum organises four zonal science exhibitions in the country every year. Science exhibitions are also organised by National Council for Science and Technology, Department of Science and Technology, and various private agencies (NGOs).

Students can be taken to venue of exhibition to observe the exhibits

A number of scientific and industrial organisations are invited to the exhibition held at state and national level. Seminar on a current issue of science is organised in which eminent persons in science are also invited to deliver lecturers and interact with students and teachers.

If science exhibitions are not organised in a school, students can be taken to the venue where district/state/national level science exhibition is being held to observe the exhibits and interact with the participating students and teachers.

13.8.9(d) Exploring linkage with district/state/central agencies

Linkage with block, district, state and central agencies should be explored to expand the scope of meaningful learning experiences inside and outside the classroom. **Establishing linkage can break isolation of individual schools and bring teachers together on a regular basis for sharing their experiences and ideas with peers to foster socialisation and develop lifelong learning attributes in students as well as in teachers.** Students and teachers can share their ideas on the innovative and creative ways of making models and exhibits on a structured space through participation in science exhibition organised at district/state/national level. Not only ideas, various learning resources can also be pooled as we have discussed in Chapter 9 (section 9.4). Teacher exchange programme for a short duration say, for one week can provide enrichment to teaching-learning experiences of the students of both the schools.

13.8.9(e) Jawaharlal Nehru National Science and Environment Exhibition for Children (JNNSEEC)

The National Council of Educational Research and Training, New Delhi organises JNNSEEC every year for popularising science amongst children, teachers and public in general.

Exhibition ground of a science exhibition

It is an effort to establish linkages among all districts, states and various central agencies and bring them at one common platform at

national level. This exhibition is a culmination of various exhibitions organised in the preceding year by various organisations at district, zonal, regional and finally at the state/UT level. Selected schools from all States and UTs, Kendriya Vidyalaya Sangathan, Navodaya Vidyalaya Samiti, CBSE affiliated Public Schools (independent schools), Atomic Energy Central Schools, Govt. Schools of the country, Demonstration Multipurpose Schools of Regional Institute of Education participate in this National Level Exhibition. One of the most encouraging impacts of the science exhibition programme is perhaps that it has spread to remotest villages of the country. The fact that students from remote villages of almost all states participate at the national level is a testimony to such assertion.

The participants of JNNSEEC truly represents a mini India with children speaking different languages, having different cultures and food habits. Yet they communicate with each other with unbelievable ease and initiate a bond of friendship within a short period of their stay. In addition to development of scientific temper, promotion of a feeling of oneness and national integration therefore is an important outcome of JNNSEEC*.

13.8.9(f) Guidelines for making exhibits and models

Teacher can help children in making exhibits and participating in the exhibition in the following ways.

- Selecting a topic, problem or idea that interests her
- Making a broad outline of plan of action
- Collecting all the materials required
- Making the exhibit/doing the experiment
- Examining its workability/collecting the data and organising them in tabular form, presenting the data and the result
- Presenting the report on a chart paper for background information to visitors
- Preparing a written report
- Preparing a presentation

13.8.9(g) Evaluation of exhibits

Entries should be evaluated on the basis of children's involvement as well as imagination and innovations made in designing the exhibit/model. Teachers should also judge whether the model is traditional or an improvement over the traditional model or innovative. Various skills involved in constructing the exhibit and model, the degree of neatness and craftsmanship may also be taken into account. Every effort must

* Present title of the exhibition is Jawaharlal Nehru National Science, Mathematics and Environment Exhibition for Children (JNNSMEEC)

be made to rule out the tendency of procuring the ready-made exhibits and models.

In order to keep a uniform criteria for evaluating the exhibits in all states/UTs for the consideration of their display in the exhibition at the national level, the following criteria for judging the exhibits is suggested (the percentage given in bracket are suggestive weightages):

Table 13.1 Evaluation of exhibits

Sl. no.	Code of the exhibition (given by the organiser)	Involvement of children's own creativity and imagination	Originality and innovations in the exhibit/ model	Scientific thought/ principle/ approach	Technical skill, workmanship and craftsmanship	Utility/ educational value for layman, children, etc.	Economical (low cost), portability, durability, etc.	Presentation aspects like demonstration, explanation and display	Total
1. 2. ...	.....	(20%)	(15%)	(15%)	(15%)	(15%)	(10%)	(10%)	(100%)

Schools can invite experts from the community to evaluate the exhibits. Engineers, scientists from colleges, universities and industry, qualified science teachers can be excellent judges. Children should be encouraged to talk to the experts to get their comments and suggestions about the exhibits. Students should review the comments and suggestions given by them so that they can further improve the quality of their exhibits.

You may visit the website www.ncert.nic.in to get ideas for facilitating preparation of the exhibits and models. Sample of a write up is given below. **It is only suggestive, not prescriptive.**

13.8.9(h) Write-up of an exhibit: An example

Title of the exhibit: Electrical Energy from Cow Dung and its Applications

Students:	Babitha	G.P.U. College
	Kusuma	Sajipa Mooda
Teachers:	Ganesha B	Bantwal Tq
	Devaki M.	Dakshna Kannada

Introduction

Energy is derived from various sources. The use of these conventional sources has alarmingly increased. To use these sources for long, search is on for other alternate energy sources such as solar, biomass, wind, tidal, geothermal, etc. In rural India, biomass is in plenty and can be used for getting energy.

Usually, energy stored in bio mass is converted into electrical energy. Cow dung is nothing but bio-mass. It contains chemical energy. Specific chemical reactions transform this chemical energy into electrical energy. Our model demonstrates this transformation in an efficient and economic way.

Materials Used

Cowdung paste, plastic containers, carbon rod (anode), zinc plate (cathode), connecting wire, an electronic clock and light emitting diode (LED).

Construction and Working

Carbon rods and zinc plates are collected from waste batteries. Water is mixed with cow dung in a plastic container to get the cow dung paste. Carbon rods and zinc plates are fixed through the lid of the plastic container, so that they do not touch each other. In this way cow dung cell is constructed Fig. 13.2(a). To increase the capacity of the output, more number of such cells can be prepared to get more energy Fig. 13.2(b).

Cow dung is basically a mixture of carbonic acid (H_2CO_3), formic acid (HCOOH), acetic acid (CH_3COOH), longer chain acids, hydrocarbons, etc. These acids in cow dung paste undergo ionisation while they are mixed with water. Common hydrogen ions (H^+) assemble around the carbon rod and attract electrons. A zinc plate releases electrons. Electrons move towards the carbon rod through connecting wire and the equipments used as load. When these electrons are received by hydrogen ions, hydrogen is formed. Thus, the chemical reaction is completed.

$$Zn \rightarrow Zn^{++} + 2e^-$$

$$2H^+ + 2e^- \rightarrow H_2$$

The electrical energy produced here is in the form of direct current (DC). Carbon rod acts as positive (+ve) terminal and zinc plate acts as negative (-ve) terminal. Each cell produces a current of 0.1 mA with a voltage of 0.8V–0.9V. It is possible to obtain more voltage by the series connection of cow dung cells.

Electrical energy produced from cow dung cell can be used in different electronic equipments such as clocks, LED calculators, etc. Our model demonstrates the working of electronic wall clocks by connecting two cow dung cells in series [Fig. 13.2(c)]. These cow dung cells can supply sufficient current for a month continuously. After one month, fresh cow dung is to be substituted to these cells.

Advantages

1. The whole arrangement is pollution free.
2. This model is easy to construct.
3. The raw materials used in this model can be obtained easily and at a low cost.
4. It is most suitable for rural areas.
5. The cow dung paste used in these cells can be used as manure after the life span of the cell.

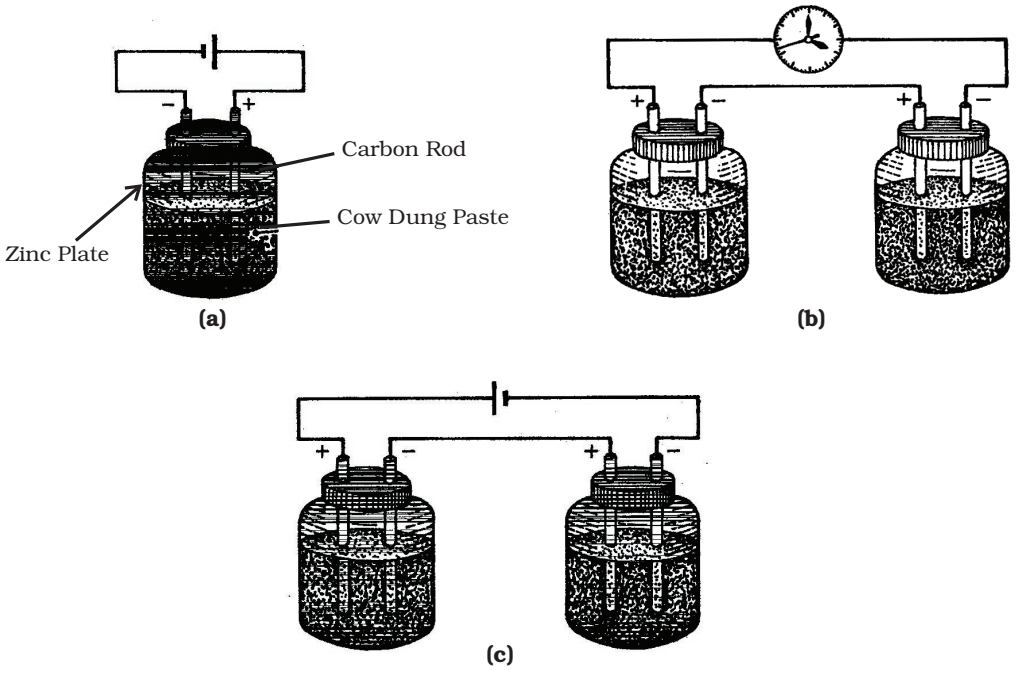


Fig. 13.2 (a) *Cow dung cell* ***(b)*** *Series connection of culb* ***(c)*** *Working of a clock by cow dung cell*

Reference: Newspapers.

–Structure and Working of Science Models (2002). 29th Jawaharlal Nehru Science Exhibition For Children, NCERT, new Delhi.

PROJECT 13.3

(i) Organise a science exhibition in your institution/college. You may display the models prepared by your classmates.

(ii) Ensure that all the exhibits are accompanied by proper write-ups and display charts.

(iii) Invite students and teachers of nearby schools and eminent persons of science to visit this exhibition.

(iv) Collect their feedback and self-evaluate your work.

ACTIVITY 13.12

Visit a science exhibition organised at school/district/state/national level. Evaluate some of the exhibits and compare your evaluation with that of your classmates.

13.9 EFFECTIVE USE OF ICT FOR LIFELONG LEARNING

In Chapter 10 *Print and ICT Resources in Learning Physical Science*, we have discussed about the use of computer, internet and other social networking sites. Using those sites can help students to choose what they want to learn and how they should learn and with whom they should discuss ideas. Competence in the use of ICT should be an important tool for lifelong learning.

13.10 TEACHER AS A LIFELONG LEARNER

No matter how wide are her experiences and extensive her education for helping students to become lifelong learners; it is of utmost importance that teacher herself is a lifelong learner. She should keep herself up-to-date to the new developments in physical science and its pedagogy. We shall discuss on this issue in detail in Chapter 14 *Professional Development of Physical Science Teachers.* A good teacher continues to be a learner and she should reveal this to her students. Observing the enthusiasm of the teacher, students are more inclined and motivated to learn. Teacher has to keep looking for innovative strategies, community resources and ICT applications, tools and techniques of assessment for enriching teaching-learning experiences of physical science. It can foster love for learning and develop capability of independent learning in students to make them lifelong learner.

13.11 SUMMARY

Lifelong learning can be developed in conjunction with teaching-learning of physical science. It is not some special learning that can be addressed separately. It is important to prepare students who are learning continuously; and own their responsibility towards society and work to build a better world. For leading students towards lifelong learning, it is necessary for them to have a grasp on the process of knowledge formation as well as initial knowledge base.

Science learning begins with curiosity, which leads to discovery and exploration and development of processes and inquiry skills. The teacher should give ample opportunities to learners to reflect on their findings, how to get them, and how the findings compare to their previous ideas and the ideas of others. In this way, children can be encouraged to develop the attitude of a scientist— that is, curiosity and scepticism

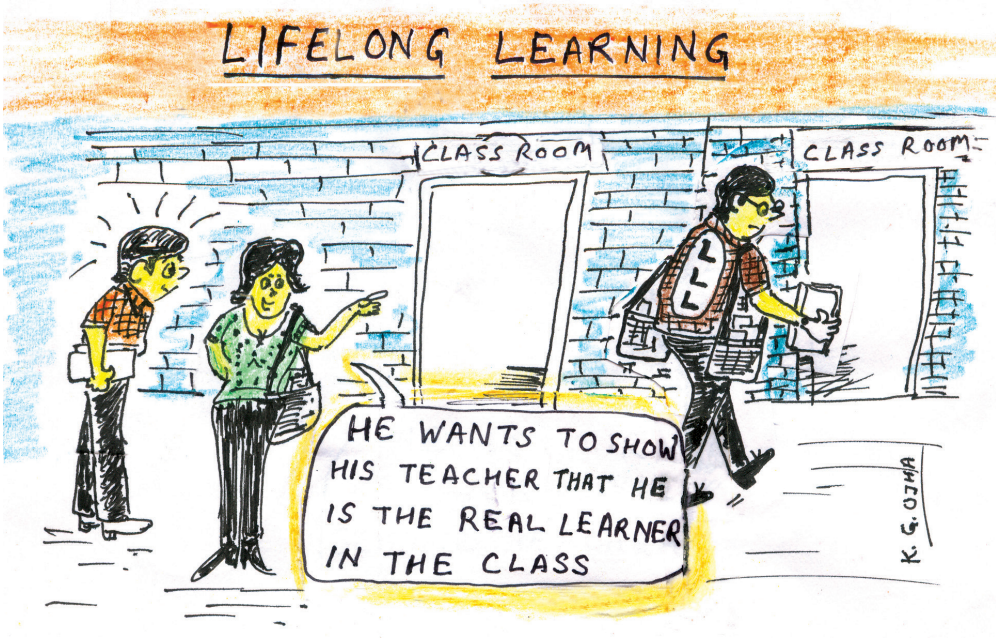
to challenge established ideas and appreciate new ideas. Investigating day-to-day activities and communicating effectively in the class offer them opportunities for a variety of experiences, like graphic representations of ideas and development of both receptive and expressive language skills. Emphasis on hands-on science leads to increased involvement of students in multi-sensory learning. Participating actively in a number of curricular activities, students learn to transfer content knowledge and the process of inquiry from school to the home environment and to their life at large.

Various non-formal modes of learning assume great significance in motivating students to become lifelong learner. Curricular transaction in formal set-up alone is not sufficient to provide scope for inventiveness and creativity.

The vast range of skills learner would require in order to survive in the knowledge society demands an equally increased range of skills in the teacher. Teacher also needs to continuously upgrade her knowledge to remain lifelong learner. One should remember that skills, value and attitudes are essentially developed among children while they are young and in the impressionable age. Once they become proficient in these aspects they find the ways and means to continue learning throughout life.

We have now understood that lifelong learning means giving ownership of learning to the learners themselves. It is an essential part of teaching-learning process. When the teacher plans lessons on physical science, she needs to consider flexibility in the approaches and strategies of teaching-learning and to keep in mind various learning activities that can be planned to develop attributes of lifelong learners. She needs to feel empowered to lead her students in understanding and participating in hands-on activities, projects, collaborative work, debate, discussion, drama, poster making, celebration of specific days, ICT applications, science club activities, science exhibition, field visits and to integrate the result of their activities into classroom activities.

The future needs of development of knowledge, reason, sensitivity and skills cannot be determined in advance. Lifelong learning is vital and dynamic basis for the future educational scenario of science. Hence, ability of learner to learn, as new needs are felt in new situation, is necessary to function autonomously in a democratic society.



EXERCISE

13.1 What do you mean by lifelong learning? Explain why lifelong learning is important.

13.2 What are the attributes of a lifelong learner in your opinion? Explain how will you develop lifelong learning attributes in students through teaching-learning of physical science.

13.3 What strategies of teaching-learning physical science can you adopt to facilitate students to be lifelong learners? Explain with examples.

13.4 Discuss how can you encourage students with special educational needs (SEN) to become lifelong learner.

13.5 What activities will you plan for students to stimulate their creativity and inventiveness in science? Describe any three in detail giving examples.

13.6 Discuss how various activities of a science club can facilitate students to become a lifelong learner?

13.7 What are the objectives of organising science exhibition? Discuss the benefits of a science exhibition for children.

13.8 What is the importance of science exhibition in stimulating creativity in children and making them lifelong learners? Explain with examples.

13.9 Describe in detail, how will you facilitate students to participate in a science exhibition.

13.10 What kinds of ***in class*** and ***out of class*** activities relevant to physical science will you organise for the learners of your class? Describe with examples.

13.11 Do you think yourself as a lifelong learner? Reflect upon your own school experiences. To what extent these experiences have motivated you to be a lifelong learner?

13.12 Talk with some teachers or persons whom you consider lifelong learners. Try to find out the conditions, factors and school experiences that have contributed to their interest in continued learning. How can you use these findings in your teaching-learning experiences of physical science? Present a report of this project.

13.13 Plan and organise various activities that could stimulate creativity and inventiveness in science among students during your practice teaching. Prepare a report of your work.

Chapter 14

Professional Development of Physical Science Teachers

14.1 INTRODUCTION

In the previous chapter on lifelong learning, we have discussed that learning is a continuous process and teacher herself is a lifelong learner. A teacher of physical 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. A continual system of new teaching-learning materials in the form of new textbooks, teachers' handbook, laboratory manual, assessment source book, science kits are being produced to facilitate teachers to enhance effectiveness of teaching-learning process. The entry of Information and Communication Technology, mass media and the satellite television into the field of education has added to the roles of the teacher. Participation of several people in creating learning situations demands newer competencies in teacher to take their help meaningfully. Therefore, it is important for the science teachers to keep themselves abreast with the new developments in science and science education for providing meaningful teaching-learning experiences to learners.

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. This chapter discusses the need of pre-service professional development programme and various opportunities for in-service professional development of a teacher of physical science. Later, role of reflective practices in professional development of the

teacher is also discussed. Before going on to those details, let us first see what are the characteristics of a profession. Is teaching a profession?

14.2 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 everyday 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.

1. A profession requires specialised knowledge with extensive training and an advanced level of intellectual skills in carrying out its service to society.
2. 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. For instance, only doctors practice surgery in this country as opposed to a variety of individuals who believe they have the skill.
3. 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.
4. Members of a profession are required to accept personal responsibility for their actions and decisions.
5. 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.
6. 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.
7. A profession emphasises the services it provides over the financial rewards.
8. 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.
9. Society must recognise an occupation as a profession.

10. A profession is considered a lifework or terminal occupation. Those involved usually stay in the field for the rest of their careers.
11. 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?**

ACTIVITY 14.1 

How teaching is a profession? In the light of the above characteristics, critically examine and discuss it with your classmates.

ACTIVITY 14.2 

Discuss with your teacher-educator on the code of ethics of a science teacher and prepare a brief write-up on it.

14.3 NEED FOR PRE-SERVICE PROFESSIONAL DEVELOPMENT PROGRAMMES

Anil was pursuing a B.Ed. course. He had already teaching-learning experience of a few years. During the course, when the 'Lesson planning' sessions started, Anil felt that there was no need to plan lessons. He thought that the exercise of 'framing learning objectives', 'writing teaching-learning materials', 'testing pre-knowledge', 'introduction' and '5Es', 'classroom proceedings', etc. were a waste of time. Similarly 'planning presentation,' and 'framing questions to be asked' were not required. He argued, "I have taught in a school for last three years. My students and Principal were satisfied with my teaching. My students even came to me during my free time to discuss. And I have never used all this planning. I just went to the class and taught them whatever was given in the textbook".

This is not only for Anil, it can be true for many student-teachers who come to get B.Ed. degree after teaching in a school for some time.

Student-teachers were working on the design of the lesson plans during their practice teaching programme. They focused their discussion on various aspects of teaching-learning such as the following:

- Why are you transacting this particular topic in the class?
- Why this content is given in this class?
- What are the expectations of the planner of curriculum with this topic?
- How will you encourage students to share their previous experiences in the class?
- How students are going to relate it with their lives outside the classroom/school?
- Will students just 'memorise' or 'learn' (make a part of their knowledge and understanding) this content?
- What will you do to develop the understanding of the students?
- How will you encourage inquiry in the class?
- What is the role of 'activity', 'practical' and 'exercise', in teaching-learning of physical science?
- What preparation will you make to carry out activities in the class?

With these questions and arguments they started to realise the importance of designing the lesson plan. They also realised the difference in teaching-learning with proper planning and without proper planning. They evaluated their own experiences of teaching-learning and students' responses. They realised that if one interacts with the class after proper planning including the questions like *why are you teaching, what is that you want to see in your students*, *what are you teaching*, and *how are you teaching*, then only she will be able to help her students move ahead, developing their understanding.

With proper planning, teacher acquires confidence and presents the content with flexibility. We have already discussed various aspects of planning teaching-learning of physical science in Chapter 12. 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.

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.

NCF-2005

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.

ACTIVITY 14.3 

Assess yourself with regard to changes in your knowledge and understanding on different aspects of teaching-learning of physical science since you joined pre-service programme. What is your view on the need of pre-service educational programmes of teachers of physical science? Share those views in the class.

14.3.1 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 class
(c)	Admission criteria	:	Entrance test

(ii) *Bachelor of Elementary Education*

(a)	Duration of course	:	4 years
(b)	Eligibility	:	12th class
(c)	Admission criteria	:	Entrance test

B. At Secondary and Higher Secondary Level

(i) Bachelor in Education

(a)	Duration of course	:	1 year [2 years at Regional Institute of Education, (RIEs), NCERT];
(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 and PGTs for students with Special Educational Needs. (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	:	12th class
(c)	Admission criteria	:	Class 12th marks and interview

ACTIVITY 14.4 

Make a list of various pre-service professional development programmes for science teachers being offered in your state. Also find out their duration, eligibility and admission criteria for admission to these courses.

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 evisages a major shift. Let us now see what are those major shifts.

14.3.2 Major shifts in teacher education programme

Teacher education must become more sensitive to the emerging demands. **NCF-2005 recommends some major shifts in teacher education programme.**

- Understanding that the learner needs to be given priority. The learner is seen as an active participant rather than a passive recipient in the process of learning, and her capabilities and potentialities are seen not as a fixed, but dynamic and capable of development through direct self-experience.
- Learning should be appreciated as a participatory process that takes place in the shared social context of the learner's immediate peers as well as the wider social community or the nation as a whole.
- The major shift is in the teacher's role where she assumes a position at centre stage as a source of knowledge, as custodian and manager of all teaching-learning processes, and executor of educational and administrative mandates given through curricula or circulars. **Now teacher's role needs to be shifted from being a source of knowledge to being facilitator of transforming information into knowledge/wisdom; as a supporter in enhancing learning through multiple exposures and encouraging the learner to continuously achieve her educational goals.**
- Another significant shift is in the concept of knowledge wherein knowledge is to be taken as a continuum, as generated from experiences in the actual field through observation, verification and so on.
- Knowledge in teacher education is multidisciplinary in nature within the context of education. Conceptual inputs in a teacher education need to be articulated in such a manner that they

describe and explain educational programmes like actions, tasks, efforts, processes, concepts and events.

- There is a need to undertake a major shift away from an overwhelming emphasis on the psychological characteristics of the individual learner to her social, cultural and economic context.
- Teacher education programmes need to provide the space for engagement with issues and concerns of contemporary Indian society and its pluralistic nature.
- The shift in performance appraisal in the teacher education programme from an annual affair to a continuous feature needs to be recognised. **The teacher-educator needs to evaluate the student-teachers' ability to cooperate and collaborate, investigate and integrate and also to appraise written and oral skills, originality in approach and presentation.**
- Such a teacher education programme would provide adequate scope for viewing a theoretical understanding and its practical aspects in a more integrated manner rather than as two separate components. It enables the student-teacher and the teacher in the classroom to develop a critical sensitivity to field approaches. Thus, once tried out by self and others, it will lead to involve one's own vision of an ideal setting for learning. Such teachers would be better equipped for creating a learning environment, would try to improve existing conditions with confidence and necessary technical know-how rather than merely adjusting to them.

In the context of changed perspective, it is imperative to persue strengthening of teacher education programmes by in-service professional development. We shall now discuss further needs for in-service professional development.

14.4 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 facilated to keep themselves

abrest of these developments, they are bound to show resistance to new ideas no matter how sound they look to educationists. Therefore, in-service training programme is conducted by many organisations 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.

After attending an in-service training programme of Master Trainers on "Activity based teaching of science at upper primary stage" Sundaram, a science teacher organised a training programme of six days in his school. Five teachers of his school and four teachers of a nearby school participated in this programme. They learnt many skills related with the science activities without disturbing their routine classroom process as the programme was organised daily for one hour only after school hours. In this process, Sundaram himself got the opportunity to enhance proficiency of his skills by interacting with the participants.

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.

14.4.1 Opportunities for in-service professional development

Some of the opportunities through which a science teacher can achieve continuous professional growth are shown in Fig 14.1 and discussed below.

14.4.1(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 mathematies 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.

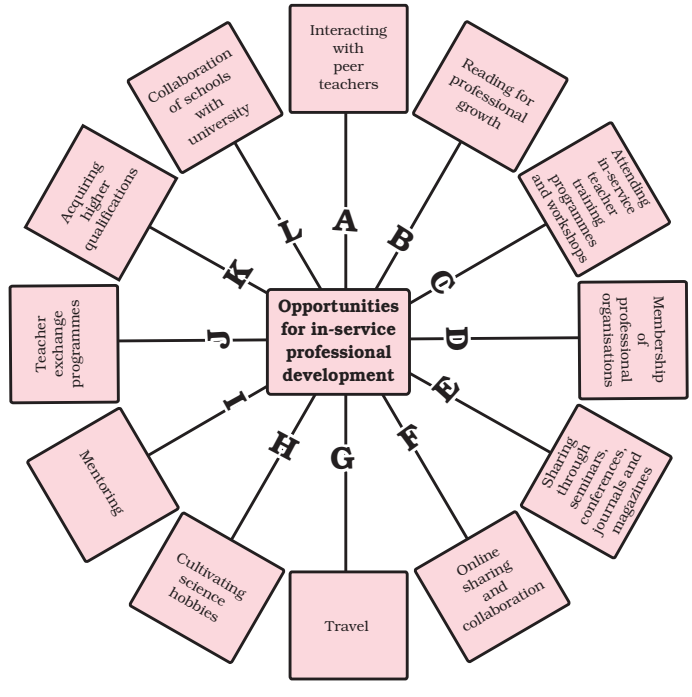


Fig. 14.1 *Some opportunities for in–service professional development*

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.

ACTIVITY 14.5 

Interact with students of other B.Ed. colleges. Share their experiences of practice teaching.

ACTIVITY 14.6 

Visit a nearby school to interact with a few senior teachers of physical science. Seek their opinion on what major area you should focus upon during your pre-service training programme.

14.4.1(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. A list of science journals which are published in India and abroad is given in Chapter 10 *Print and ICT Resources in Learning Physical Science* (section 10.2.3).

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.

ACTIVITY 14.7

(i) Visit a library to find various journals and magazines which you feel might be useful for a science teacher. Prepare a list of these publications for your future reference.

(ii) Read and review any article/paper of your interest in the journal/ magazine and present the report in the class.

ACTIVITY 14.8

Obtain membership of a library in your neighbourhood.

14.4.1(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

various organisations conduct training programmes for 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.

ACTIVITY 14.9 

Search the internet to get information regarding in-service teacher training programmes and workshops that are scheduled to be organised in your district/state during the next few months.

14.4.1(D) Membership of professional organisations

There are many national and international professional organisations 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 more associations 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)

Project 14.1

Look for an organisation of science teachers in your district/state and find out:

(i) What activities on science programme are conducted there?

(ii) What are the benefits of the membership of this organisation?

You may join science teachers association of your district. If possible, attend some of the meetings to share your ideas and experiences on teaching-learning of physial science.

14.4.1(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.

ACTIVITY 14.10

(i) Identify the institutions and organisations that regularly organise seminars and conferences on various aspects of science and science education.

(ii) Collect the information about the themes of the seminars and conferences that were organised during last five years.

ACTIVITY 14.11

Visit library of your institute/college to know what science and science education journals and magazines are subscribed. Read the instructions for the authors regarding the format of the manuscript. You may send an article for publication.

14.4.1(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.

ACTIVITY 14.12 

There are many online teacher community discussion boards/blogs. Identify one, become a member and contribute to it. Share your experiences with your classmates.

14.4.1(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.

Project 14.2
Plan a field visit to a nearby industry/power station/mines/refineries/ Science Centre/National Laboratories with your classmates under the guidance of the teacher-educators. Observe the things/situations carefully and discuss with your classmates:

(i) how information of such things/situations could be used in teaching-learning of physical science, and

(ii) to make a plan for organising a field visit for your students.

Present a report of your visit in the class.

14.4.1(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.

14.4.1(I) Mentoring

Experienced science teachers may play the role of mentors for less-experienced teachers. Mentoring can be done to improve teaching-learning 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.

14.4.1(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 utilise the services of visiting teachers. Teachers can share their expertise in science education with each other.

14.4.1(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.

14.4.1(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.

14.5 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.14.2. 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 physical science.

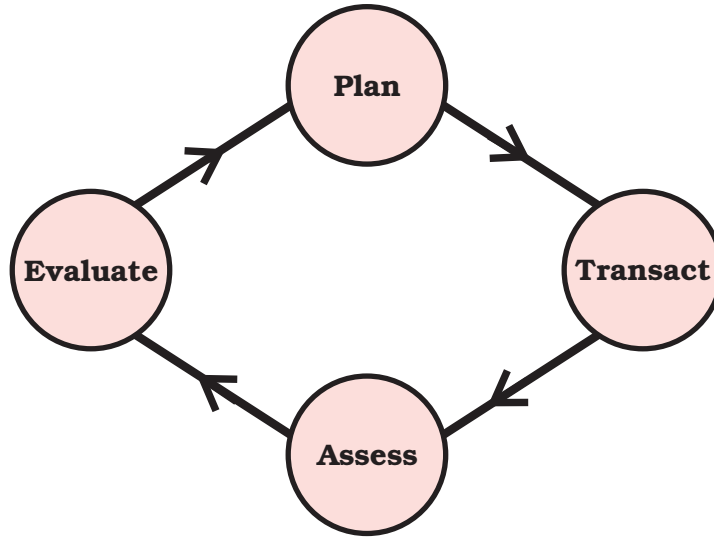


Fig. 14.2 Reflective practice is a continuous and cyclic process

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. Let us now see how

getting feedback from **questionnaires,** conducting **research** and maintaining a **portfolio** can facilitate a teacher in reflective practices.

14.5.1 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.

Examples of questionnaire to obtain feedback of teacher's performance are given in **Table 14.1**. 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.**

Table 14.1 (i), (ii), (iii) Examples of questionaire to get feedback about teachers performance in the classroom

(i) An example of questionnaire to obtain feedback of teacher's performance in the class from students/colleagues.

Rating scale : **1.** Always **2.** Frequently **3.** Sometimes **4.** Seldom **5.** Never

Questions	1	2	3	4	5
1. Is the teacher enthusiastic about the subject?					
2. Is the teacher well aware with subject content?					
3. Is the teacher able to connect the concepts involved in the lesson with the examples of everyday life?					
4. Is the teacher using any other type of teaching aid in the classroom to make the science lesson interesting?					
5. Is the teacher carrying out activities during teaching-learning of the concept?					

6. Are the activities/experiments well organised in the class/laboratory?					
7. Do these activities/experiments designed by the teacher encourage inquiry in the class?					
8. Is the teacher giving opportunity to students to ask questions?					
9. Is the language used by the teacher comprehended by the students?					
10. Are the students attentive to classroom activities?					
11. Does the teacher encourage the students to think to take up projects inside and outside the classroom?					
12. Does the teacher give opportunity to the students to work in the laboratory to carry out their project?					
13. Is the teacher paying attention to the students who are learning with different pace and style in a heterogeneous class?					

Selecting some criteria, teacher herself can develop a lesson evaluation proforma. It can be evaluated on a four/five point scale by her peers.

(ii) An example of lesson evaluation proforma.

Rating seale : **1.** Excellent **2.** Good **3.** Satisfactory **4.** Unsatisfactory

Criteria	1	2	3	4
1. Up-to-date knowledge				
2. Learning resource management				
3. Involvement of students				
4. Promotes inquiry				
5. Class management				
6. Variety in strategies				
7. Consideration of learning needs of all students				
8. Feedback to students				
9. Assessment				

(iii) An example of a questionnaire for observing professional behaviour of a science teacher

Rating seale : **1.** Always **2.** Frequently **3.** Sometimes **4.** seldon **5.** Never

Questions	1	2	3	4	5
1. Does the teacher keep abreast with the latest development in science and pedagogy of science?					

2.	Does the teacher get herself involved in various science activities in the school?					
3.	Does the teacher manage to seek cooperation of other subject teachers to bring integrated and interdisciplinary approach to science?					
4.	Does the teacher interact and involve various learning resources of community?					
5.	Does the teacher incorporate innovative ideas in teaching-learning of physical science?					
6.	Does the teacher show interest in attending various professional meeting?					
7.	Does the teacher show interest in reading science journals, periodicals and latest books in science?					
8.	Is the teacher member of any professional organisation?					
9.	Does the teacher go along well with her colleagues?					

ACTIVITY 14.13

(i) Ask your fellow students to observe the practice lessons taken by you and provide their feedback. Refine your presentation in the light of their feedback.

(ii) Observe some practice lessons taken by your fellow students and try to give them critical feedback about their teaching-learning proceedings.

ACTIVITY 14.14

Select a topic that you would like to transact when you go for practice teaching. Prepare a questionnaire on it to obtain students' feedback on your teaching-learning.

14.5.2 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, collegues, 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.

A teacher may undertake action research to find solutions of some problems faced by her in the classroom. Detailed discussion on the *Action Research* is done in the next chapter.

ACTIVITY 14.15

Reflect and act:

(i) Write down your career goal and ambitions as a teacher.
(ii) List down your positive points and strengths.
(iii) Identify the area where you feel, you need an improvement.
(iv) Formulate an action plan and time scale to achieve them.

S.No	Area you need an improvement	How will it improve teaching-learning process?	Action you will take	Time frame
1. 2.				

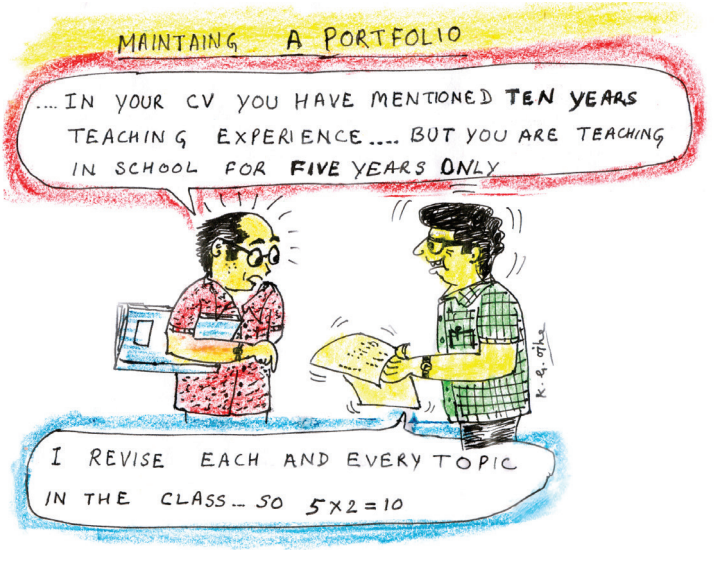
ACTIVITY 14.16

Almost all of you will join as a teacher after completion of this pre-service teacher education programme. Where do you see yourself in the field of education after 10 years? Share your long-term career goals with your-friends. What action would you take to achieve these goals?

14.5.3 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.



ACTIVITY 14.17

You have to apply for the post of teacher in a school. Prepare your resume including some of the achievements you got during practice teaching. Show it to the teacher-educator to get a feedback. Revise it on the basis of his/her feedback.

14.6 SUMMARY

The process of professional development starts the moment a teacher starts her pre-service education programme. As learning is a continuous process so is the professional development of science teachers. She has to strive for her professional growth throughout her profession as a teacher. She needs to remain active in various professional activities such as participation in science workshops and meeting, in-service training, membership of professional organisation, attending seminar and conferences, reading journals and periodicals, writing articles and papers for science magazines and journals, etc. At the same time, she must continuously evaluate her teaching-learning process herself to reflect on her thinking and be self-motivated to improve her performance. A teacher of physical science should realise the benefit of her professional development. For any development to take place, it is necessary that teacher is interested in assessing and analysing her own performance, and realising the need of improvement and change. She needs to remain open to constructive criticism of her peers and authorities and new ideas and experiences of teaching-learning

situations. Teachers should strive to look for various professional activities to reinvent herself from all available sources. Also, there is a need to recognise the variety of in-service programmes.

The practice of giving extraneous non-academic responsibilities to teachers at the cost of their teaching-learning duties should be discontinued. Various schemes of incentives and awards to honour and encourage the deserving teachers can contribute towards the sustained professional development of teachers.

EXERCISE

14.1 After completing pre-service training, do you think it is necessary to interact with senior teachers of your school to learn from their practical experiences of teaching-learning of science? If yes, why and how?

14.2 How will you update your knowledge in science and science education? What type of readings will you select and from where can you get them?

14.3 Explain the major shift in teacher education programme as recommended in the National Curriculum Framework–2005.

14.4 You are aware of various in-service training programmes organised for school teachers. In your opinion, what is the need of organising such programmes? How will it be useful for you?

14.5 At what time of your career, would you like to attend in-service training programmes? Give reasons.

14.6 Would you like to continue your education after completing your B.Ed course? List out the reasons.

14.7 As a teacher of science, how will you develop interest in your students in science by organising various curricular activities in science? Explain.

14.8 Develop a questionnaire to observe professional activities of a teacher involved in the laboratory (physics/chemistry) work with her students. How could this observation be used for the further improvement of teaching-learning process and situation in the laboratory?

14.9 Reflect on your activities related to the efforts you are taking to learn the pedagogy of physical science and brush up your skills as a teacher during pre-service education programme. Develop a checklist to self-assess your professional growth since you joined the programme.

14.10 Self-assess yourself with regard to knowledge, skills, qualities and attitudes essential for a teacher of physical science. Think about the ways you can develop these further in the context of your role as a teacher for child-centred teaching-learning of physical science.

Chapter 15

Teacher as a Researcher

15.1 INTRODUCTION

As a successful teacher you would always like to improve teaching-learning practices and grow in your career. If you collect evidences of problems and solutions regarding these practices and apply systematically in the classroom, it would create more dynamic learning

environment and lead to better understanding of students. Moreover, the findings of the research will give you a sense of achievement, boost your self-confidence and develop a sense of ownership to your 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 undertaken 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 hand she 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:

- analysing her problem scientifically in the specific perspective in which the problem has emerged;
- suggesting a solution based on the above analysis;
- testing the solution herself; and
- 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 herself accountable for her work and influence the learning of her students.

In this chapter various aspects of 'Action Research' have been dealt with. 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.

15.2 ACTION RESEARCH VS. RESEARCH

In order to comprehend the meaning of action research, it may be helpful to make a distinction between action research and research.

Let us first understand the meaning of research. George J. Mule has defined research in his book *Educational Research: The Art and Science of Investigations* as:

"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.

Besides the fact that research is not everybody's cup of tea, formal research suffers from some other limitations as well.

- Generally findings of a research take a long time in seeing the light of the day and their implementation takes even longer time.
- Formal research findings are many a time not applicable at ground level as in a formal research, professional manoeuvres 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.

ACTIVITY 15.1 

Do you think 'Action Research is a process by which a practitioner tries to solve his/her own problem in a scientific way.' Have a group discussion on this issue in the class.

15.3 SELECTING PROBLEM FOR ACTION RESEARCH

A researcher generally faces challenge in identifying a suitable research problem as she has yet to develop sensitivity to the problem. After

gaining some experience, one finds research issues in various areas of one's work. For example, if we think about students, there are number of research issues related to students such as:

- Why does a student fail in one particular subject?
- What are the common errors committed by students at Upper primary/Secondary/Higher secondary stage in science?
- Why is a particular teacher most popular among students?
- Why does a particular student feel isolated in classroom activities?
- How to deal with students, learning with different paces?
- Can changing seating arrangement in the class facilitate integrating experimental work with theory?

So, whatever area we take, we can list out a number of research problems. There is no dearth of research problems. Section 15.7 of this chapter discusses in detail the different areas in which you can identify the problem. Student-teachers, thus should make themselves aware of the characteristics of good research problems and format of a research plan and proposal. While selecting the research problems, certain points as given below need to be kept in mind.

Precision: The broad area like learning difficulties in various topic's, creativity, etc. need to be narrowed down or pinpointed and made as precise and specific as possible. It should have limited variables to be studied. As an example, one can investigate why learners have difficulties in understanding the concept of ray diagram in optics.

Critical thrust areas*:* Identified problem should throw light on some important problems related to teaching-learning.

Accessibility to data: Before finalising the research problems, make sure to have easy access to necessary and valid data.

Completion within reasonable time limit: If it takes too long to complete a research project, the findings and conclusions of the study may become obsolete due to change in the circumstances.

Not against ethical norms: A problem that harms the existing ethical norms of the society should be avoided as far as possible.

After considering and identifying a research problem, the next step is to make a format of the research proposal. Two formats of action research designs are discussed here.

15.4 FORMAT OF A RESEARCH PLAN

Research should be planned properly for keeping the researcher focused on the problem. The researcher can revisit and modify the plan whenever required.

The format of a research proposal plan can be changed as per the nature of the problem and teacher's way of carrying out the work. Two formats of an action research design are suggested below in Fig.15.1(a) and Fig.15.1(b).

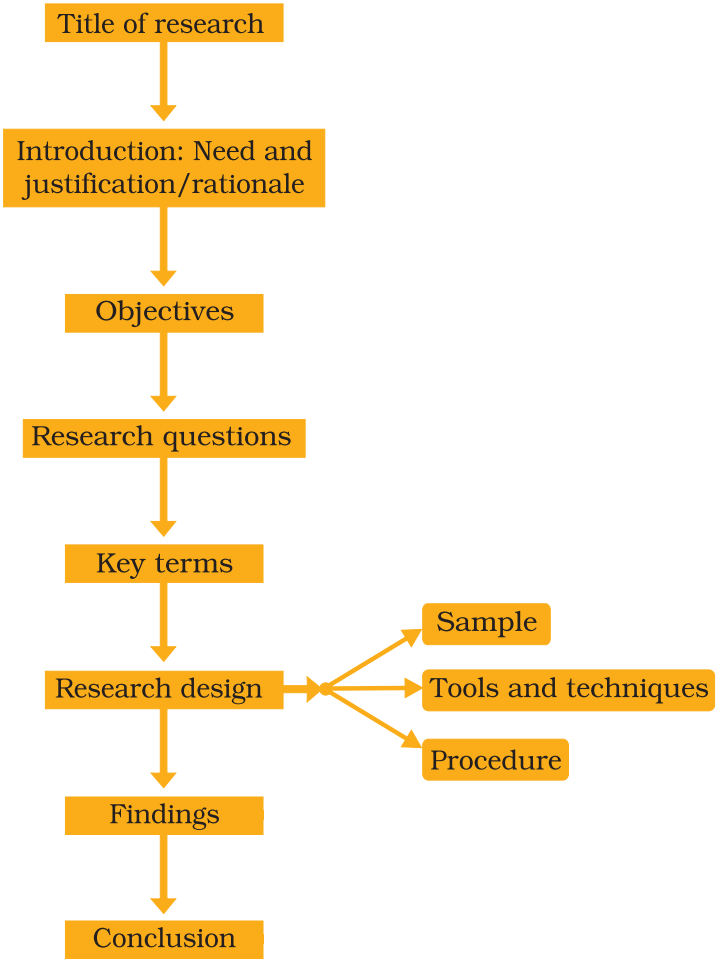


Fig. 15.1(a) *Format I of an action research design*

Depending on the nature of the research, plan can be prepared in the form of a flow chart, concept maps or other pictorial form. It helps in collecting and recording data systematically, selecting the methodology for the research and revisiting the plan easily, whenever required.

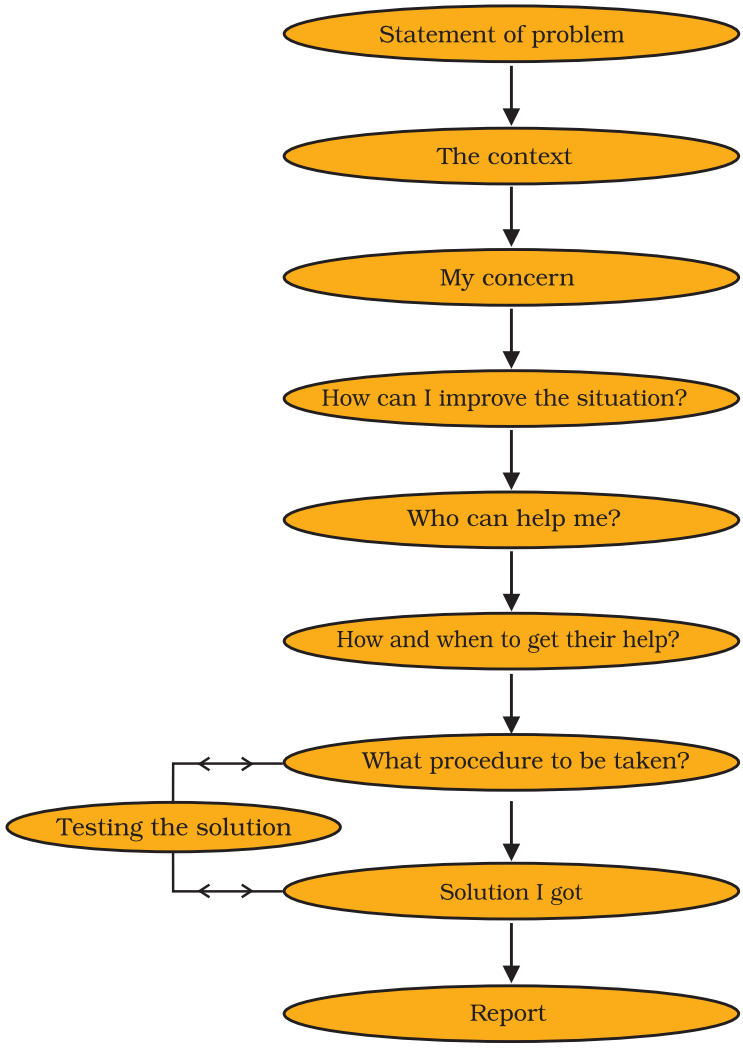


Fig. 15.1(b) *Format-II of an action research design*

Balwinder was assigned the duty to take up physics of Class XI. The new session started with great enthusiasm among students and the teacher. But gradually, he realised, many students who were doing very well in previous classes, were losing interest. In the first unit test, he found performance of the class below average. He started pondering over the issue — "What is wrong in the teaching-learning process?" "Have students become careless after reaching Class XI?" "Are the strategies adopted by me not suitable to the learning needs of students?" "Has the subject matter become too complex for them?"

He interacted with them in a friendly manner and felt that students loved him a lot; they were interested in learning the subject, but somehow they were not able to comprehend the subject matter. Going a little deeper into the problem, he realised that students were able to comprehend the qualitative aspects of the concepts, but faced difficulty in derivations and were not able to solve numerical problems, as they did not have required mathematical foundation. Considering this he formulated the hypothesis—"if students become proficient in the required mathematical techniques to be applied in the derivations and solving numerical problems, their interest in the subject will get revived."

In order to test this hypothesis, he took the following steps:

- Identified the mathematical concepts needed to learn for understanding derivation of equations and formulae.
- Prepared a plan to transact the above identified topics and estimated that roughly one week will be needed to transact them.
- For one week he emphasised on teaching-learning of these mathematical concepts.
- Helped students to revisit the related concepts of physics that they studied in previous classes.
- Conducted a test on the same unit.
- Matched the scores obtained by each student with her previous scores.
- He thus found that there was a significant improvement in the performance of the students in the second test as compared to the first test.

ACTIVITY 15.2

You observe that students of Class X find difficulties in drawing ray diagram for spherical lenses. Discuss how would you plan and carry out action research to solve this problem. You may give a powerpoint presentation in the class.

ACTIVITY 15.3

Is action research intended as a substitute for experimental or quasi-experimental research? Discuss in a group and share your group view with others in the class.

15.5 KNOWLEDGE IS TENTATIVE

Traditional researchers tend to believe that:

- knowledge is certain and out there to be discoverd. There is answer to every question;

- answers to questions are fixed; All feasible answers are commensurable;
- knowledge can be discovered by scientific method that aims to control the outcome; and
- This perspective of knowledge does not necessarily work in a classroom situation where human factors are involved as every child is unique.

Action researchers tend to believe that:

- knowledge is uncertain and ambiguous. A question may have multiple answers;
- knowledge is created, not discovered. This is usually a process of trial and error; and
- any answer is tentative and incommensurable. People have to live with dissonance and do the best they can.

This implies that in action research we do not look for a fixed outcome and it cannot be applied everywhere.

15.6 ACTION RESEARCH IN PHYSICAL SCIENCE

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, realises 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 absenteism, 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 (Non-government Organisation) concernd 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.

Salma, in her science class helped her students to explain that the blue colour of the sky is due to scattering of sunlight. However, on interacting with the students, Salma found a few students who still had the misconception that the blue colour of the sky is due to the reflection of the colour of the ocean. She tried to bring conceptual change in them using collaborative learning strategy where students could interact with their peers. She observed that the strategy was quite effective. However, the exact steps of this action research may not be applicable to all other situations.

15.7 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 physical 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 can not 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 conducive 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 chemistry/physics;
- Formation of misconceptions and naive concepts in physical science in various students; and
- The effect of using computers and various audio-visual aids for teaching-learning of physical 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.**

Project 15.1
Formulate one precise action research problem in each of the broad areas given below:

- Falling academic standards
- Medium of teaching-learning
- Approaches and strategies of teaching-learning
- Behavioural problems of students

Think-pair-share your ideas in the class.

ACTIVITY 15.4 

Prepare a brief plan in any one of the formats given in section 15.4 (Chapter 15) on a problem related to any naive concept on physical science. Share your ideas with your friends. Write your action research plan in some other format also as thought by you.

15.8 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. 15.2).

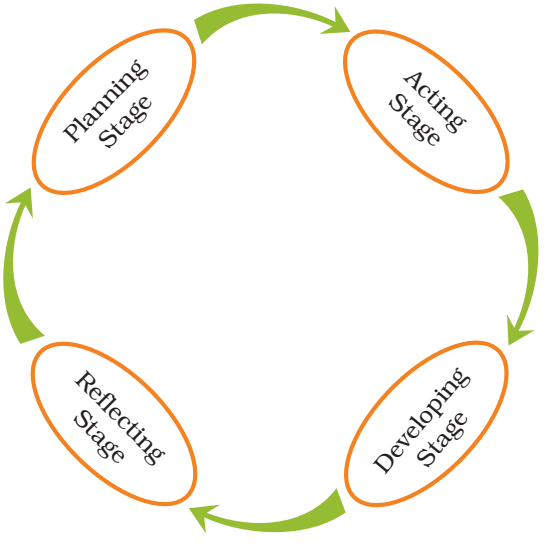


Fig. 15.2 *Action and reflection cycle*

Each stage may consist of one or more steps. In all, there can be eight steps. These are shown in Table 15.1.

Table 15.1 Process of action research

Planning stage	Acting Stage	Developing Stage	Reflecting stage
• Identifying and limiting the topic or problem. • Reviewing the related literature. • Developing a research plan.	• Implementing the plan and collecting data. • Analysing data.	• Developing an action plan.	• Sharing and communicating the results. • Reflecting on the process.

15.8.1 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.

Kamlesh, a teacher at higher secondary stage was facilitating students of class XII to perform experiments to find out the refractive index of water using convex lens and a plane mirror. (Fig. 15.3)

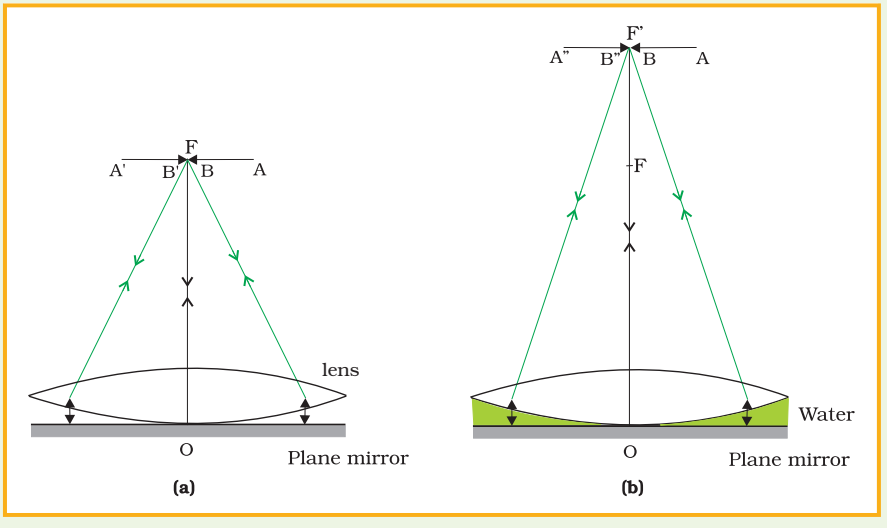


Fig. 15.3 *(a),(b) Refractive index of water using convex lens and a plane mirror*

She observed that most of the children found the value of the refractive index of the material of the convex lens to be more than 2. Kamlesh was disturbed and she wanted to find out why students were getting higher value of refractive index.

15.8.2 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.

Kamlesh used internet, laboratory manuals, library and some of the related journals to find out the possible reasons of higher value of refractive index. It helped her to design the study.

15.8.3 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.

Kamlesh identified two research questions.

- Do the students know how to determine least count and zero error of a spherometer?
- Do the students know the experimental procedure and the technique properly?

15.8.4 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 analysing 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.

Kamlesh asked all the students to conduct the experiment again after a gap of one week. She observed and interacted with them while doing the experiment. She also helped the students doing the calculation stepwise.

15.8.5 Step 5 – Analysing data

Teacher can analyse the data qualitatively or quantitatively. Quantitative data maybe analysed by either descriptive statistics or inferential statistics. Qualitative data may be analysed by studying the patterns or categories that emerge.

She analysed stepwise calculation done by students and her interaction with them. She came to know that the students had done mistakes in calculating the least count and the zero error of the spherometer.

15.8.6 Step 6 – Developing an action plan

After analysing the data, the next step is to develop an action plan. This is the 'action' part of the action research.

Kamlesh developed her action plan to help students understand the meaning of least count of the spherometer (Fig 15.4). Then she facilitated them to explain the concept of least count by giving examples of various measuring instruments, such as measuring cylinder, watch, scale and protractor. Students determined the least count of various instruments. Students then started working with the spherometer again in smaller group. She first helped them to explain the meaning of pitch as the vertical distance moved by the central screw in one complete rotation of the circular disc scale. Students measured its value. Some groups of students reported the

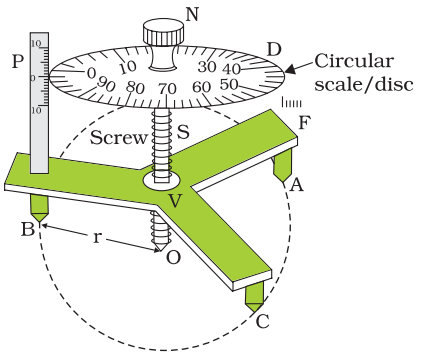


Fig. 15.4 *Spherometer*

value of pitch as 1mm and some as 0.5mm. Kamlesh then facilitated each student to count total number of divisions on the circular scale of the spherometer. All of them found that there were 100 divisions. Students divided the pitch of the spherometer screw by the total number of divisions on the circular scale. They reported the least count to be .01 mm or .005 mm depending on the spherometer used. The teacher helped them to explain that the least count of a spherometer is the distance moved by the spherometer screw when it was turned through one division on the circular scale. Students repeated the experiment and found the value of the refractive index of the material of the lens to be lower than 2 (approximately 1.5).

15.8.7 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 an evidence of how she has learned to do things differently and in a better way. Teacher can publish her reseach work in the research journals for its wider dissemination. She can get critical response that may help her to work further.

Kamlesh gave a presentation about her research work in Subject Committee Meeting in her school. She was upfront in telling her colleagues, "If I can solve my problem arising in teaching-learning process, you can do this too." Her colleagues also got motivation.

15.8.8 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.

Kamlesh reviewed her work at each stage of the research to ensure that each student learns to use spherometer properly. She found that some students needed her help in correlating the meaning of the least count of the spherometer with that of a vernier calipers and a screw gauge.

Generally, action research includes all the above eight steps. However, the teacher has the flexibility to conduct it without following all the steps rigidly.

Many teachers might say, "That is what I am already doing. What is new in action research?" The difference is that **in action research you justify your claim, provide validated evidences and make your findings public for its critical evaluation in order to further improve teaching-learning process.**

ACTIVITY 15.5

(i) Suggest any three research problems in which techniques of observation can be used for data collection.

(ii) Also prepare an interview schedule consisting of a few questions on any topic/area of your choice for collecting data for the above research problems.

Bijoy, the science teacher of Class VIII observed that the students have not done well in the test conducted on the topic *Electricity*. As he was not satisfied with the achievement of the students, he analysed their answer scripts. He found that only 40% of the students have attempted the questions related to electrical circuits correctly; 40% have attempted wrongly and 20% did not attempt the questions. He collected the data from the answer scripts and analysed to know why the students had not understood the concepts. He then formulated a strategy for improving the situation by engaging the students in performing experiments related to electrical circuits.

The steps were:

1. ***Topic of Action Research:*** Improving students' achievement in concepts related to electric circuits.
2. ***Background:*** This action research was planned to improve the achievement level of students by engaging students in hands-on activities, and collaborative learning.
3. ***Probable Reasons:***
   - Students were not given hands-on experiences.
   - Students were not given the opportunity of collaborative learning.
4. ***Action Hypothesis:*** If the students are provided with various electric components to perform activities on the electrical circuits

and share ideas with other students, they can learn in a better way the essentials of the electrical circuits. This can improve their achievement level.

5. ***Tools:***
   - Students will be provided with necessary materials like connecting wires, bulb, battery, key, etc. Teacher will facilitate them to work in small groups.
   - Teacher will observe the way students are working.
   - Questionnaire will be prepared and administered to measure the achievement level of students.
6. ***Action Steps:***
   - Students having problem with completing electrical circuit will be identified.
   - Individual attention will be given to the students struggling with the activity.
   - Opportunities will be provided to students to interact with peers and teacher.
   - Related problems will be given for conceptual clarity.
   - Post-test questionnaire will be administered for knowing the effectiveness of the teaching-learning strategy.
7. ***Sharing and communicating the result:*** If the strategy will be effective, it can be revealed by the data analysis of the post test questionnaire. The teaching-learning strategy may be recommended to other teachers. It can be communicated to others, how providing hands-on experience and collaborative work helped students to understand better.

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 set up a discussion forum on various websites and publish her work in the journals.

ACTIVITY 15.6 

Discuss how can you use students' notebook and journals for action research?

ACTIVITY 15.7 

Prepare an action research plan for any action research problem in the area of physics/chemistry. Give a power point presentation on it and discuss in the class.

Project 15.2

Search the websites/library to find the details about following journals:

(i) Educational Action Research

(ii) Action Research International

(iii) Reflective Practice

Read critically any one paper in any journal and discuss it in the class.

15.9 HELPING STUDENTS TO DEVELOP ATTITUDE OF RESEARCH

Teacher's involvement in action research and commitment for the improvement of teaching-learning of science has the potential to motivate many students to do research in their own area of learning. Encouraging students to do mini research empowers them in being independent learners and seeing the importance of inquiry in science.

Teacher should encourage students to get engaged in inquiry and investigation for developing interest in research work. Students should be given opportunities to perform activities and experiments. She should motivate students to pose questions, search and examine various prints, ICT and other learning resources, make models on scientific concepts, collect data, analyse and interpret data, plan investigation, propose answers and explanations and communicate the result.

Teacher should motivate students to gather information and data from various sources like reference books, journals, newspaper articles, web resources, etc. For this, teacher can relate the various concepts of science to students' day-to-day life and immediate environment and pose such questions to them for which they necessarily need to refer to diverse sources to collect information, analyse them and compile the relevant information.

Teacher can also plan field trip to science centre, science museum, planetarium, botanical garden, wildlife century, industrial visits, etc., where students are motivated to gather information and they get a feel of science and realise that learning of science is not just confined to textbook and classroom activities.

Teacher can think about using video clips, or film strip, games, quiz, puzzles, debate in teaching-learning process of science to motivate students for doing research on any topic.

The students of Class IX greeted their science teacher when she entered the classroom and became curious to observe the materials she had brought in the class. She placed a measuring cylinder filled with water on the table and put a number of equal sized cubes in it. Students observed that some cubes floated, some sank and some partially submerged. One of the students asked why all the blocks were not sinking. Teacher said, "Do you think there is some property related to the material of the blocks which determines it?" Students immediately recalled the concept of density. Teacher facilitated them to find the density of materials of different blocks. Later she facilitated students to observe and investigate, what happens when two blocks of different materials are tied together and immersed in water. Students had identified the problem for their research work.

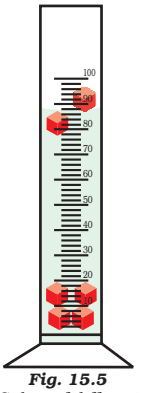


Fig. 15.5
Cubes of different materials in a measuring cylinder

15.10 SUMMARY

The process of action research can be ongoing, because when the teacher arrives at the solution of a problem, a new problem maybe identified. It guides the teacher to move in new directions and it can be seen as one of the ways of improving teaching-learning of science. She can say with confidence, what new she is doing and why she is doing in that way by providing evidences and significance of her findings. It further develops her self-confidence and reflective thinking and she becomes a knowledge creator. Her findings can have transformative influence for bringing modification in the existing practices. Engagement in action research develops commitment and the skills to modify teaching-learning process.

Teaching practices are generative in nature and there are possibilities of continuous growth and development. Understanding one's teaching-learning practices helps in professional development of the teacher. Action research is one of the many forms of research. It is for empowering teachers to reflect on her own practices and work with her own insight for the betterment of teaching-learning processes. Findings of the action research not only encourages others to develop new vision, but it also instils the idea that new vision for teaching-learning of science is possible.

EXERCISE

15.1 What do you mean by action research in the context of physical science? How is it different from other researches?

15.2 What points would you keep in mind in selecting problems for action research? Discuss with an example.

15.3 Discuss different areas in which you can identify problem for action research.

15.4 Can you generalise the findings of action research? If not, how can action research add to the existing knowledge? Discuss.

15.5 Discuss why should a teacher participate in action research? Justify your answer with an example.

15.6 'Action research is carried out by teachers with the aim to improve educational processes and class practices.' Justify the statement. Make a survey report by selecting the practising teacher who are conducting action research.

15.7 Can action research be quantitative? Formulate one such action research problem from the area of physical science.

15.8 Interact with a practising teacher and talk about the problems she faces in teaching-learning situations. Make a list of them. Select any one problem and develop a detailed plan for the action research discussing with her.

15.9 Identify the areas/steps in action research, where a computer can be used as a tool for collection, analysis and interpretation of data and communication of the findings of action research in physical science? Explain with an example.

15.10 When you were engaged in practice teaching, what questions/problems regarding teaching-learning of physical science came to your mind, the answers/solution of which you would like to look for? Write any three. Formulate brief action plan to solve those questions/problems.

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