

# UNDERSTANDING OF SCIENCE CONCEPTS USING PRACTICAL SKILLS AT SCHOOLING

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## ABSTRACT

The central role of experiments and practical work in the school science curriculum is universally accepted. A balanced science curriculum should not only give due emphasis to both theory and experiments but also integrate these complementary aspects of the subject in the teaching-learning process. Present-day science, as we all know, is the result of the creative interplay of observations, experimentation, and theoretical inferences. The importance of practical work in science education has also been recognized and greatly emphasized in the national policy of education for the past several decades. However, despite several laudable efforts in the past, experiments, by and large, have continued to be marginalized in the schools. The challenge arises due to the combination of several factors. The school should be keen to find out ways to promote laboratory work in the subject and introduce greater uniformity, objectivity, and reliability in the assessment of practical work. The National Policy of Education (NPE) 1986, stresses the importance of science education, in these words, "science education will be strengthened so as to develop in the child well-defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to ask questions and an aesthetic sensitivity". This enhanced responsibility can be adequately performed only when science teachers are equipped with required scientific competencies. Science teaching, as these do not adequately develop the mastery of such competencies. It has, therefore, been emphasized that innovative approaches may be inducted into science clubs to sharpen the scientific competencies in both students and teachers. According to NCF-2005 teacher should act as a facilitator and not as a transformer of content where they can think, realize, analyze and develop their own way of learning which something beyond the textbook.

**KEYWORDS:** Practical skills, Science concepts, Science and technology.

## INTRODUCTION

In many parts of the world, science education occupies a comparatively insignificant place in school. Unfortunately what actually happens in the classroom under the label of science is often totally inadequate. Teacher training both pre-service and in-service, is one of the keys to this problem. Starting from the premise that this training should be carried out in ways more closely related to the active methods which teachers are expected to use in their school. The crucial role of experiments in the school science curriculum is universally accepted. A good science curriculum must not only give balanced emphasis to both theory and experiments but also integrate these two essential and complementary aspects of science in the teaching-learning process. Modern science, as we all know, is the result of a creative interplay of experiments, observations and theoretical inference.

There are several ways in which experiments facilitate and improve the learning of science. First and foremost, experiments help students develop the right perspective of science, namely that science is not just a theoretical abstraction – it is an attempt to describe the working of the real world around us. A hypothesis or idea in science is acceptable only if observations and experiments confirm it. Second, experiments are among the most effective ways to generate interest in science. For many students, an apparently 'dry', 'uninteresting' fact of theory in the textbook can become live and exciting when translated into an experiment. Third, experiments promote the basic skills and competencies of doing science: procedural and manipulative skills, observation skills,

skills of representing and interpreting data and the accompanying conceptual and critical abilities. For these various reasons, promoting activity and experiment-based learning has been at the heart of many efforts aimed at improving science education in our country.

Despite several laudable efforts in the past, experiments, by and large, have continued to be marginalized in our schools. There seem to be two principal difficulties. Firstly, experiments require a certain minimum infrastructure – a laboratory with some basic equipment and consumables on a recurring basis. Secondly, an assessment of practical skills in science in a sound and objective manner is by no means an easy task. The difficulty multiplies manifold if an assessment is to be carried out on a large scale. Thus lack of infrastructure and, more important, lacks of reliable assessment have resulted in the unfortunate neglect of experimental work in most of the schools in India. In the last two decades, the impact of science and technology is visible everywhere. These recent innovative ideas in science have influenced every aspect of existence- vocational, social, economic, political and cultural. Science is intimately related to the means of production and means of communication. The exposure to science that students in our schools normally get creates in them an impression that science is a well-settled body of facts, principle, and theories. Even the laboratory work which they sometimes do consist of experiments set to a pattern, leading to results that are already known. With a little modification in approach however, the teacher can so design the experiments, that this weakness is removed from learners.

Science is a human endeavor which sharpens the mind through systematic and logical thinking. The practical skill inculcates many values in the learners. Noteworthy, among these, are reasoning ability, democratic and cooperative learning, accepting and rejecting the arguments on the basis of its merits and demerits, creative thinking and above all satisfaction of doing something. All these values generate confidence in the mind of the learners, which in turn helps the learner to become a responsible citizen of the country.

An experimental skill for science concepts, on the other hand, involves a search to understand the unknown and begins with a question. In doing the usual science concept for practical, you report on, something that someone else has discovered. This does not mean that doing an experiment will earn your world- fame as a discoverer. It does mean that you can discover something, a fact or relationship that was unknown to you and that was not recorded in any book available to you. Scientists refer to this as an independent discovery. The National Policy of Education (NPE) 1986, stresses the importance of science education, in these words, "science education will be strengthened so as to develop in the child well-defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to ask questions and an aesthetic sensitivity". According to NCF-2005 teacher should act as a facilitator and not as a transformer of content where they can think, realize, analyze and develop their own way of learning which something beyond the textbook.

Encouraging learners to carry out practical's would also help develop in them the scientific attitude with its emphasis on objectivity and open-mindedness. The idea for practical skill may originate from something that has been taught in the class or read in a book or from the general surroundings. Science can be learned efficiently through experimentation. Abstract scientific principles can be understood and can be correlated with daily life experiences through activities and experiments. Though a science textbook incorporates many activities these activities are not being performed properly in the classrooms. Hence these activities need to be systematized and procedure of some important experiments must be formulated which will translate the basic scientific principles. The science teachers at the school level must be trained properly to perform some basic experiments in order to inculcate scientific temperament and appreciation for science. Use of the practical skills for science concepts may be helpful to understand several science terms.

## NATURE OF LEARNING IN SCIENCE

In this step, we discuss some of the central reasons for promoting active learning in science. It is most important for teachers to have a rationale which makes sense to them and explains to others why learners should have certain learning experiences. This rationale relates to the nature of the scientific activity, what it means to learn science and how learning is brought about. Views of these things have a profound influence on the activities teachers provide for learners, how they organize and manage their classrooms? what role they adopt, the way they use equipment and materials, and the criteria they use in assessing and evaluating the success of the work.

To substantiate this claim, suppose, just for the sake of the argument, that a particular teacher's view of learning is that it is a matter of rote memorization. This teacher will provide learning experiences which expose students to accurate facts and encourage them to memorize procedures and algorithms. To do a good job of this the teacher will probably provide the information in digestible packets, each to be mastered before the next is attempted. The class will be arranged to optimize exposure to information from the teacher, from the blackboard and from books and to minimize interference from nonauthoritative sources, such as other learners. The teacher's role will be seen as to ensure attention, to present information clearly and to reward accurate recall. The student's role is to attend, to memorize and to recall, materials may be used to illustrate applications of facts already learned or simply to add interest and prevent boredom. Assessment criteria will be defined in terms of recall of information.

If the teacher has a different view of learning, where the learner is active in creating understanding and using process skills to test and modify ideas, then the classroom provision consistent with it will clearly be quite different from that described for rote learning. Now the experiences provided will enable learners actively to seek evidence through their own senses, to test their ideas and to take account of others ideas through discussion and using sources of information, the organization will facilitate the interaction of students with materials and students with students, the teacher's role will be to help learners to express and test their ideas, to reflect upon evidence and to question the way they carry out their investigations, the materials have a central role in providing evidence as well as arousing curiosity in the world around. The assessment criteria must include the reference to process skill development and understanding of ideas, and not neglect the development of scientific attitudes. Both of these teachers provide a learning environment which is consistent with their view of learning. Many teachers cannot provide all the opportunities for their learners which they value and would like to provide, but they find ways of minimizing the effect of the constraints on their work and they are aware of the shortcomings of some of the learner's classroom experiences. It is the self-imposed constraints under which some teachers work because of a limited view of science and of learning in science, which can be avoided. Thus it is important to begin by discussing the nature of learning in science.

### Scientific activity

Science is a human enterprise through which we come to some understanding of the biological and physical aspects of the world around. This 'understanding' involves the development of ideas or concepts which enable related situations, objects or events to be linked together so that past experience enables us to make sense of new experience. Developing concepts is an essential part of all learning not just in science. If we did not develop concepts, then each new object we encounter would cause us a problem of identification, we would not be able even to identify a chair for what it is unless it was identical to one with which we were already familiar. But as it is we can recognize a chair we have never seen before as a chair, or a previously unknown living thing as living, or realize that something which seems to disappear in water has dissolved rather than vanished, because we already have ideas which help us make sense of these things.

Building up ideas about the scientific aspects of the world is the business of science and science education. The ideas of science change as scientists extend their explorations and expose their theories to wider testing. In attempting to understand something new, scientists use existing ideas and test the extent to which they fit the evidence from the new situation or object under investigation. The result of this testing may be the confirmation that the existing ideas do fit and help in understanding the new observations, or it may reveal the need to modify or perhaps entirely reject the use of existing ideas because they do not fit the new evidence. Similarly, in learning science the ideas that an individual has gradually change as experience and ability to reflect on experience accrue. Imagine there is a very small candle or taper burning in a large, darkroom. As you gradually move away from it, it becomes fainter and fainter. At some distance, you cannot see it anymore:

1. Would the distance at which this happens be the same if the room were lit up?
2. If not, would the distance at which you cannot see the candle be shorter or longer than when the room is dark?
3. If the candle were replaced by a small white ball (table tennis ball, for example), what would your answers be to these same questions?

### Reflecting on learning in science

Reflecting on these and on other learning experiences which you may recall, you were developing greater or new understanding by testing initial ideas against evidence. If necessary, you change your ideas so that they agree with the evidence. Building ideas in this way is at the heart of science and of science education.

If we now change focus from the ideas about light to the way in which the ideas were tested and used, you will probably find that in these activities you have been:

- Making predictions.
- Giving hypotheses.
- Planning and then carrying out an investigation to test your predictions.
- Making observations.
- Interpreting observations
- communicating with others about your and their ideas. These are among the activities often described as the processes or methods of science. They are chiefly mental skills, but also involve some associated physical skills. They are concerned with processing evidence and ideas, and so are often called process skills.

Through using these process skills you may have clarified, queried, perhaps modified, or in other ways developed your initial ideas or concepts about light and how things are seen. This development is not an automatic process, however. What results from trying out ideas depends on the way in which they are tried out. If these processes are not carried out in a rigorous and scientific manner, then the emerging ideas will not necessarily fit the evidence, ideas may be accepted which ought to have been rejected, and vice versa. Thus the development of ideas depends crucially on the processes used.

In the case of learners, we know that they often observe superficially, looking for confirmation of their ideas rather than being more open-minded and using all the evidence available, we know that their first attempts at prediction are really based on what they already know to be the case rather than being true predictions, the tests they carry out are often far from being 'fair' or controlled, they rarely check or repeat observations or measurements. Just as their ideas or concepts are limited and immature, so are their process skills, and both are



capable of development. The dependence of concept development on the way in which learners are tested, that is, on the use of process skills, provides one part of the rationale for the importance of developing these skills. It cannot be too strongly emphasized that attention to developing process skills is not for any supposed value in their own right, but because of their value in developing concepts.

A second part of the rationale for giving attention to process skills is implicit in the type of learning just described, learning in which the learners collect. The evidence and does the reasoning, making the ideas his or her own. This is what we may call learning with understanding. Learning without understanding, as in rote memorization, does not require the use of process skills. We need not linger long on the faults of rote learning, but it is worth observing that much science was taught in a way which leaves students little option but to learn facts by heart. This leads to science is regarded as a mystery, as not making sense and has nothing to do with understanding the world around, which is surely the aim of our science education. Moreover, we want students and future citizens to feel at ease with science, to know its strengths and weaknesses, even if they are not practicing science, and the best way of achieving this is through the experience of finding things out and working out ideas. We now consider at a theoretical level how learning, in terms of the development of ideas, depends on the way of gathering evidence and testing ideas.

### **Process skills in teaching-learning**

We have just seen that the understanding of the world around depends on the development of concepts, but this development depends on the use of the process skills. One of the existing ideas is linked to the new experience in preference to other possibilities because of some perceived similarities. The processes involved in this may include observing, hypothesizing and communicating. The idea which has been linked is then tested against evidence to see whether or not it helps in making sense of the new experience. If it does, it will emerge reinforced as a more useful idea, strengthened by having a wider range of applications. But whether or not this happens, or whether the idea is found to need modification or should be rejected, depends on the way in which the testing processes are carried out.

The testing processes include raising questions, predicting, planning, carrying out investigations, interpreting, making inferences, observing, measuring and communicating. The process depends on the learners using and testing ideas they already have. If we now think of the new experience as being one provided in school so that learner can learn, then we see that process skills and attitudes exercise a determining influence on the extent to which conceptual learning takes place. The ideas and understanding which learners achieve from an experience will depend on their ability to carry out the processes scientifically. But, like concepts, these skills and attitudes have to be developed gradually. The points related for investigation of process skills are given below:

- Manipulating materials and equipment effectively
- Measuring and calculating
- Observing
- Predicting
- Devising and planning investigations
- Finding patterns and relationships
- Hypothesizing
- Raising questions
- Communicating effectively

## PRACTICAL SKILLS FOR SCIENCE CONCEPTS

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 learners 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 the ability to identify a problem, to design and to set up the experiment, to collect and analyze data through experiment, and to interpret data to arrive at a plausible solution in due course of time. These are, in fact, the long term objectives of laboratory work and become the nucleus of the philosophy of construction of knowledge by the learner. A school science laboratory is a place where basic experimental skills are learned by systematically performing a set of prescribed and suitably designed experiments. Performing experiments by one's own hands are not only a thrilling experience but are also important because it entails learning by doing. It also facilitates an understanding of the concepts of science. The experiments and project work suggested at the secondary stage intend to develop basic skills of measurement, handling of some common measuring instruments, equipment, and chemicals, setting simple apparatus, handling microscope and preparing slides, making observations, collecting data and presenting it in appropriate format interpreting and drawing conclusions, and preparation of report. There are certain rules and regulations that every student must be familiar with before undertaking practical work in a laboratory. A student is required to be acquainted with the general facilities and the equipment available in the laboratory and follow the rules and regulations. Generally, at the beginning of the session, the teacher takes the students around the laboratory to familiarise them with the general facilities available in the laboratory and tells them about certain do's and don'ts while performing the experiments in the laboratory. For the laboratory work categories of practical skills are given below:

### 1. Procedural and manipulative skills

- Select appropriate apparatus / instruments for performing the experiment.
- Know the limitations of the apparatus/instruments regarding their size, least count and accuracy.
- Arrange/assemble/ set and adjust the apparatus systematically.
- Handle the apparatus, instruments, chemicals carefully to avoid any damage or injury.
- Perform the experiment with reasonable efficiency and accuracy.
- Separate and remove desired parts of a specimen for detailed study without damaging it.
- Use appropriate methods and materials for specimen mounting.
- Locate and rectify the errors in apparatus, instruments, etc.
- Add chemicals in the appropriate quantity.
- Dismantle the experimental set-up carefully.
- Practice the precautions in handling sensitive apparatus or chemicals or flame.

### 2. Observational skills

- Find the least count of the instrument.
- Read the instrument correctly.
- Notice color change, the evolution of gases, formation of precipitates, chemical reactions, etc., carefully.
- Notice the relevant details in the given specimens minutely.
- Locate the desired parts in a specimen accurately.
- Take observations carefully and in a systematic manner.
- Read the graph correctly.

### 3. Drawing skills

- Make proper observation tables.
- Draw circuit diagrams, ray diagrams, experimental set-ups, sketches, etc. correctly and proportionately.
- Label sketches and diagrams correctly.
- Draw graphs from observed data correctly.

### 4. Reporting and interpretative skills

- Make a proper plan for recording the observations.
- Record the observations/data/information correctly and systematically.
- Classify and categorize organisms.
- Make correct calculations/predictions.
- Use proper formulae and mode of summarizing and reporting the result.
- Report the result using correct symbols, units, terms, and chemical equations.
- Interpret the observations and results correctly.

Laboratory skill is an integral part of school level science curriculum (Primary, Upper Primary, Secondary, and Higher Secondary level). If properly planned and conducted, practical skills can provide a first-hand experience of the various activities that comprise science. Practical skills are meant to (i) develop the skills required to perform the experiments and (ii) to strengthen the understanding of the theoretical concepts pertaining to the experiments done in the laboratory. The important skills required in science practical are meant to assist the learners to learn and develop the skills of manipulation- involve the correct and skillful handling of the apparatus by the experimenter. Observation- involves the use of senses hearing, sight, touch and smell to detect changes/reactions. Reading- refers to the ability to comprehend written or printed information. Recording- entails writing down, for example, measurements or statements of facts or other details for reference. Computation- the use and application of mathematical knowledge on the data collected. Interpretation- studying the data collected and drawing conclusions based on the established science principles/theories. The success achieved by following these skills not only trains one in these abilities but also increases confidence in the method of science. Encouraging learners to carry out practicals would also help develop in them the scientific attitude with its emphasis on objectivity and open-mindedness. The idea for practical skill may originate from something that has been taught in the class or read in a book or from the general surroundings. Science can be learned efficiently through experimentation. Abstract scientific principles can be understood and can be correlated with daily life experiences through activities and experiments. Though a science textbook incorporates many activities these activities are not being performed properly in the classrooms. Hence these activities need to be systematized and procedure of some important experiments must be formulated which will translate the basic scientific principles. The science teachers at the school level must be trained properly to perform some basic experiments in order to inculcate scientific temperament and appreciation for science. Use of the practical skills for science concepts may be helpful to understand several science terms which include the following:

1. To stimulate an interest in science subjects.
2. To improve their experimental and communicational skills and to develop scientific attitude and interests.
3. To inculcate divergent thinking and cooperative attitude among the students.
4. To make science subjects more creative, enjoyable and sound fundamental knowledge of facts and principles.
5. To satisfy scientific curiosity.

6. To encourage independent thinking.
7. To make use of the environment.
8. To give practice in critical thinking.
9. To develop problem-solving techniques.
10. To make scientific principles more meaningful.
11. To increase self-confidence.

The experiment should be so designed that its results are clearly interpretable. Interpretation becomes difficult if the variables are not identified and suitably controlled. The initial design of the experiment must be carefully looked into so that some of the possible sources of error can be located and steps taken in the design to correct. Before actually starting the experiment, a list of materials required must be prepared and all the materials procured according to the list. It would also be convenient if a method of recording the data has been decided upon so that the necessary tables etc. , could be prepared before the experiment is started. During the experiment, accurate observations must be made and duly recorded, exactly as they happen. The data collected should be arranged in a methodical manner so that interpretations would be facilitated. The results and conclusions of the practice will have to be presented finally as a report. There are a number of ways in which the experiments can be modified and improved. If these practical skills can generate ideas not only for the improvement of the suggested designs but also for new experiments, their purpose would be amply served. The steps involved in an experiment skill for science concept are:

**1. Providing a situation-** Experiment work almost always should be initiated by teachers. He/She should provide situations to the students which motivate to create some problem for them and in which they feel interested to work.

**2. Purpose and selection-** While selecting the experiment, for science concepts, the teacher should see that practical should be relevant to this level of skills. The objectives of practical should be clearly defined and understood by the students.

**3. Planning-** The success of an experiment work depends upon a good planning. The students should plan out the whole scheme under the proper guidance of the teacher. After a discussion of the practical work with the teacher and group of students should write down the plan properly.

**4. Executing-** The teacher should assign different tasks among the students of a group according to their interest and abilities. Every student should contribute actively towards the execution of practical work and skill. Some of the students may be assigned the work of library to collect information about the experiment. The student who is good in laboratory work must be given the task to perform an experiment and he/she can also collect the data. In the same way, different tasks may be assigned to different students and teacher should give instructions wherever need be.

**5. Evaluation-** Evaluation should be done in terms of objectives. The work must be judged by the teacher and it should be reviewed in terms of the error committed by the students. Each practical should be evaluated on its own merits, not in competition with other practical's and with the abilities, interest, and background of the student given full consideration.

**6. Recording-** The students should keep a record of all the work i.e. how they planned, what discussion was held and finally criticism of their work and some key points for future reference.



## CONCLUSION

Experiment skills for science concepts can make the study of science more exciting, enjoyable and educational. This provides an opportunity for teachers and learners to get a first-hand experience of the process involved in scientific concepts at the school level. It represents one method of helping learners explore their special interests in depth. The resulting finding is often for more valuable to the students who are involved than the information presented in regular class periods. The main objective of this book is to assess on science concept to promote the practical skills in order to enrich the science teachers and students in learning and systematic performance of science experiments to relate the science concepts effectively with experiment skills.

## REFERENCES

1. National Policy of Education (1986) New Delhi, MHRD, Govt., of India.
2. National Curriculum Framework-2005, National Council of Educational Research and Training, New Delhi.
- 3..Position paper on National Focus Group on Teaching of Science-2006. National Council of Educational Research and Training, New Delhi.
- 4.Science textbook for Class IX -2005. National Council of Educational Research and Training, New Delhi.
- 5.Science textbook for Class X -2006. National Council of Educational Research and Training, New Delhi.
- 6.Laboratory Manual Science Class IX -2008. National Council of Educational Research and Training, New Delhi.
- 7.Laboratory Manual Science Class X -2008. National Council of Educational Research and Training, New Delhi.
- 8.Pedagogy of Physical Science Part I and Part II-2013. National Council of Educational Research and Training, New Delhi.
- 9.Development & training programme on practical skills for secondary science teachers, held at Regional Institute of Education(NCERT), Bhopal,2015-16.
- 10.Training programme of secondary science teachers on conducting an experiment of science using secondary science lab. kit, held at Regional Institute of Education(NCERT), Bhopal,2016-17.
- 11.Training programme on practical skills in science using science kit for secondary school science teachers, held at Regional Institute of Education(NCERT), Bhopal,2017-18.
- 12.Training on the use of science kit for secondary school science teachers, held at Regional Institute of Education(NCERT), Bhopal,2018-19.

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