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NOTES PAPER- V

PEDAGOGY OF PHYSICAL SCIENCE

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Meaning & Nature of Science:

According to APEID (1983) document, 'Science is an organized and ordered way of investigating and understanding the world which is essentially practical in nature.'

Einstein says, "Science is an attempt to make the chaotic diversity of our sense experience correspond to logically uniform systems of thought."

In the words of Griggs, 'In the literal sense science means the pursuit of knowledge but it has a wider cannotation for our purpose, and can be said to mean a knowledge of nature in the widest possible form. This includes nature study, physics, astronomy, mateorology and much more. It is equally important to look beyond mere precise definition and see what science includes and the following are of fundamental importance to the approach to this subject:-

(a) Direct & indirect observation.

(b) Scientific Inquiry-asking questions.

(c) The Drawing of inference from evidences.

(d) Recording observations.

(e) Developing ways and means to find answers.

(f) Classification and checking evidences.

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

According to the Columbia dictionary – 'Science is an accumulated and systematized learning, in general usage restricted to natural phenomenon.'

On the basis of these & many other definitions, we can conclude, that:-

(a) Science is a study of natural phenomena.

(b) It is an organised & systematized learning.

(c) It is a body of cumulative & ordered observations.

(d) It is the knowledge based on observation, experiment & interference.

(e) Science is a process as well as the product of that process.

Thus, we can conclude, **Science is a systematic & organized body of knowledge, based on cumulative observations, experiments & inferences, and is involved in finding out the meaning of various phenomenon of nature.** (S. P. Kulshrestha & J. K. Sood, 1987)

Meaning & Nature of Physical Sciences

The science teaching is generally divided into two main categories:

1. Life sciences or Biological sciences,

2. Physical sciences.

1. Life Sciences: According to Sharma (1982), **"Life Sciences is the new nomenclature by which Biology-i.e. Botany and Zoology-is referred to, in the new set up and it is quite apt, that the science of life and living things is so termed. It would be our endeavour to try some of the new ways, in the discipline of life-sciences, for a proper and utilitarian outlook in the teaching methods."**

2. Physical Sciences: 'Physical sciences group includes those branches of science which are related with the study of non-living material.' In other words, the Physical Sciences includes mainly two subjects-Physics and Chemistry.

Physics is the branch of science which deals with the nature and natural phenomena. It is the science which explains the natural phenomenon or the behaviour of a natural system on the basis of the established laws of nature.

Physics is the 'study of the properties of matter & energy and concerns both, the macroscopic & microscopic state of the matter.'

Chemistry, is the branch of science, which deals with the study of material substances particularly about their composition, properties (i.e. characteristic qualities) and reactions that change them into other substances.

Chemistry is the study of the materials that make up the universe and the changes which these materials undergo. The develop-

ment of Chemistry is based upon the systematic approach of the scientists in carrying out different experiments, recording careful observations and making scientific inferences and generalisations.

In simple words, **'Chemistry is the study of the composition of substances and of their effects upon one another.' (Dictionary of science).**

Physical sciences is the combination of both Physics and Chemistry.

Nature & Charactristics of Physical Sciences:

Physical sciences has the following characteristics:

(1) Physical sciences provide essential background of knowledge for cultural developments.

(2) Physical sciences help in developing & fostering the scientific attitude, scientific interest and scientific outlook among children by providing solutions for day to day problems.

(3) It helps in training the children for developing scientific temper and scientific creativity.

(4) It stresses on the values of open-mindedness, intellectual honesty, creative thinking, and dedication.

(5) It helps in building the self-confidence, and systematic approach to day to day problems.

(6) It provides training in scientific method.

(7) It studies non-living things, material & substances.

(8) It explains the natural phenomenon on the basis of established laws of nature.

(9) It is also the study of the composition of various substances and of their effects upon one another.

(10) It is both product & process. In its process form, it suggests ways and means of exploring the truth and in its product form it presents a systematic and organised body of knowledge.

(11) The process form of physical sciences is more important than its product form.

(12) Physical Sciences always (constantly) remains in search for truth.

(13) The Physical sciences adapts the **'scientific method'** which is known as reliable, valid, objective, unbiased and verifiable.

Therefore, it is true to say that the **physical sciences is 'an over all product of human activity in the form of a systematic and organized body of knowledge. It is the product of all facts, connected with our information,**

concepts, generalisations, laws and theories framed on the basis of vast fund of accumulated knowledge.'

W. C. Dampier, defines it as, **"ordered knowledge of natural phenomena and the national study of the relations between the concepts in which those phenomena are expressed."**

On the basis of the above definitions, explanations, characteristics & nature, we may conclude that the **Physical Sciences is the discipline, which concerns with the study of properties of matter & energy and also with the study of the composition of various substances and of their effects upon one another. It helps in explaining the natural phenomenon on the basis of established laws of nature. Physical sciences helps children in developing scientific temper and other scientific virtues and values. (Kulshrestha & Sood)**

Values & Importance of Physical Sciences

Physical sciences is a very important and valuable discipline for any country. It is already said that it helps in developing scientific temper, scientific outlook and scientific attitude. Without them no country can make any scientific advancement. The values, importance, applications and advantages are being discussed in the following pages:-

(1) Intellectual Value:

According to the **American Association of Advancement of Science (AAAS), "We believe that the primary goal of science education should be intellectual development of individual."** Physical sciences helps to know facts, spirit of enquiry & judgement. Its aim is to search the truth. It requires diligence & patience. It helps in to understand, evaluate and solve numerous social problems of life. It trains the students in scientific method. Students become more logical, develop better reasoning ability, creativity and sharp intelligence.

The study of Physical Sciences provides opportunities to develop all the intellectual abilities like sense of meaningful observation, fact reasoning, purposeful thinking, concentration, analysis and synthesis. It avoids bias/prejudices and helps individuals to sharpen their intellect and makes them intellectually honest. **Thus, Physical Sciences, gratifies and quenches the thirst of knowledge.**

(2) Utilitarian Value:

No subject can be compared with Physical Sciences as far as its importance and utility in daily life is concerned. We are living in the age of science. We find a net work of scientific gadgets everywhere in our daily life. e.g. Television, Video, Tape Recorder, Computer and Robbets etc. We

travel by train and plane or by other vehicles. We listen news on Radio, T.V. & Computer. We talk with a person who is in the remote area with the help of Telephone & Wireless. Today the man has reached the Moon and trying to reach Sun etc. They are able to explore Mountains, Deserts, and Oceans. In other words, now science is playing an utilitarian role to improve the standards of our life. Physical science has become more useful and helping instrument in guiding our daily living and living styles.

(3) Disciplinary Value:

Physical Sciences develops and controls the mental abilities of an individual. It also helps in developing the habits of truthfulness, sense of logical reasoning, creative and critical thinking. It inculcates spirit of enquiry, seriousness, open-mindedness, and unbiased decision taking. It helps in conducting proper, unbiased and balanced evaluation.

It promotes the concentration, systematic work, healthy exchange of thoughts and hard work habits. It trains mind and develops the habit of spending disciplined life and working with confidence.

(4) Vocational Value:

Physical Science has generated a number of vocations and helps individuals in earning their bread. Now a days, Physical Sciences have become an integral part of Dairy, Poultry, Agriculture, Banking, Teaching, Factories, and many other vocations. The job of scientists, engineers and research workers need the knowledge of science.

Thus, Physical Sciences play a vital role in learning and acquiring different professions & their professional skills. **"The study of science at school forms the basis of many useful hobbies and other productive activities in the later life of students."**

Scienfitic hobbies motivate to adopt simple cottage industries like manufacturing of soaps, washing powders, face creams, scented oils, powders, polishes etc. Repairing of T.V., Computer, Telephone/cordless etc. are the new avenues provided by the Physical Sciences. Thus, almost in every vocation, the knowledge of Physical Sciences is must and hence possesses wider signficance.

(5) Aesthetic Value:

It is correct to say, **"Science is beauty, art, a source of entertainment and a successful means of attaining physical comforts."** Science promotes **'truth' and 'Truth is beauty'. "The discoveries of mysteries of nature are the concern of science and everything in nature is beautiful."** Thus, Physical Sciences possess aesthetic value.

Every scientist relishes the aesthetic aspect of his inventions and discoveries. It provides, training in cleanliness, truthfulness and honesty. They help us in developing aesthetic values, which emphasizes on systematic, well-organized and well-thought out plans & actions.

(6) Cultural Value:

Physical Sciences possess cultural value as it forms an essential part of our social heritage. It effects our way of thinking & way of living. **'The cultural aspect of science should be fully appreciated by science students. Science has aided the growth of consciousness by making us more aware of the universe we live in and more so by heightening our intellectual discrimination just as a work of art can be valued for its effects in refining, and subtlizing our emotions.'**

Indian Education commission is right [illegible] observes, **"If science is to be pursued with full vigour and zest and is to become a mighty force in the Indian renaissance, it must drive its 'nurishment' from our cultural and spiritual heritage and not bypass it Science must become an integral part of our cultural and spiritual heritage."** Physical Sciences affect & influence thinking, beliefs, traditions, customs, ways & life styles which in turn affects & influences the culture as a whole.

(7) Psychological Value:

The teaching of Psychology is based upon sound scientific principles and the teaching of science depends on fundamental principles of psychology. Science satisfies common psychological instincts as creativeness, self-assertion, curiosity and emphasizes on the psychological principles of 'Learning by doing', 'Learning by observation'; and 'Activity method' etc.

(8) Social Value:

Science and society have become two sides of one coin. Science gives impetus to the progress of society by its new ideas, thoughts, discoveries and inventions. It brings the whole world and all people very close. Computers, Intranets, Internets, P.C.Os, S.T.Ds I.S.Ds. are contributing to their maximum to bring whole world together. Science has become the boon for the society. Without science society cannot progress. Science has become the pillars of the society. Science helps in making social life happy, healthy, comfortable and easy.

(9) Moral Value:

Science develops morality in human being. **'A man of morality is the true and exact man. This truth and exactness is the outcome**

of science, Darwin says, 'Only the men with high morals exist and they are the believers and followers of Science.'

According to the Kolhari Commission "Science strengthens the commitment to man of free enquiry and to the quest for truth as his highest duty and obligation. It loosens the bonds of dogmatism and acts as a powerful dispeller of fear and superstition, fatalism, and passive resignation." Science builds a love for truth. 'True scientists are lover of mankind'. They cannot ignore truth as their success is based on truth and honest experiments. They draw honest conclusion based on true observations. They never manipulate observations and never misinterpret the facts.

Bhandula & Chadha are right when they say, 'Truth', 'Goodness' and 'Beauty' are the three vital necessities of a morally high person. Science teaches students to be intellectually honest, truthful, and morally integrated as it is the only activity, where the essential condition for success is impartial, honest, unemotional and truthful mind."

In the words of Mangal (1997), "Science and its pursuit not only include all the traits of morality but also develop them. The qualities of honesty of purpose, truth, justice, puntuality, determination, patience, self-control, self-respect, self-confidence and tolerance are automatically developed in man if he follows scientific method in his pursuit of knowledge."

Thus, we may conclude that the physical sciences are very essential discipline and possess an important place in our life. It gives the knowledge about various phenomena & facts and also trains students as balanced, & cultured citizen by preparing them vocationally, intellectually, aesthetically, psychologically, culturally and also morally. It is very useful subject in developing scientific hobbies, scientific attitudes and scientific temper. Therefore, this subject has every right to be included in the school curriculum in modern times. ●

HISTORY OF SCIENCE IN THE WEST

1. Amateurs—At the end of 18th century, Western Universities sadly neglected the teaching of science and it had no place in the school curriculum. Chief scientific discoveries were made by amateurs such as *Cavendish, Priestley, James Watt* and *Hershel.*

2. Societies—A number of philosophical societies were started such as Society of Arts, London, Literary and Philosophical Society of Manchester founded in 1781 and Lunor Society of Birmingham (1766) to fill the gap between the educational provision and social need. These societies did remarkable work for popularising science among the general public.

3. Royal Institute of Great Britain—In 1799, Rumford was influential in founding the Royal Institute of Great Britain, intended for teaching youngmen in the mechanical profession by courses of philosophical lectures and experiments on the application of science to common purpose of life. But later its policy was altogether changed by the influence of Sir Humphry Davy and of Faraday, and this society became a great centre of research.

4. Mechanic's Institute—An important event in the history of teaching science happened with the Mechanic's Institute of the early nineteenth century. *John Anderson* was the first who attempted to give a course of lectures on Experimental Physics. He was, however, convinced of the cultural possibilities of science teaching. In 1823 was established Glasgow Mechanics Institute raised to Technical College in 1866.

5. Other Instiutes and Societies—Many other mechanical institutes were started in nineteenth century. In the early part of the nineteenth century, many other philosophical societies were at work. By the middle of nineteenth century, however, there were very few

schools which were imparting instruction in science. The first practical Chemistry lessons were started by *Thomas Hall* at City of London School in 1847. The centenary of science teaching was celebrated by a large and eminent gathering at the school in 1948.

6. Royal Commission of Education Report Follow up—Royal Commission of Education reported that in none of the schools was science taught as an independent subject though at Rogby, Natural Science was taught to boys who elected to study it instead of languages. They described it as 'a plain defect and a great practical evil'. They suggested that Natural Science should be taught and should include two main branches, one comprising Physics and Chemistry and other Comparative Physiology and Natural History. As a result of this, Physics was introduced in 1837 at Rugby under Dr. Arnold. Dr. Tait, his successor, introduced Botany, Chemistry and Geology in the curriculum in 1859. A science lectureroom and laboratory were built for the first time at a cost of over £ 1,000.

7. Exhibition of 1851—The great Exhibition of 1851 gave a further impetus for teaching science in schools. A Department of Science and Art was established in 1853.

8. Eminent Scientists—In 1854, three eminent scientists urged the claims of science as an essential part of general education.

(i) *T.H. Huxley* delivered an important address on the Educational Value of the Natural History of Sciences.

(ii) *John Tyndall* lectured on the study of Physics as a branch of education.

(iii) *Faraday* stressed the importance of cultivating a scientific outlook.

(iv) In 1861, *Herbert Spencer* believed that 'knowledge of life was the important knowledge for all Moral and Physical'.

(v) The most staunch advocate of teaching science in the 'sixties' and 'seventies' was Huxley.

9. Progress of Natural Science—The establishment of natural science course in the Universities of Oxford and Cambridge further paved the way for the inclusion of science in the curriculum of Secondary Schools. A full survey of the position of science teaching in Secondary Schools is contained in the *Devonshire Commission Report* published in 1895. It begins with the discussion on the difficulties attending the introduction of science teaching in the schools. It

recommended that (i) in all public and endower schools, a substantial portion of the time allotted to study be devoted to Natural Science, and that not less than six hours a week on the average should be assigned for this purpose; (ii) school laboratories should be constructed to supply accommodation for practical work in Physics as well as in Chemistry. The publication of this Report marked the beginning of the widespread introduction of Physics and Chemistry in the curriculum of Boys' schools and of Botany into that of Girls' schools.

10. Public Examinations—Public examinations in sciences and other subjects are of very recent origin. Designed to qualify for membership, Society of Arts of London held science examination in 1852. In the course of few years the system became established. Papers were set in Chemistry, Physiology, Botany, Mathematics and Mechanics. For the guidance of candidates, the society published a handbook entitled *"How to Learn and What to Learn."*

11. H.E. Armstrong—The most outstanding contribution to the history of teaching science in the last quarter of nineteenth century was that of *H.E. Armstrong,* professor of Chemistry in the Central Technical College, City of Guildes of London Institute. Very much dissatisfied with the science work in schools he was critical of the teaching method adopted. He advocated that all pupils, even beginners, should be allowed to discover things for themselves, and should be placed in the position of the original observers. Later on, this methods was known as the Heuristic method. It has been largely modified now. Nevertheless, the heuristic spirit permeates the whole of science teaching.

12. Beginning of 20th Century—Since the beginning of twentieth century, there has been an adequate increase in the equipment and facilities for teaching science in schools. The Great World War of 1914-18 opened the eyes of the general public to the importance of general science in the modern world. In 1916, *Sir J.J. Thomson* appointed a committee, to inquire into the position of Natural Science in the educational system. The so named 'Thomson Report' was published under the title 'Natural Science in Education'. As a consequence many advanced courses in science were added to many schools. The Science Masters' Association and the Association of Women Science Teachers were formed in the early century. School Science Review, the S.M.A. Periodical, created a good influence on the teachers as well as the public.

Board Education set up a consultant committee on secondary education, in 1933, under the chairmanship of Sir Will Spens. The report was published in 1938 under the title *"Spens Report"*. The teachers were, however, disappointed with the attitude of the Report towards school science. A few years later, a committee of the Secondary School Examination Council was formed under the chairmanship of Sir Cyril Norwood. Their recommendations and conclusions were published in 1943. Briefly known as *'Norwood Report'*, it, contained a chapter dealing with Teaching of Science. As a consequence of all this the *Education Act* of 1944 came into force in April, 1945 which has meant an increase in the amount of science taught though not to the extent to which it should have been.

Development of Science Education in India after Independence

In India, the reviews issued by the Government of India in the years 1877-92 gave an insight into the sorry state of science teaching.

1. Indian Science Congress—Even in the begining of 20th century, science was not a school subject in our country and it was only in name in the universities. Indian Science Congress was formed a few decades back but it also did not do any notable work towards the Teaching of Science in schools.

2. The Report of the Secondary Education Commission, 1953—It recommended the teaching of General Science as a compulsory subject in the high and higher secondary schools.

3. All India Seminar on Teaching of Science—The *All India Seminar* on the teaching of science in secondary schools held at Tara Devi (Simla Hills) in 1956, dealt with almost all the problems facing the inclusion of General Science as a core subject for the Higher Secondary Classes. It was the first to touch almost all the aspects concerning the teaching of science in schools *viz.* syllabus, equipment and apparatus method of examination, teaching aids in science and other allied topics like Text-Books, Science Clubs, Museum etc. It suggested a unique and uniform system of science teaching for the entire country, suited to its needs and resources.

4. Indian Parliamentry and Scientific Committee—In view of the rapid influence of science on society and of the Government policies, it was flet that both the scientists and the politician should be brought on a common platform to formulate new policies and procedure in accordance with the scientific developments. The Parliamentarians, must be acquainted with the developments of science and technology and

with the scientific viewpoint. The *Indian Parliamentary and Scientific Committee* was set up in August, 1961, under the Chairmanship of *Late Shri Lal Bahadur Shastri*. It took up in early 1962 the study of the problem of "Science Education in Schools", to find out the relation between the policies and decision of the Centre and the States, and the courses offered in the schools. It also studied the allied problems of –

(i) growth of school population.
(ii) shortage of qualified teachers.
(iii) accelerated achievements in science.
(iv) the demand for increase in technically trained manpower.
(v) growing importance of science in the affairs of mankind.
(vi) changes in the processes and goals of science, and
(vii) the views held by different thinker in regard to the structure of the school system and the content necessary for education of youth.

5. UNESCO Planning Mission – In 1963, the USSR Experts of the UNESCO Planning Mission visited India on teachnical assistance Projects. They worked on the problems from 3rd December, 1963 to 10th March, 1964 and gave their recommendations on different issues of Science Education in Secondary Schools. Three reports were prepared by the team, which gave the total picture of Science and Mathematics education in India and suggested ways to improve it.

6. Pilot Projects – As a follow-up programme of the Report of UNESCO Planning Mission of Experts, the Department of Science Education in the National Council took up the pilot projects of preparing new curriculum, text-books, teacher's guides etc. To start with, these experimental projects were started in about 20 selected schools in Delhi.

7. Conference of Science Education (21st-23rd April, 1966) – It was convenced to plan an effective programme for the development of a total curriculum of science education for different stages. Indian, Russian, American and UNESCO experts in science education participated in the conference.

8. Indian Education Commission (1964–66) – The Commission pointed out that our science education is in bad shape and it becomes worse if we fail to reckon with the explosion of knowledge. To meet this immediate threat, the commission recommended upgrading school

curricula by 'research in curriculum development, the revision of the text-books and teaching learning material.' The Commission recommended that :

(i) Science and mathematics should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling.

(ii) In the lower primary classes, science teaching should be related to the child's environment. The Roman alphabets should be taught in class IV to facilitate understanding of internationally accepted symbols of scientific measurement and use of maps, charts and statistical tests.

(iii) At the higher primary stage, emphasis should be on the acquisition of knowledge and the ability to think logically, to draw conclusions and to make decisions at a higher level. A disciplinary approach to the teaching of science will be more effective than the general science approach.

(iv) A science cornor in lower primary school and a laboratory-cum-lecture room in higher primary schools are minimum essential requirements.

(v) At the lower secondary stage, science should be developed as a discipline of the mind. The newer concepts of Physics, Chemistry and Biology and the experimental approach to the learning of science should be stressed.

(vi) Science courses, as an advanced level, may by provided for talented students in selected lower secondary school with necessary facilities of staff and laboratory.

(vii) Science teaching should be linked to agriculture in rural areas and to technology in urban areas.

(viii) The methods of teaching science should be modernized, stressing the investigatory approach and the understanding of the basic principles. Guide materials should be made available to help teachers adopt the approach. Laboratory work will need considerable improvement. There should be flexibility in the curriculum in order to cater to the special needs of the gifted pupils.

(ix) The development of science must derive its nourishment from our cultural and spiritual heritage and not bypass it.

(x) At the university level, better conditions for research should be provided.

9. Efforts by NCERT—As a follow-up of the Kothari Commission Report, the Ministry of Education and Social Welfare appointed an expert group in 1973 to develop curriculum for the 10+2 pattern. The group drafted an Approach Paper in 1975.

A publication entitled "The Curriculum for the Ten-Year School—A Framework" was published by the NCERT which also prepared syllabi, text-books and the materials in a phased manner. Materials for classes IX and X were prepared in a few subjects for 1975-1976 session, and for classes I, III and VI for 1976-1977 session. The Central Board of Secondary Education adopted some of the text-books prepared by NCERT for classes IX and X, and the first badge of candidates appeared in the public examination for class X held in April 1977.

The syllabi and the text-books prepared by NCERT, specially for classes IX and X, evoked a lot of criticism from parents, teachers and students. The main criticism was that the scheme of examination contained many subjects for students, the textbooks were too many and too voluminous and, therefore, there was no time for self-study and physical activities. Another area of criticism was that work experience did not find a proper place in the teaching-learning process in the new pattern of education, thus maintaining the same system of bookish education.

Aims of Physical Sciences Teaching at Different Stages of School Education

There have been many attempts from time to time in our country as well as abroad by the educationists to think about the aims of science teaching at different stages of school education. Two such attempts made in our country are worth mentioning. One of these attempts was made in 1956 at Tara Devi Hills through an All India Seminar organised on the topic "Science Teaching in Secondary Schools". The other one relates to the recommendations made by Kothari Commission in 1966. Recently some serious observations have also been made in the new educational policy. In the light of all such attempts the following aims can be set at different stages of school education for the teaching of physical sciences.

At Primary Stage (From Class I to IV)

1. To make the children interested in the study of nature and to help them in getting acquainted with their natural surroundings.
2. To educate them regarding the application of science in their physical and social environment.
3. To inculcate good habits of cleanliness and healthful living among children.
4. To develop their faculty of observation.
5. To provide opportunities for the development of their inventive and creative faculties.
6. To give them the basic knowledge of numerals and alphabets for the comprehension and understanding of scientific vocabulary and language.
7. To provide essential knowledge regarding personal and social hygiene.
8. To cultivate the habit of doing work systematically and neatly.

9. To make them able to read and understand simple graphs, charts, maps and statistical tables.
10. To encourage the children to read and listen to the life story of great inventors and scientists.

At Middle or Higher Primary Stage (From Class V and VII)

1. To help the students to get acquainted with the impact of science over the environment surrounding them and to develop their interest in the study of physical sciences.
2. To provide knowledge about the basic primary facts, principles and theories related to physical sciences.
3. To cultivate the habit of systematic and logical thinking.
4. To develop scientific attitude among children.
5. To help the students in disciplining their mental faculties.
6. To develop the habit and ability of drawing correct inferences out of the available facts and evidences.
7. To provide essential base for further studies in the higher classes.
8. To acquaint the students with the history of the development of physical sciences and help them to understand and appreciate the progress and development made in this sphere.

At the Secondary Stage (Form Class VIII to Class X)

1. To provide the students deep insight (more than the previous classes) with the facts and principles of physical sciences.
2. To develop their ability to perform scientific experiments more skilfully and to help them in getting better insight into the application of physical sciences.
3. To provide appropriate opportunities for the development of the inventive and creative faculties of the students.
4. To provide essential base for the higher specialized studies in the areas and fields of science and technology.
5. To equip the students with all the basic scientific knowledge and skills helpful in day to day life.
6. To help them in adopting and learning some useful scientific activities as hobbies and leisure hours purposeful activities.
7. To create in them proper attitude and faith regarding the values and contribution of physical sciences.

Aims of Teaching Physical Sciences

1. *Knowledge aim.* Teaching of physical sciences should aim for the necessary increase in the span of one's knowledge regarding physical sciences helping him to understand himself and his environment as adequately as possible. The starting in the lower classes may be made with the awareness of simple facts and principles used and observed in day to day life and the sphere of this awareness may then be progressively increased in the higher classes.

2. *Practical aim.* The knowledge is useful only when it is capable of being applied practically. It is in this sense obligatory on the part of a science teacher to teach practical aspect of all the scientific principles and knowledge imparted to his students. The students should not only know about the scientific principles and facts, but should also be able to use them practically in understanding themselves and environment surrounding them. They must be able to harness the forces of nature and secrets of scientific world for the welfare of the society in a more useful way by learning the use of scientific principles and facts as practically as possible.

3. *Development of scientific attitude.* Science education should aim for the development of scientific attitude among the learners. It should help in removing the superstitions, false beliefs, wrong notions spread in the society and cultivate the habits of proper reasoning, observation and experimentation, leading to a firm belief in the testing and verification of hearsay and observed facts. The physical sciences education thus should aim in providing proper opportunity for the development of scientific temperament and attitude among the students. It should create among them a spirit of curiosity for knowing about the new things, discovering their environment and penetrating deeply into the nature of the things and events surrounding them and doing all this quite systematically by adopting scientific method of thinking and solving the problems.

4. *Cultural aim.* The development of the culture and civilization of a country is essentially linked with the progress and improvement in the study of physical sciences. This fact becomes quite imperative if we see that the countries who are said to be quite developed today are those countries who are considered to be more advanced in the matter of physical sciences education imparted to their youngsters. The history

of the development of sciences also reveals the same fact. The countries, quite ahead in the study of sciences, are known to have well developed civilization and rich cultural aspect. In fact, our civilization owes much to the development of science and technology and therefore if we want to go ahead in the matter of the development of civilization and culture, we have to strive for bringing progressive improvement in the study of sciences. In case our citizens remain aloof and ignorant about the development of science and technology, it will naturally lead us to lag behind. The key for utilizing what science has given us lies in the way and manner science is being taught in our schools. Therefore physical sciences should be taught in the schools in such a way as (*i*) to grasp the progress in the field of sciences, (*ii*) apply it for the enhancement of our cultural heritage and development of our civilization, and (*iii*) appreciate the contribution of the study of science in the progress and development of the culture and civilization.

5. *Social aim.* Study of physical sciences should also aim in the development of social virtues among the students for leading a well adjusted social life and contributing significantly towards the welfare and progress of the society. It should help a child to understand and apply all what is going on around him in the name of developments in the field of science and technology. It will not only help him to adjust socially but also contribute towards the progress of his society, nation and humanity at large. He must also be made to understand that his welfare is completely interlinked with the welfare of others living in the society. The study of physical sciences thus should aim in helping the children to imbibe essential social qualities and virtues for becoming a responsible useful citizen. It should help him to use the knowledge and skill of science for the progress and improvement of the society and educate him properly with the evils of the misuse of science and technology for the destructive ends.

6. *Vocational aim.* On attaining maturity one is supposed to earn his livelihood. Our physical sciences education should also strive for the achievement of this end. It becomes more essential by noting a significant development that today, our day to day life, activities and all that is manufactured, consumed and applied is completely dominated by the knowledge of science and technology. In other words, today the key of almost all the professions and vocations lies in the knowledge and proficiency achieved in the field of science. The requirement of the latest technological advancement in all fields of life and vocations has thus made us to replan and set our science education for achieving the vocational aim *i.e.*, to prepare our youngsters to earn their livelihood by (*i*) learning the essential facts and principles of sciences, (*ii*) studying relevant courses of study, and (*iii*) preparing themselves for choosing,

entering and becoming successful in various occupations and vocations not only for gaining economic independence but also for contributing significantly towards the prosperity of their nation.

For achieving this end, physical sciences education in our schools must have a proper systematic programme. It must prepare the students for the different occupations and vocational courses. It should also provide them proper opportunities for the adoption of those scientific hobbies which can lead them to earning their livelihood by engaging into self employment projects and small scale industries.

7. *Utilization of leisure time.* Physical sciences education must also aim in helping the students to learn ways and means of utilising the leisure hours as fruitfully as possible. It must provide us the ways to relax and seek proper entertainment from the nature as well as from the technological advancement. Besides that it may be aimed to cultivate useful scientific hobbies for the profitable utilisation of one's leisure time such as photography, vegetable growing, gardening, manufacturing of soaps, face powder, cream, tooth paste, ink, varnishes etc. and repairs of electrical gadgets and day to day use appliances like radio, watches, stoves, gas burners, cycles and scooters, fountain pens etc. In this way, science education may be easily aimed to utilize the leisure hours of the students in a very fruitful way.

8. *Psychological aim.* Physical Sciences, if taught properly, may prove a potent means for the satisfaction of the psychological needs of the youngsters. Children have excessive curiosity for knowing and investigating the things and events around them. Their areas of interests are quite wide and diversified. They want to do things with their own hands and verify the truth by actual observations and experimentation. Science education is capable of providing proper opportunities for all the students in satisfying their varying psychological needs and thus making them grow and develop as well balanced individuals. Consequently physical sciences education in our schools must provide for meeting out the psychological needs of the youngsters.

9. *Helpful in the study of other subjects.* All the subjects taught in the schools strive in their own ways to achieve the purposes or aims of education. They have many things in common with regard to the contents, nature and purposes. Therefore, the study in one subject is, directly or indirectly, influenced by the study in other subjects. Keeping this thing in mind, we must plan the study of physical sciences in such a way as we may (*i*) derive necessary help from the study of other subjects for studying physical sciences and also (*ii*) may utilise the knowledge of physical sciences in studying other subjects of the school curriculum.

10. *Skill aim.* Study of physical sciences at all levels should essentially aim to develop useful skills pertaining to scientific observation, experimentation and practical use of scientific facts and principles. Although we cannot expect a very high degree of manual proficiency and technical skills from the children studying in schools, we may safely aim to cultivate (*i*) the habit of doing things independently, (*ii*) to manipulate and explore the things, (*iii*) to observe and experiment by handling suitable appliances and instruments, and (*iv*) to infer and draw conclusions in a very systematic and scientific way.

a particular type of learning exper...

General Objectives of Teaching Physical Sciences at the School Stage

Physical sciences are taught or learning experiences in the subject of physical sciences are given to children for bringing desirable behavioural changes. These changes are expected from all the three behavioural domains, namely cognitive (knowing), conative (doing), and affective (feeling). Therefore when we try to mention the objectives of teaching physical sciences, we have to take care of these three domains in which behavioural changes are expected as an outcome of the teaching and learning of these subjects. Moreover, the different instructional objectives set for this purpose must also be stated in behavioural terms, *i.e.* the expected changes in the behaviour of the pupil. Let us mention the major objectives of teaching physical sciences in behavioural terms.

1. *Knowledge objective.* The pupil acquires knowledge of the terms, facts, concepts, definitions, principles and processes related with physical sciences.

2. *Understanding objective.* The pupil develops understanding of terms, facts, concepts, definitions, principles and processes related with physical sciences.

3. *Application objective.* The pupil applies his knowledge and understanding of the subject, physical sciences to the day to day life activities and to the new or unfamiliar situations.

4. *Skill objective.* The pupil develops mathematical skills and skills like manipulative skills, drawing etc.

5. *Interest objective.* The pupil develops interest in the world of physical sciences.

6. *Attitude objective.* The pupil develops scientific attitude through the study of physical sciences.

7. *Appreciation objective.* The pupil appreciates the contribution of sciences to human welfare.

Let us now discuss about the various specific behavioural changes under the heading Specifications for the above mentioned objectives of teaching physical sciences.

Specifications for the Objectives of Teaching Physical Sciences

Knowledge Objective. Specifications :

1. The pupil *recalls* terms, facts, concepts, principles and processes etc. related with the subject Physics/Chemistry.
2. The pupil *recognises* terms, facts, concepts, principles and processes etc., related with the subject Physics/Chemistry.

Understanding Objective. Specifications :

1. The pupil illustrates a term/concept/principle by citing examples.
2. The pupil translates verbal statements into symbol and *vice versa.*
3. The pupil detects errors in given statements, concepts, arrangements etc. and rectifies the same.
4. The pupil compares and contrasts or detects similarities and dissimilarities between closely related concepts, principles, processes etc.
5. The pupil identifies relationship between various facts, concepts, principles, processes etc.
6. The pupil interprets charts, graphs, diagrams, data etc.
7. The pupil gives explanation of concepts, principles, phenomenon etc.
8. The pupil classifies substances, concepts etc.

Application Objective. Specifications :

1. The pupil analyses situations.
2. The pupil formulates and tests the hypothesis.
3. The pupil establishes relationship between cause and effect.
4. The pupil gives reasons for a scientific phenomenon.
5. The pupil draws inferences and conclusions from the observed facts.
6. The pupil relates basic scientific principles in solving life problems and understanding one's environment.
7. The pupil predicts scientific phenomena from the given data.

Skill Objective

A. Manipulative and experimental skills. Specifications :

1. The pupil arranges and sets up the apparatus in a systematic and desired way.
2. The pupil handles the apparatus and instruments properly.

3. The pupil observes and records relevant readings accurately and systematically.
4. The pupil takes necessary precautions in conducting the experiments or recording the observations.
5. The pupil performs experiments with reasonable speed, accuracy and neatness.
6. The pupil improvises apparatus and aid material.

B. Drawing skills. Specifications :

1. The pupil draws accurate and neat sketches, diagrams and graphs.
2. The pupil records and presents data in tables, charts, graphs, etc.
3. The pupil draws diagrams showing the actual arrangement of the apparatus and experiment.
4. The pupil labels the parts of a diagram neatly and accurately.

C. Mathematical skills. Specifications :

1. The pupil represents the relations, facts and principles concerning physical sciences graphically.
2. The pupil measures the objects and events in terms of physical quantities and units.
3. The pupil solves numerical problems concerning physical sciences.

Interest Objectives. Specifications :

1. The pupil puts questions in discussion on related to physical sciences.
2. The pupil reads literature related to physical sciences and biographies of the man of physical sciences.
3. The pupil voluntarily takes part in debates, lectures, paper reading etc. belonging to scientific interest.
4. The pupil visits places of scientific interest.
5. The pupil collects, mounts and preserves materials and specimen of his interests.
6. The pupil organises or actively participates in science club activities.
7. The pupil improvises apparatus and models in his spare time.

8. The pupil voluntarily contributes material to the school from his own collection and writes articles in the science bulletin and magazines.
9. The pupil voluntarily engages in the scientific hobbies.

Attitude Objectives. Specifications :

1. Pupil does not accept or reject anything without valid proofs and evidences.
2. Pupil believes in cause and effect relationship of scientific phenomena.
3. Pupil shows a keen desire to know how and why of anything that happens or exists.
4. Pupil develops intellectual honesty in expressing and recording scientific data.
5. Pupil is prepared to reconsider his own judgement and admitting his mistakes unhesitatingly.
6. Pupil pursues his activities with precision and consistency undaunted by failures.
7. Pupil is clear and precise in his statements and activities.
8. Pupil shows spirit of team-work, self-help and self-reliance.
9. Pupil develops a sense of respect towards the science teacher and positive attitude towards the learning of the subject physical sciences.
10. Pupil realises the danger in the misuse of the scientific knowledge.

Appreciation Objective. Specifications :

1. Pupil shows respect and admiration for the great scientists.
2. Pupil derives pleasure in understanding the scientific advancement.
3. Pupil shows thrill and excitement in his own activities and experimental achievements as well as those of others.
4. Pupil derives pleasure in the pursuit of scientific study and realises the real significance of the

   (*i*) Contribution of science in the progress and development of the society and individual,

   (*ii*) Role of the knowledge of physics or chemistry in making our world more comfortable and useful.

What are Instructional Objectives ?

At the time of imparting instruction, *i.e.* teaching learning of a particular lesson, unit or sub unit of the subject Physical Sciences, a teacher has to place before him some definite and very specific objectives for being attained within a specified classroom period and resources in hand. Through these specific classroom teaching learning objectives, known as

instructional objectives, a teacher tries to bring desired changes in the behaviour of his pupils. In this way *the term instructional objectives in relation to the teaching of Physical Sciences may be defined as a group of statements formulated by the teacher for describing what the pupils are expected to do or will be able to do once the process of classroom instruction is over.* In fact, instructional outcome is the teaching learning product in the form of behavioural changes in the pupils that a teacher expects as a result of his instruction related to a particular lesson, unit or sub unit of the subject. Instructional objectives are thus nothing but descriptions of the pupils, terminal behaviour expected out of the ongoing classroom instruction.

Relationship of Instructional Objectives with General Aims and Objectives of Teaching Physical Sciences

In comparison to general aims and objectives of teaching Physical Sciences, instructional objectives are quite narrow and specific. They are definite, tangible, precise and functional. They are predetermined and are always formulated in such a way that their attainment becomes quite practicable through the usual classroom teaching within the stipulated period of fixed duration. They are the desired learning or teaching outcomes and are always stated in terms of expected pupil's behaviour or desired behavioural changes. They are, therefore, be termed as teaching-learning objectives or behavioural objectives. The main purpose of these objectives is to provide statements of skills, concepts or the behaviour that learners are expected to demonstrate after going through a particular instruction.

Objectives of teaching Physical Sciences falls midway between goals or aims of teaching Physical Sciences and instructional objectives. They are more specific and definite than the general aims or goals but less specific and much wider than the classroom instructional objectives. Their attainment is quite possible within the educational structure and means.

In fact classroom instructional objectives, objectives of teaching physical sciences at a particular or entire stage of school education, and general aim or goals of teaching physical sciences represent a hierarchical order as shown below.

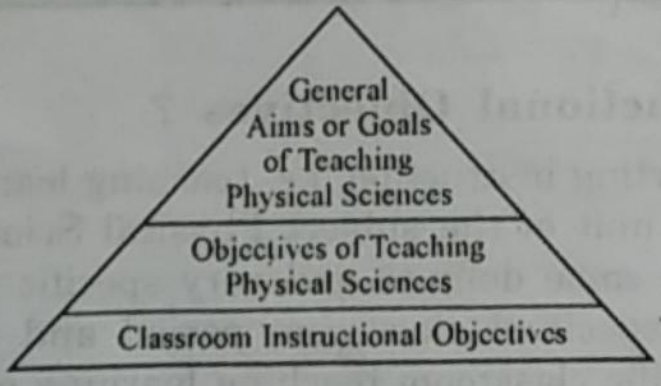


Figure 3.1 : Hierarchical order of aims and objectives

The above figure may well illustrate that instructional objectives are the fundamental and basic targets that could be easily achieved within the limited period and means while general aims or goals of teaching mathematics are quite broad based, lofty and quite difficult in their attainment :

Their narrower or broader viewpoints or area of influence may be further illustrated as shown in the diagram below.

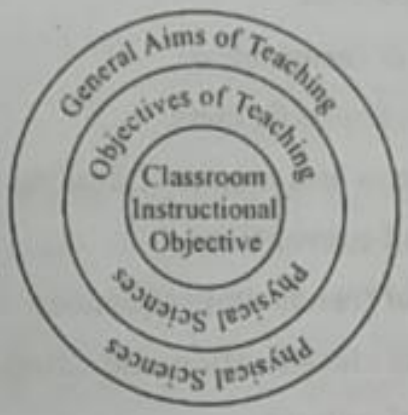


Figure 3.2 : A diagrammatic view of aims and objectives

According to the above view, classroom instructional objectives view may be submerged in the reservoir of general objectives of teaching physical sciences at a particular school stage which in turn are further submerged in the ocean of general aims and goals of teaching physical sciences.

Taxonomy of Educational and Instructional Objectives

"Taxonomy" means a system of classification and in this sense a taxonomy like Bloom's Taxonomy presents a system of classification of the objectives in the similar way as Dewey's Decimal System tends to classify a number of books in a library.

The taxonomy of educational and instructional objectives has been worked out on the assumption that the teaching-learning process may be conceived as an attempt to change the behaviour of the pupils with respect to some subject matter or learning experiences. Behaviour is divided into three domains — Cognitive (knowing), affective (feeling) and psychomotor (doing). The taxonomy of educational and instructional objectives have also been considered to be belonging to these three domains.

The taxonomy related to cognitive domain has been presented by Bloom (Bloom, et al, 1956), the second related to affective domain by Krathwohl, Bloom and Masia (Krath Wohl, et al, 1964) and the third related to psychomotor domain by Harrow (Harrow, 1972) and Simpson (1966).

Taxonomy of Teaching Objectives

S.No.	Cognitive Domain Category	Affective Domain Category	Psychomotor Domain
1.	Knowledge	Receiving	Impulsion
2.	Comprehension	Responding	Manipulation
3.	Application	Valuing	Control
4.	Analysis	Conceptualisation	Co-ordination
5.	Synthesis	Organisation	Naturalization
6.	Evaluation	Characterisation	Habit-formation
	Dr. Basyamin Bloom 1956)	**Krathwohl (1869)**	**Simpson (1969)**

1. Taxonomy of objectives in Cognitive Domain

1. **Knowledge** : It represents the lowest level of the objectives belonging to the cognitive domain and primarily aims for the acquisition of the knowledge. Concerning :

   (i) Specific facts, terminology, methods and processes.

   (ii) Generalized principles, theories and structures.

The knowledge objectives mainly call, for the recall and recognition level of one's memory and therefore their evaluation is primarily made through a simple recall or multiple choice type questions.

2. **Comprehension** : It is based upon the knowledge. If there is no knowledge, there will be no comprehensions. It means the basic understanding of the facts, ideas, methods, processes, principles or theories etc. so that the pupil may be :

   (i) translate or summarize the communicated knowledge in his own words.

   (ii) Interpret, i.e., cite examples, discriminate, classify, verify or generalize and

   (iii) Extropolate, i.e. estimate or understand the use of knowledge and extend it to other subjects and fields.

3. **Application** : The knowledge is useful only when it is possible to make it employed. The category of application automatically involves both the earlier categories, i.e., knowledge and comprehension. Under this objective the learner is required to acquire the ability to make use of the abstract or generalized ideas, principles in the particular and concrete situations.

4. **Analysis** : Analysis refers to an understanding at higher level. It is a complex cognitive process as the learner is expected to acquire the necessary skill in drawing inferences, discriminating, making choices and selection and separating apart the different components or elements of a concept, object or principle.

5. **Synthesis** : The objectives belonging to this category aim to help the learner to acquire necessary ability to combine the different elements or components of an idea, object, concept or principle as to produce an integrated picture i.e., a figure of wholeness.

6. **Evaluation** : This category of objectives aims to develop in the learner the ability to make proper value judgement about what has been acquired by him in the form of knowledge, understanding, application, analysis and synthesis. As a result the learner is expected to take proper decision about the quantitative and qualitative decision about the matter and

methods by making uses of all the cognitive abilities acquired through the earlier categories of cognitive objectives.

2. Taxonomy of Objectives in the Affective Domain

1. **Receiving** – It represents the initial category for the objective belonging to affective domain. For the inculcation of certain interests, attitudes, values or ideas it is essential that the learner should be made to receive or attend the desired ideas, events or objects. This category points out towards this necessary and takes into consideration three types of following sequential activities –

   (i) Firstly, the learner is made aware about the existence of certain stimuli.

   (ii) Then the desired intension for receiving the stimuli is created in the learner.

   (iii) Lastly, the efforts are made for the control of the attention of the learner. He may be trained to selective attention and sustain it for a desired period.

2. **Responding** – It represents the second level for the categories belonging to affective domain. Once a learner receives or attends to a particular idea, event or thing he must be made to respond to it as actively as possible. The responses here do not confine itself in just paying attention or arousal of a simple intention or desire of getting a thing, as in the first category of receiving but manifest themselves in the active behaviour like obeying, answering, reading, discussing, recording, writing and reacting to a stimulus etc.

3. **Valuing** – When one attends as well as responds to a particular thing, idea or event he is naturally drifted towards taking value judgement about that thing, idea or event. In practice the objectives belonging to this category are usually concerned with the development of typical value patterns, attitudes etc.

4. **Organising** – This category, concern with the construction of relatively enduring value structure in the learner by organising and synthesizing the different value patterns imbibed by him from time to time. So organising the learner to form a set value structure.

5. *Characterizing by a value or value complex.* It is the highest level category of the objectives belonging to the affective domain. Upto this stage, the learner is able to imbibe all the essential affective behaviour, *i.e.* various interests, attitudes, values, value complex or value patterns, a permanent set value structure and therefore, all the earlier categories are automatically involved in the objectives of this category. At this stage, the learner is destined to imbibe typical characteristics of his individual character i.e., life style of his own. In fact it is the end point or ultimate goal of the process of education.

Taxonomy of Objectives in Psycho-motor Domain

The classification of psychomotor objectives was first produced by Simpson (Simpson, 1966) and latter modified by Harrow (1972). Those given by Harrow are being described below under six different categories arranged from the lowest to the highest level of functioning.

1. *Reflex Movements.* Reflex movements may be considered as the involuntary motor responses to the various stimuli in the environment. Examples of such reflex movements or actions are : the jerking of hands, the closing of eye lid, stretching of the arms etc. These movements represent the lowest level of the psychomotor behaviour. They are largely controlled by the autonomous nervous system. However, they are very much essential not only for the development of psychomotor abilities but also for the survival of the human beings.

2. *Basic Fundamental Movements.* These fundamental movements are just a step ahead of the simple reflex movements. They are not so inborn and innate as the reflex movements but a child may be seen to demonstrate such movements in his very early days of life. Their movements in the from of kneeling, creeping, stumbling, walking, jumping, moving hands, neck, head etc. may be named as basic fundamental movements. They represent the simple basic movements of the body almost requiring no serious attempts or skilled practice for their occurrence. In the later years of our life, these movements are made as a result of obeying certain kinds of orders.

3. *Perceptual Abilities.* The development of motor abilities related to the phenomenon of perception belongs to this category of objectives. When

some meaning is attached to sensation, it is termed as perception. As a result, the learner is able to derive useful meaning out of the exposure of their senses to various stimuli in the environment. His bodily movements are then governed and controlled by his perceptual abilities. Whatever is perceived by him through his senses becomes an ignition point for the motor behaviour. Such type of behaviour is a learned behaviour. It is always acquired through experience and systematic training.

4. *Physical Abilities.* For an effective motor behaviour, there is an urgent need of the development of desirable physical abilities. If one has adequate physical stamina and abilities, he may go ahead in the task of improving his psychomotor behaviour. Therefore, this category of objectives aims to develop the various physical abilities of the learners like tolerance to bear and stand against rough weather; to do hard labour, to carry the large load, to bend an article, to demonstrate one's physical power in starting, stopping or running an object or machine etc.

5. *Skilled Movements.* Skilled movements are those complex bodily movements which help in performing the skilled tasks. These movements are to be acquired through an organised and systematic learning process. Their acquisition requires an intelligent understanding and sufficient drill or practice work on the part of the learner. The art of dancing, diving, driving, playing the musical organs, skating, typing, swimming, tailoring, etc. represent such skilled movements. The development of the abilities concerning such skilled movements depends upon the development of the motor abilities described under all the earlier four categories.

6. *Non Discussive Communication.* This category represents the highest level of the psychomotor behaviour. The bodily movements are hereby integrated with the inner feelings and affective behaviour of the learner. In this way, the non-discussive communication may be defined in terms of the overt behaviour activities related with the communication of affective behaviour feelings or emotions. This communication may range from a simple behaviour expressible through posing of facial expression to a complex behaviour performed through a highly sophisticated classical dance, sketching, painting or acting.

An Alternative Taxonomy of Psychomotor Objectives

An alternative taxonomy in the psychomotor domain has been proposed by Dr R.H. Dave (1969) in the shape of a working hypothesis as below.

Table 3.3 : Taxonomy of psychomotor objectives (R.H. Dave)

1. *Imitation*
   - (*a*) Impulsion
   - (*b*) Overt repetition
2. *Manipulation*
   - (*a*) Following direction
   - (*b*) Selection
   - (*c*) Fixation
3. *Precision*
   - (*a*) Reproduction
   - (*b*) Control
4. *Articulation*
   - (*a*) Sequence
   - (*b*) Harmony
5. *Naturalization*
   - (*a*) Automatism
   - (*b*) Interiorization

Let us have a necessary explanation for the above steps.

Imitation. For the learning of a psychomotor activity, *i.e.* drawing or surveying skill in mathematics, the task begins with the imitation of observed acts. The child observes the demonstrated behaviour related to drawing of a line, angle or circle etc. He feels an inner push or an impulse (by having an inner rehearsal of the psychomotor activities) to imitate action. It is followed by the overt repetition (imitation) of the demonstrated behaviour.

Manipulation. This second category of psychomotor objectives emphasizes manipulation on the part of the learner for the acquisition of skills by following directions, performing selected action and fixation of performance through necessary practice.

Precision. In the third category of psychomotor objectives learner is able to perform skilled acts or motor activities with a derived level of precision (accuracy, exactness and right proportion) and as such may be said to reach a higher level of refinement in reproducing a given act or skilled task.

Articulation. It is the fourth category in the hierarchy of learning the psychomotor activities or skills. At this stage learner becomes capable of coordinating a series of acts by establishing appropriate sequence and accomplishing harmony or internal consistency among different acts.

Naturalization. It is the highest stage reached in terms of the development or proficiency acquired in the learning of a skill or psychomotor act. One can now perform a single act or a series of articulated acts with greater refinement, ease and convenience as automatic and naturally as possible.

Writing Objectives in Behavioural Terms

The major weakness about the taxonomies of objectives given above lies in the fact that they do not state objectives in terms of terminal behaviour, *i.e.* what the learner should be able to do at the end of teaching specification of objectives in a task of teaching and learning may prove more effective and purposeful if they are translated into behavioural language.

The structure of the educational or instructional objectives mainly consists of two parts, namely.

(*i*) the modification part, and (*ii*) the content part.

The modification part represents the behavioural changes that are designed to occur in the behaviour of the learner through the related instruction or learning experiences.

The content part refers to the syllabus in particular and to the curriculum in general to be covered by the related instruction.

Therefore, the writing of an objective in behavoural terms is always done in relation to the following three things :

(*i*) The nature of the objective, *i.e.* knowledge, application etc.

(*ii*) The area or domain of the behaviour, *i.e.* cognitive, affective etc.

(*iii*) The specific content areas in which behavioural changes are planned to be brought about, *i.e.* measurement of temperature, sources of heat, types of frictions etc.

There are several methods of writing objectives in behavioural terms. In this text here we are going to discuss the following three approaches :

1. Robert Mager's Approach.
2. Robert Miller's Approach.
3. RCEM Approach.

Robert Mager's Approach

According to Robert Mager (Mager, 1962), instructional objectives are best described in terms of the terminal behaviour expected from the learners. He recommends the following things for the writing of the objectives.

1. Identification of the terminal behaviour of performance and its naming.
2. Description of the important conditions under which the behaviour is expected to occur.
3. Specification of the criteria of acceptable performance (desired terminal behaviour) by describing how good a learner's performance must be for being acceptable.

Mager's approach has adopted Bloom's Taxonomy as a starting base for the writing of objectives. He has sought the help of the associated action verbs for stating the different objectives. The verbs help in describing the outcomes of learning or terminal behaviour of the learner in a well defined way (observable and testable). A list of associated action verbs for cognitive and affective domain has been presented in Tables 3.4 and 3.5.

Table 3.4 : A List of Associated Action Verbs for the Cognitive Domain

Objectives (Based on Bloom's Taxonomy)	Associated Action Verbs
1. Knowledge	Define, List, Label, Measure, Name, Recall, Recognise, Reproduce, Select, State, Write, Underline etc.
2. Comprehension	Change, Classify, Distinguish, Explain, Formulate, Identify, Illustrate, Indicate, Interpret, Justify, Judge, Name, Represent, Select, Summarize, Transform, Translate etc.
3. Application	Assess, Change, Choose, Conduct, Construct, Compute, Demonstrate, Discover, Explain, Establish, Find, Generate, Illustrate, Modify, Predict, Perform, Select, Solve, Use etc.
4. Analysis	Analyse, Associate, Compare, Conclude, Contrast, Criticise, Differentiate, Identify, Justify, Point out, Resolve, Select, Separate etc.
5. Synthesis	Argue, Conclude, Combine, Derive, Discuss, Generalize, Integrate, Organize, Precise, Prove, Relate, Restate, Select, Summarize, Synthesize etc.
6. Evaluation	Associate, Choose, Compare, Criticise, Conclude, Defend, Determine, Evaluate, Judge, Identify, Recognize, Relate, Select, Summarize, Support, Verify etc.

Table 3.5 : A List of Action Verbs for Affective Domain

Objectives (Based on Bloom's Taxonomy)	Action Verbs
1. Receiving	Ask, Accept, Attend, Beware, Catch, Discover, Experiment, Identify, Favour, Follow, Observe, Prefer, Perceive, Receive, Select etc.
2. Responding	Answer, Assist, Complete, Derive, Discuss, Develop, Help, List, Label, Name, Obey, Present, Practice, Record, Select, State, Write etc.
3. Valuing	Accept, Attain, Complete, Choose, Decide, Demonstrate, Discriminate, Develop, Increase, Indicate, Influence, Participate, Prefer, Recognise etc.
4. Organising	Add, Associate, Change, Compare, Complete, Coordinate, Correlate, Determine, Find, Form, Generalize, Integrate, Judge, Project, Prepare, Relate, Select, Synthesize, Organise etc.
5. Characterizing	Accept, Change, Characterize, Decide, Discriminate, Demonstrate, Develop, Experiment, Face, Identify, Judge, Prove, Revise, Serve, Solve, Verify etc.

In case we strictly follow Mager's approach for the writing of objectives in behavioural terms we have to adopt the following procedure for writing an instructional objective in behavioural terms.

1. First state conditions under which the performance is to occur like "Using a Doctor's Thermometer the students are able to or will be able to----."
2. Then use an action verb for telling what students will be able to do like measure/read/identify etc.
3. Finally state a criterion for success like "using a doctor's thermometer the students will be able to read the temperature of the body of their fellow students with cent-percent accuracy."

By following such procedure an instructional objective related to the topic "Computation of kinetic energy" may be written as under.

"Given a mass 'm' and velocity 'v', the students are able or will be able to compute kinetic energy of a moving body by using the formula K.E. = $\frac{1}{2} mv^2$ with cent-percent accuracy."

Limitations of Robert Mager's Approach

Mager's approach although quite popular in the development of programmed instruction suffers from the following limitations :

1. Mager's approach is a behaviour approach but human learning cannot be confined merely to simple S—R learning.
2. It concentrates on cognitive and affective domains and neglects the psychomotor domain of the learner's behaviour. Therefore, its use is limited for the writing of cognitive and affective objectives.
3. For the writing of objectives it gives emphasis on action verbs designating behaviours and does not tell anything about the related mental processes or mental abilities. Therefore, it does not even serve the purpose of writing cognitive and affective objectives in an appropriate way.
4. The overlapping of action verbs in different categories of the cognitive as well as affective objectives creates confusion in the use of appropriate action verbs for writing particular instructional objective.
5. Moreover the list of action verbs provided is too long and unwieldy to have any meaningful application to classroom teaching.

Robert Miller's Approach

Mager in his approach badly neglected the conative domain or psychomotor aspect of the behaviour. Robert Miller (Miller 1962) for meeting the requirement of writing psychomotor objectives put forward his scheme based on skill analysis by outlining the following procedure.

1. Description of the indicator, indicating the relevant activity.
2. Description of the indication or stimulus which calls for a response.
3. Controlling of the object which is to be activated.
4. Description of the activity to be performed.
5. The indication of the adequacy of responses or feedback.

Like Mager, he also tried to enlist associated action verbs for the psychomotor objectives.

For the purpose of using Miller's approach a list of appropriate action verbs is being provided in the following table based on the classification of psychomotor objectives pointed out by Harrow (Harrow, 1972).

Table 3.6 : Associated Action Verbs for Psychmotor Objectives

Objectives (Based on Harrow's Classification)	Associated Action Verbs
1. Reflex Movements	Bite, Harden, Jerk, Lengthen, Loosen, Make Small, Relax, Stop, Straighten, Stretch etc.
2. Basic Fundamental Movements	Befall, Catch, Creep, Drink, Hold, Jump, Kneel, Move, Reach, Run, Walk etc.
3. Physical Abilities	Begin, Bear, Bend, Conduct, Increase, Lean, Reform, Smash, Start, Stop etc.
4. Perceptual Abilities	Balance, Bend, Catch, Discover, Eat, Explore, Feed, Identification by touching, seeing, smelling or hearing, Memory Tracing, Smell, Throw, Write etc.
5. Skilled Movements	Dance, Dive, Drive, Knit, Play the musical organs, Row, Skate, Shoot, Swim, Type etc.
6. Non-Discursive Communication	Mimic, Pose, Sit, Sketch, Smile, Stand, Tease etc.

RCEM Approach

Both Mager's and Miller's approaches have remained unsuccessful in the task of writing all instructional objectives belonging to all three domains of behaviour. Where Mager's approach serves the purpose of cognitive and affective objectives, Miller's scheme is meant for psychomotor objectives. Thus none of these two approaches cover all the domains of human behaviour. Moreover both of these approaches lay emphasis on associated action verbs (which are more often overlapping within and among the objectives of the domains) designating behaviours for writing a particular objective and completely neglect the mental processes or abilities of the learner in the learning process. On account of these limitations both these approaches have come into severe attack in our country and now being replaced by a more reasonable approach known as RCEM approach developed by Regional College of Education, Mysore.

This approach makes use of mental processes or mental abilities in place of action verbs in the writing of instructional objectives. It makes use of its own taxonomy of objectives, known as RCEM Taxonomy of objectives, which is somewhat a modified form of the Bloom's Taxonomy. Here there are four categories in place of six given by Bloom. For doing

so the last three categories, Analysis, Synthesis and Evaluation of the Bloom's Taxonomy have been replaced by a common category, Creativity. The other difference lies in naming the Bloom's Comprehension Category as Understanding in the RCEM approach. These objective categories of RCEM approach, alongwith the associated mental processes or abilities, are given in Table 3.7.

Table 3.7: Objectives and Mental Processes in RCEM Approach

Objectives	Mental Processes or Metal Abilities
1. Knowledge	1.1 Recognize
	1.2 Recall
2. Understanding	2.1 Seeing relationship
	2.2 Cite Example
	2.3 Discriminate
	2.4 Classify
	2.5 Interpret
	2.6 Verify
	2.7 Generalize
3. Application	3.1 Reason out
	3.2 Formulate hypothesis
	3.3 Establish hypothesis
	3.4 Infer
	3.5 Predict
4. Creativity	4.1 Analyse
	4.2 Synthesize
	4.3 Evaluate

Note : For comparison of Bloom's objectives with the RCEM objectives, readers are advised to refer Table 3.5.

The four categories of objectives, as may be evident from the above table, have been divided into seventeen mental processes or abilities. These processes or abilities are used for writing the objectives in behavioural terms. For this purpose RCEM approach lays down the necessary outline of the seventeen frames or statements given ahead.

1. *Knowledge Objectives*

   1.1 The learner is able to recognize.....

   1.2 The learner is able to recall.....

2. *Understanding Objectives*

   2.1 The learner is able to see relationship between..... and.....

   2.2 The learner is able to cite example of.....

   2.3 The learner is able to discriminate between..... and.....

   2.4 The learner is able to classify.....

   2.5 The learner is able to interpret.....

   2.6 The learner is able to verify.....

   2.7 The learner is able to generalize.....

3. *Application Objectives*

   3.1 The learner is able to reason out.....

   3.2 The learner is able to formulate hypothesis of.....

   3.3 The learner is able to establish hyporthesis of.....

   3.4 The learner is able to infer about.....

   3.5 The learner is able to predict about.....

4. *Creativity Objectives*

   4.1 The learner is able to analyse.....

   4.2 The learner is able to synthesize.....

   4.3 The learner is able to evaluate.....

How to Write Objectives in RCEM Approach

The procedure may be sequenced as below :

1. First of all, have in mind the entry behaviour of the learner.
2. Try to think over the element of content, topic or the learning experiences to be given to the learner.
3. Try to think over the teaching or learning objective or objectives.
4. In view of the entry behaviour, element of content and the particular objective, try to select appropriate mental processes or mental abilities for writing the objective in questions.
5. Try to make use of the seventeen frames or statements of the RCEM approach given earlier in this chapter and fill in the blanks in view of the entry behaviour of the learner and learning experiences given to him.

Differences Between Aims and Objectives

AIMS	OBJECTIVES
(1) Aim is a general declaration of intent which gives direction to a teaching programme.	(1) Objective is a particular point in that direction.
(2) Aim is the answer to the question of why a subject is taught.	(2) It is an answer to the question of what will be achieved after the teaching of that topic.
(3) They are indefinite and Vague.	(3) They are generally definite and clear.
(4) These are close to the ideals which cannot be fully achieved. (Not 100%)	(4) They can be achieved. (100%)
(5) Schools, society and nation are responsible for their fulfilment.	(5) Mostly the teacher is responsible for their fulfilment.
(6) A lot of time is taken for their achievement.	(6) Time taken is not much. The achievement of objectives can be verified along with the teaching of the lesson or after the completion of the lesson.

Good Science Teacher

1. In a democracy, a teacher, being a good citizen fulfils all his duties. He is related to all the aspects of society. He has a knowledge of science related problems, needs of society and solves them in a democratic manner.
2. He represents as a teacher of science in college and community. He imparts knowledge of science according to the educational principles and needs of the community. His knowledge should be correct, complete and novel. This teacher works towards fulfilling the objectives of education and special objectives of science teaching.
3. The science teacher teaches the theoretical, experimental and practical aspects of every subject/topic.
4. In the class-room and laboratory the teacher uses the best 'knowledge acquisition process.'
5. A good science teacher not only makes use of Instructional Material and other Audio-Visual Aids but also prepares them. He pays more attention to new, nobel and latest knowledge rather than only bookish knowledge.
6. He selects important principles and facts from the entire syllabus and presents it in front of his students in a collective manner using appropriate method.
7. He is familiar with the techniques of evaluation to evaluate his students correctly.
8. He makes his teaching successful by knowledge acquisition process by obtaining complete knowledge of the personal needs, understanding capacity and problems of the students.
9. He is fully competent in selecting 'Science Apparatus' and making proper use of it.
10. An ideal teacher provides systemetic instructions to his students. He takes part in all instructional activities.
11. He is expert in organising exhibitions, science fairs and other activities for the people of school and community.
12. A good teacher gives introduction of his capabilitis in laboratory, work sphere and school community and helps others.

13. He is proud to be a teacher. In order to improve his teaching skills he takes part in various conventions, clubs, scientific group activities, inservice teaching experiments/research. In this way he is always aware about his responsibilities.

Teachers having above mentioned attributes can definitely be called ideal or good teachers if, along with the above mentioned qualities the teacher has the following attributes also –

1. Complete command over the subject.
2. Should have a zeal for the subject.
3. Proper preparation.
4. Special preparation for teaching each topic.
5. Firm control-power.
6. Practical skill and resourcefulness.
7. Complete knowledge of the child.
8. Parental behaviour.
9. Affectionate and sympathetic behaviour.
10. Practical and investigative attitude.
11. Sincerity/honesty.
12. Patience and endurance.
13. Voice Modulation-sweet, soft, courteous and awe- inspiring/authoritative.
14. Easy and interesting language.
15. Sharp intellect.

of National Association of

Some 'Must' for a Good Teacher

Every good ideal teacher should take a note of the following :

1. The syllabus should be changed according to the need of community, level of students, problems of community, the availability of time and examinations. In this reconstructing the co-operation of students should also be taken.
2. The teacher should plan his teaching for the year according to the importance of topics of syllabus keeping in mind all holidays, examination etc. Drawing a balance between theoretical, experimental and practical knowledge and taking into consideration the entire syllabus the teacher should preplan excursions, Science Day Projects etc.
3. He should select proper audio-visual aids, all apparatus and make use of them correctly and completely.
4. He should select appropriate teaching methods to make teaching lively and activity oriented.
5. He should have clear and novel knowledge of the subject.
6. He should have a positive attitude towards school management, teaching and students.

Good Teachers and Their Professional Ability

It is not sufficient to have the good qualities of a teacher but it is also essential that his abilities also increase, so that the teacher can impart knowledge of correct and new facts to the students. Thus, the teacher should increase his professional ability and do the following jobs.

1. The teacher should participate in community workshops, in service training course, workshops, meetings, conferences etc. He should have information of various new research developments.
2. To subscribe to good books, magazines, bulletins and newspapers for the library and study them.
3. To listen to and watch various programmes based on science on the radio and T.V.
4. To participate in the activities of occupational organizations of science teaching.
5. To have good of other school, colleges, universities, research institutes and regional laboratories and acquire knowledge.
6. To take part in the local, regional and national meetings.

7. To acquire knowledge of good teaching methods of science at national level.
8. To participate in meetings of committee preparing Instructional Material.

By participating in all these programmes the teacher will be aware of new facts/happenings and latest information which he will be able to impart to the students.

Evaluation of Good Science Teacher

A good teacher should evaluate himself form time to time. The following questions will help the teacher to evaluate himself better :

1. As a teacher of the school, how well are you fulfilling your duty ?
2. In teaching your subject, how far are you imparting latest knowledge by appropriate methods ?
3. What is your contribution in National Extension Services and Community Development ?
4. Are you a nucleus of activities for students, parents and local leaders in rural and urban areas.
5. Do you organise the curriculum at the appropriate time, according to the needs for the student community ?
6. Are you imparting theoretical knowledge along with practical knowledge in a correct manner with full capability ?
7. Are you making efforts to increase your professional qualification?
8. What opinion do the students, other teachers and the principal have of you ?

If the teacher is able to evaluate his/her performance honestly with the help of these questions, he/she can go a long way in improving the teaching competencies, creating appropriate learning experiences for qualitative improvement of teaching of physical sciences. By doing so prove him/herself an asset to the institution and society.

Micro-Teaching

Introduction

Micro–teaching is one of the most important development in the field of teaching practice. The workers in the centre for Research and Development in teaching have evolved an approach to practical teacher education/ training programme. It is more analytical method and completely new approach to provide the feed – back to modify teacher's behaviour according to the specified objectives. The recent researches in advanced countries in class–room teaching have proved that classroom teaching may be objectively analysed and modified according to the requirements, to develop desirable teaching skills and competencies in the student-teachers and even in in-sevice teachers. It is one of the important innovations in this direction. It is a process of subjecting samples of human behaviour to 5 R's of 'Vidio Tape recording', 'reviewing', 'responding', 'refining ' and 'redoing'. Micro – teaching is a controlled practice in which the normal complexities of class-room are reduced and that makes possible to concentrate on teaching behaviour in the student teacher training programme.

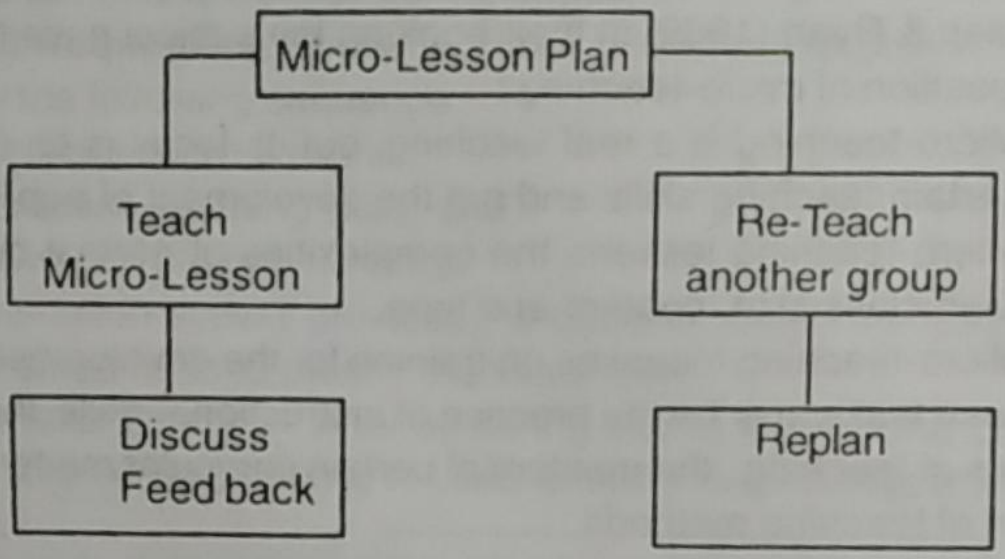
Meaning and Definition :–

Micro–teaching is like a simulated social skill teaching to provide the feed–back to teacher trainee for the modification of teacher behaviour. It aims at simplifying the complexities of the regular teaching process. Basically micro–teaching is a 'Scaled down teaching encounter'. It is scaled down in terms of class size to a group of 5 to 10 pupils. The lesson is scaled down in length of class time and is reduced to five to ten minutes. It is also scaled down in terms of teaching tasks.

These tasks may include : the practising and mastering of a specific teaching skill such as tecturings, questioning or leading a discussion. nastructional of speifi teahing strtigies: fleibility instructional dicision making. atternative uses of specific curricula. instructionar materials and class-room management.

The basic principles of micro -teaching are simple. A pupil-teacher teahes a short lesson of about five minutes duration to a small group of pupils which is recorded on an audio or vides tape recorder and the traine gets to hear and see himself immediately after the lesson. The pupils who

attend the lesson are asked to fill the questionnaires evaluating specific aspects of the lesson. The trainee's own analysis of the lesson based on the authentic feed-back from the tape together with the pupils, reaction and a supervisor's analys and suggestions, assists the trainee in restructuring the lesson, which he then immediately reteaches to a new group of pupils. Further assessments by the 'learner' and the supervisor lead to further improvement when he teachers again, either immuediately after or several days.



Micro-teaching cycle.

DEFINITIONS OF MICRO-TEACHING :

Micro-teaching has been defind in a number of ways. Some selected definitions are given here:

Allen. D.W (1966) : "Micro-teaching is the scaled down teaching encounter".

Allen D.W and Eve A.W (1968) : "Micro-teaching is defined as a system of controlled practice that makes it possible to concentrate on specified teaching behaviour and to practise teaching under controlled conditions".

Clift J.C and others (1976) : "Micro-teaching is a teaching training programme which reduces the teaching situation to a simpler and more controlled encournter achieved by limiting the practice teaching is a specific skill and reducing time and class size".

Passi B.K and Lalita M.S. (1976) : "Micro-teaching is a training technique which requires student-teachers to teach a single concept using specified teaching skill to a small number of pupils in a short duration of time".

Dr. L.C. Singh (1977) : "Micro-teaching is a scaled-down teaching encounter in which a teacher teaches a small unit to a group of five pupils for a small period of 5 to 20 minutes. Such a situation offers a helpful seeting for an experienced or in-experienced teacher to acquire new teaching skills and to refine the old ones ".

Jangira N.k and Singh Ajit (1982) : "Micro-teaching is a scaled down teaching encounter or miniatured classroom teaching".

Encyclopedia of Education (E.d . Deighton, L.C) : "Micro-teaching is a real, constructed, scaled down teaching encounter which is used for teacher training, curriculum development and research".

ASSUMPTIONS OF MICROTEACHING :

Micro-teaching is an idea, at the core of which lie five essential propositions. Allen & Ryan (1969) in their book on the subject gave the following main proposition of micro-teaching :

1. Micro-teaching is a real teaching, but its focus is on the development of certain teaching skills and not the develoment of pupils abilities.
2. Micro-teaching lessens the complexities of normal classroom by scaled down class size, content and time.
3. Micro-teaching focusses on training for the development of specific tasks. These tasks may be the practice of instructional skills, the practice of techniques of teaching , the mastery of certain curricular matter or the demonstration of teaching methods.
4. Micro-teaching permits for the increased control of practice by providing the feedback, to the pupil-teachers. A high degree of control can be imposed on the training programme.
5. Micro-teaching greatly expands the normal knowledge of results or feed back dimensions in teaching.It is highly individualized training programme.

Two related areas can be pointed out where there are clear advantages

(i) training in teaching skills.
(ii) research in teaching training.

CHARACTERISTICS OF MICRO-TEACHING :

(1) It is a real teaching. It focusses on developing teaching skills and competencies.

(2) Micro-teaching is an analytical approach to training.
(3) It is relatively a new innovation in the field of teacher education.
(4) It is a highly indivdvialized training device to prepare effective teachers.
(5) It provides adequate feed back for trainee's performance.
(6) Micro-teaching is a scaled down teaching :
(a) It reduces the class size upto 5 to 10 pupils.
(b) It reduces the duration of period 5 to 10 minutes.
(c) It reduces the size of the topic.
(d) It reduces the teaching skill. A single skill is practised.

(7) Use of video-tape and closed circuit televirsion makes observation very objective.

PHASES OF MICRO-TEACHING :

According to J.C. clift and others, micro-teaching procedure has three phases :

(i) **Knowledge Acquisition Phase :–** It involves two major activities.

(a) To observe demonstration skill.

(b) To analyse and discuss demonstration.

(ii) **Skill Acquisition Phase :–** Three activities are preformed under this phase in the following sequence :

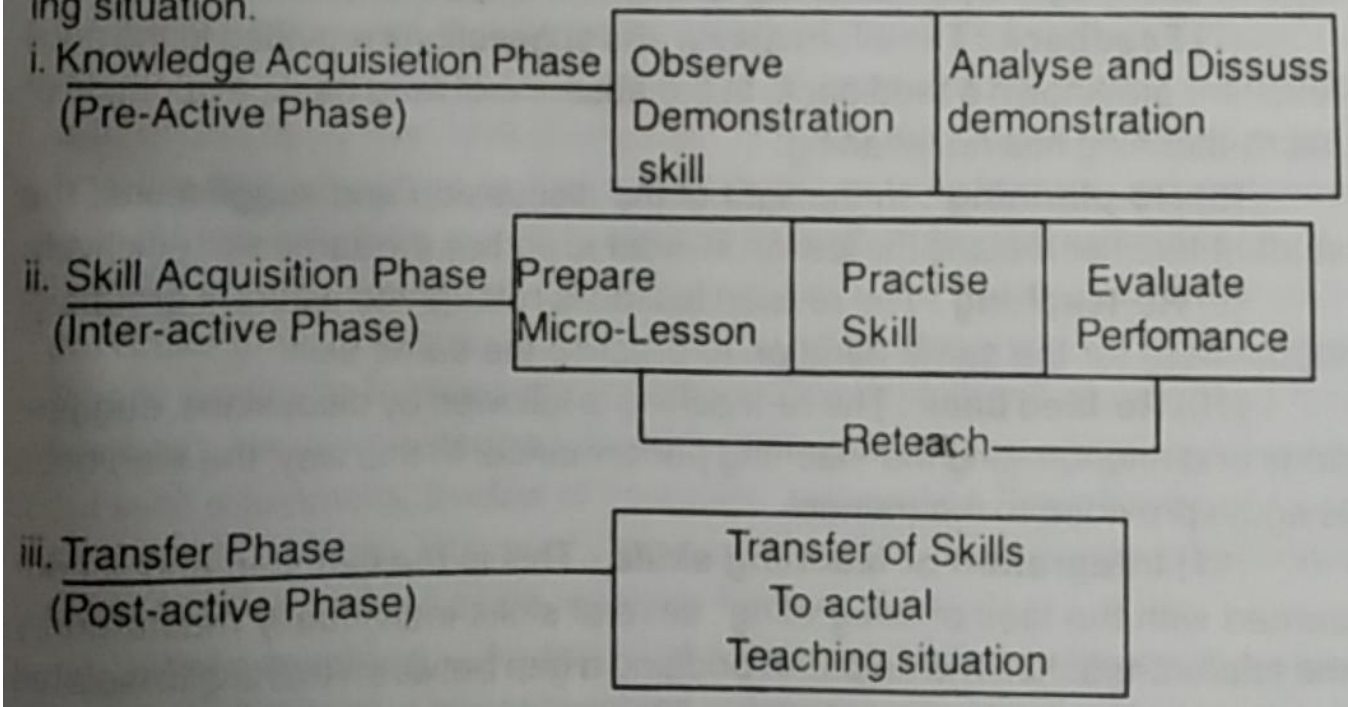
(a) To prepare micro-lesson.

(b) To practise teaching skills, and

(c) To evaluate the performance.

The evaluation activity provides the basis to replan the lesson for re-teaching the same topic to practis the same skill.

(iii) **Transfer Phase :–** After acquiring skill in the second phase, the trainees are given an opportunity to use the skill in normal classroom teaching situation.



The three phases involve certain steps which are given as under :

(1) **Orientation of the student-teacher :** This involves providing necessary information and therotical background about micro-teaching on the following aspects :

(a) concept of micro-teaching.

(b) Rational or significance of using micro-teaching.

(c) Procedure of micro-teaching.

(d) Requirement and setting for the adoption of micro-teaching technique.

(2) **Discussion of teaching skills :** Under this step the knowledge and understanding of the following steps are to be developed :

(a) Analysis of teaching into component teaching skills.

(b) Discussion of the rationale and role of these teaching skills in teaching.

(c) Discussion regarding the component teaching behaviours comprising various teaching skills.

(3) **Selection of a particular skiil :** Each skill needs to be practised at a time. Student teachers should be given necessary background for the observation of a model of demonstration lesson on the parlicular skill.

(4) **Demonstration of skill :** The skills are demonstrated through the micro-teaching lessons. These specific skills are demonstrated by an expert or shown through video-tape or film to the teacher trainees.

(5) **Micro-Lesson Plan :** The student-teacher prepares Micro-Lesson plans concerning some specific skills training or by using the skills.

(6) **Teaching a Small group :** The student-teacher teaches the lesson to a small group of 5 to 10 pupils which is observed by supervisor or video tape or audio tape when teaching is finished, lesson is criticized.

(7) **Feedback :** The informations and suggestions provided to the pupil teachers are known a feed back. In the absence of feed back, evaluation of micro-teaching has no meaning.

(8) **Re-planning :** In the light of the discussion and suggestions, the student-teacher replans the lesson in order to prctise the same skill effictively.

(9) **Re-teaching :** The revised lesson is retaught to different groups of same class for the same duration to practise the same skill.

(10) **Re-feed back :** The re-teaching is followed by disussions, suggestions and encouraging the teaching performance. In this way, the feed back is again provided to the trainee.

(11) **Integration of teaching skills :** This is the last step and is concerned with the task of integrating several skills individually mastered by the student-teacher. It is helpful in bridging a gap between training in isolated teaching skills and the real teaching situation faced by a teacher.

Duration of a Micro-teaching cycle is given below :

Teach	6 minutes
Feed back	6 minutes
Replan	12 minutes
Reteach	6 minutes
Re-feed back	6 minutes
Total	36 minutes

ADVANTAGES OF MICRO-TEACHING

The following are the advantages of micro-teaching –

1. Micro-teaching is an effective-feed back device for the modification of teacher-behaviour.
2. Micro-teaching is useful for developing teaching efficiency in pre-service and inservice teacher education programme.
3. It can be done either in real classroom conditions or in simulated conditions.
4. It is a training device for improving teaching practice and to prepare effecive teachers.
5. The knowledge of practice and teaching skill can be given by the use of micro-teaching.
6. The spsific teaching skills are developed by the micro-teaching experiences-eg. reinforcement skills, probing questions etc.
7. It lessons the complexities of the normal classroom teaching by scaled down teaching.
8. The training of teachers becomes individualized. Each trainee makes progress in developing teaching skills at his own rating depending upon his ability.
9. The mechanism of feed back device can be combined with other devices such as simulated social skill training (SSST) and interaction analysis device which provide continuous reinforcement to the trainee-performances.
10. It permits increased control and regulates teaching practice.
11. It is an economical device and use of videotape enables the trainee to analyse his own teaching performances.
12. It focusses attention on teaching behaviour to modify and improve in a desired direction.

Drawbacks (Limitations) of Micro-teaching

Following are the drawbacks of micro-teaching.

1. Micro-teaching tends to reduce creativity of teachers.
2. For successful implementation, micro-teaching requires competent and suitably trained teacher-educators.
3. Micro-teaching can be carried on successfully in a controlled environment only.
4. Micro-teaching is very time consuming.
5. The application of micro-teaching to new teaching practices is limited.
6. Micro-teaching alone may not be adequate. It needs to be supplemented and integrated with other teaching techniques.

The

Common Teaching skills;

1. **Skills of Introducing the Lesson :** It involves first to create set for introducing the lesson by greeting, accepting greeting, securing attention, giving instructions and establishing rapport. It is then followed by linking the lesson with past experiences. The main parts are linked with introduction by using appropriate devices/techniques like questioning, examples, exhibits etc.

2. **Skill of Questioning :** The art of questioning is the most potent weapon in the educational armoury of the teacher. Questioning plays an

indispensable part in 'learning', 'teaching' and 'testing'. If used in a right way, at the proper time, they lead to new realms of understanding. They serve as means of organizing knowledge or correlating the results of educative experiences, of tying together units of learning, and of integrating personality.

The questions can be classified as

1. Introductory or Preliminary questions.
2. Developing questions.
3. Recapitulatory questions.
4. Evaluating or Testing questions.

3. **Skill of stimulus variation** : It has been generally observed that children especially upto the age of 10 years are not able to attend to one thing for a long period. The effectiveness of the teaching learning process in such a situation depends to great extent on the stimulus variations used by the teacher behaviour. Hence, this skill involves deliberate changing of various attention producing behaviour by the teacher in order to keep pupils attentive at high level. Some of the common teacher behaviours in the class -room which fall under variation are :

(i) Teacher movement.
(ii) Teacher gesture.
(iii) Changes in speech pattern.
(iv) Changes in sensory focus.
(v) Changes in postures.

4. **Skills of illustrating or illustration with examples** : Illustrating an idea or a thing means throwing light upon it. It means using those aids which will make ideas clear to students and assist them acquire correct knowledge. Illustrations make instruction or learning concrete and interesting. They stimulate interest and enable the student to understand abstract ideas. They secure attention and possess a 'fixing power'. Illustrations are a valuable means of cultivating the power of observation and judgement and train the senses to greater acuteness and perception.

Illustrations are verbal as well as non-verbal. Here we deal with verbal illustrations which help in illustrating a lesson or topic. The media or way of illustrating with examples may cover giving analogy, telling stories or incidents etc.

Components of the skills of illustrating are : Formulating simple, interesting, relevant and linking examples with day to day life.

5. Skill of Explaining : An explanation is a set of inter-related statements made by teacher in order to increase the understanding in the pupils about the ideas and concepts. There should be clarity & continuity in the explanation. The explanation should be relevant i.e according to the content by using beginning and concluding statements. The explanation should also

cover all the essential points of the content.

6. **Skill of using Black-board :** This skill requires legibility, neatnes, appropriateness, continuity, simplicity of black-board work. It is very essential skill for a successful teacher. The effectiveness of presentation depends upon the proper use of black board.

7. **Skills of Reinforcement :** It involves teacher encouraging pupils responses using verbal praise, accepting their responses or non-verbal cues like smile. These skills may be classified as :

(a) **Positive verbal Reinforcement :** Following a pupil's answer, the teacher verbally indicates pleasures at the pupil's response by the use of words like 'Good', 'Fair', 'Excellent', 'Correct' etc.

(b) **Positive Non-Verbal Reinforcement :** These include nods and smiles.

Teachers friendly movements towards pupils.

Teachers-friendly look.

Teachers-writing pupil's response on the black-board.

(c) **Negative Non-verbal :** This comprises gestures smeering, frowning, expression of annoyance, impatience etc.

(d) **Negative verbal :** This includes comments like 'No', 'wrong', 'No good', 'Poor', 'of course not' etc.

(8) **Skill of Increasing pupil participation :** This skill involves the four components creating set questioning encouraging pupils activites and pausing in such a participation is maximised. Opportunities are provided to pupil by asking questions, creating climate of participation, by using silence and non-verbal cues calling upon pupil's physical participation.

Lecture-cum-Demonstration Method

It may be adjudged as the most practicable and useful method of teaching physical sciences in the available circumstances of our schools. Physical sciences can never be told or talked about. It is a very practical subject, the study of which needs richer experiences in the form of self-observation, and experimentation on the part of every pupil. However, to arrange for such learning experiences to all students in the school may not be possible or even feasible on account of so many reasons. Neither our educational system nor the available circumstances in the form of material and human resources permit us for the organisation and gaining of the individual practical experiences. The only suitable alternative in such a situation lies in the form of demonstration or lecture-cum-demonstration method in which the scientific facts and principles are practically demonstrated as well as explained to all the students of the class simultaneously by the physical sciences teacher.

The Shape of the Method

In the presentation of the subject matter, the teacher makes use of both the lecture and demonstration method in a well integrated way. What is to be conveyed through explanation, narration or lecture is necessarily supplemented through the practical demonstration of the objects, instruments and phenomena. For example, while teaching about water pump, the teacher may make use of a water pump model. He explains the construction and working of the water pump by showing its parts and actual working. Similarly, for teaching the concept 'air has weight', or 'solids expand on heating' the facts are first demonstrated through the relevant experiments and then students are helped to generalize and learn the related facts or principles. In this way, this method helps all the students of the class simultaneously to gain practical experiences with the common demonstrations exhibited by the class teacher. The students can use both their eyes and ears simultaneously for the gaining of learning experiences. They can get opportunity for the active participation by asking questions or helping the teacher in the demonstration work.

The teacher while demonstrating the experiments goes on asking questions to test their knowledge. The students are also able to ask questions regarding the experiment and get their doubts and difficulties removed. They may also be called by the teacher to get desired assistance in carrying out the demonstration work.

Advantages

1. All shortcomings of lecture method are removed.
2. All plus points of demonstration method are included.
3. The students get a clear picture of the topic.

Limitations

1. The students do not get a chance to make use of apparatus independently.
2. They do not perform experiments, but only observe it. Each child is not able to observe and collect proper data.
3. This method is not economically feasible.

Suggestions for Improvement

1. The teacher should have a clear knowledge of theory and practical prior to demonstration.
2. He should be able to use audio-visual aids, whenever required.
3. Experimental demonstration should be easy and according to the understanding level of students.
4. Prior to demonstration, he should try out the experiment himself and clear all related doubts.
5. The help of the students should be taken while performing the experiment. They should be given small responsibilities pertaining to the conduction of experiment.
6. The suggestions given in the experiment conduction method should be followed.

(8) Project Method

W.H. Kilpatric, a student of **John Dewey** is the exponent of this method. According to him **"Project that activity which is performed with complete attachment in a social atmosphere to achieve the goal". Prof. Stevenson** has called the Project method as problem solving method which is achieved in natural circumstances.

In this method a problem is posed to the students and they find solution to it. The student works according to his interest and willingness.

Principles of project:

1. Principle of Purposiveness
2. Principle of Activity
3. Principle of Reality
4. Principle of Utility
5. Principle of Freedom

6. Principle of Social Development.

For planning and administrating each project, these principles are stressed upon:

Steps of Project Method:

1. Selection of a Project – The teacher should create such circumstances that the students start formulating projects. The teacher and the students should discuss these projects independently. As far as possible the student should get a chance to formulate a project. The teacher should give the necessary suggestions.

2. Prepare an outline – After the selection of the project a programme should be prepared for the completion of the project. The students should be given full freedom to discuss the project among themselves. After an outline has been chalked out, the students should be given various responsibilities according to their capabilities and all this should be noted down.

3. Execution of programme – After the outline of the programme has been prepared, work should started accordingly. The responsibilities which have been given to the students, they start working on them. The students have to acquire various types of knowledge to complete their responsibilities. The knowledge thus attained is more permanent. The teacher encourages the students, supervises their work and makes changes if required.

4. Evaluation – After the project is completed the teacher and students together evaluate it. Based on the objectives of the project, its success or failure is discussed. The students discuss their work and rectify their mistakes and recollect useful knowledge.

Types of Projects:

In Physical Sciences various types of projects can be prepared and the students get practical knowldege.

Some important projects are given below:-

(a) Cleanliness of the school campus,

(b) Establishment of a Science Museum,

(c) Improvising apparatus,

(d) Electrification of school campus,

(e) Establishing the Physical Science Laboratories,

(f) Painting iron apparatus to prevent it from rusting,

(g) Soap/chalk/candle/polish/Ink making.

(h) Beautifying science room

(i) Arranging science fairs

(j) Preparation of perfumes.

Merits of Project Method:

1. The students contemplate, study and work.
2. The students remain active throughout the execution of the project.
3. The students have to perform mental and physical work thus they develop the values of dignity of labour.
4. The students realise their responsibilities and shoulders it.
5. The students develop qualities of patience, contentment and satisfaction.
6. This is a psychological method.
7. This is based on 'learning by doing'.
8. Relationship is developed among various subjects.
9. The acquired knowledge is permanent.

Demerits:

1. It takes more time.
2. Knowledge is not acquired in a sequential manner.
3. It is difficult to complete the syllabus by this method.
4. The teacher has to put in more labour.
5. This method poses problems for unexperienced teachers.
6. Correct knowledge of the true principles is not obtained.

Suggestions:

1. Project should have definite objectives.
2. All students should be given responsibilities according to their capabilities.
3. All figures should have graphical representation.
4. The students should be given the freedom to interact among themselves.

(11) PROBLEM SOLVING METHOD

In the words of **Hammonds Carsie** "Problem solving in teaching refers to the task making decisions or doing things that learner wants to make or to do, the nature of which he is able to understand, but for which at that particular time he has no solution". The method of problem-solving is a result of necessity. The student puts forth his topic related problem in front of other students and they start finding a solution to it according to their interest and capability. The problem should be placed in front of the students in clear words and should be according to the understanding experiences of the students. The student does the analysis-synthesis of the problem with the help of the teacher and tries to find the solution.

Steps in Problem Solving Method

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

Advantages

1. Students learn to find the solution of their problems themselves.
2. They develop the power of observation and argumentation.
3. They are capable to generalize.
4. They are familiar with the process of the collection of data, evaluation and drawing inferences.
5. They learn to use old facts in new references..
6. They develop a feeling of working together.
7. It is based on "Learning by doing".

Limitations

1. It is a wastage of time and energy.
2. There is always a doubt of drawing wrong conclusions.

3. In order to practise this method, talented teachers are required.
4. It is not suitable for junior classes.

Physical Science Laboratory:

The study of Physical Sciences is not possible without a laboratory. Science teacher provides them an opportunity to observe facts and carry out experiments so that his students may obtain proper & complete knowledge of the subject. The students work in the laboratory by themselves, observes, and on the basis of these, they try to deduce conclusions. **'Laboratory' word is used for large room where practical classes are conducted and a group of students carry out practicals. 'Science laboratory' is needed to keep instruments, apparatus, chemicals and other materials safe and secure and ready for use.** Various types of apparatus and material are placed in shelves or almirah under lock and key. The environment and the setting of the laboratory should be congenial to encourage students' participation. Labotatories help in the development of sense of cooperation and spirit of competition.

Objective of Laboratory:

Objectives of laboratory are given below: –

(1) To develop scientific attitude among children through practical work in the laboratory.

(2) To develop the skill in handling scientific apparatus, instruments & equipments;

(3) To provide opportunity for the training in scientific method.

(4) To help students in developing the feeling of cooperation, resourcefulness initiative, self-dependence, self-confidence, cohesion, sociability, self-reliance, and self-discipline.

(5) To provide real and stable knowledge of science.

(6) To provide opportunities to think, observe, apply reaso§3,5anch to arrive at a decision/conclusion independently.

(7) To encourage students to save the time, resources as well as energy.

(8) To arrange an atmosphere which is very conducive for learning science.

(9) To enable them to interpret & verify the various science- principles and substances.

Planning a Science Laboratory: The Govt. of India, committee on plan projects in its report on Science Education in secondary schools, em-

phasizes that the following factors be taken into consideration at the planning stage for the laboratory:-

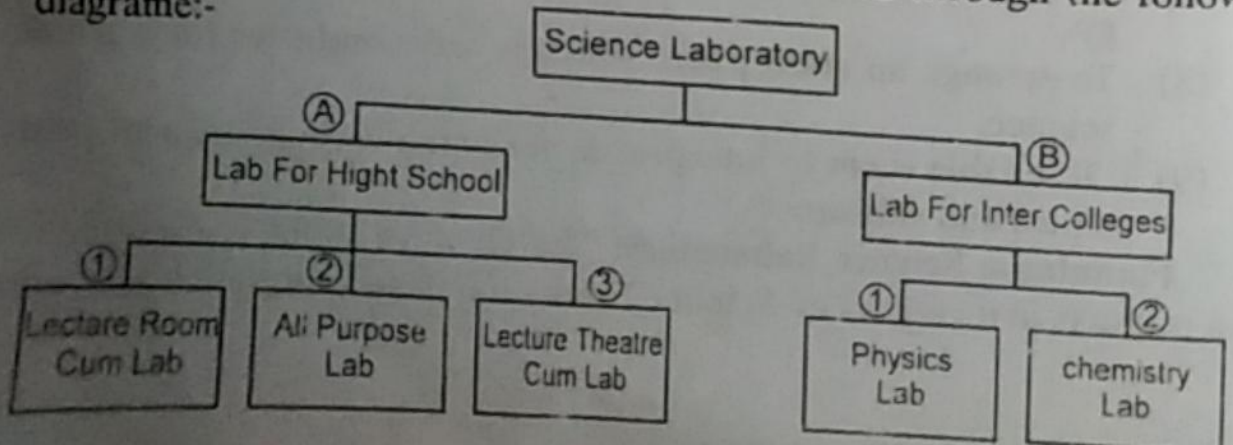
(a) The number of students working at a time in the laboratory.
(b) The minimum space necessary for every students for comfortable working.
(c) Limitation of number of science teacher in secondary schools.
(d) Need for ancillary accommodation for storage.
(e) Designing the science-classroom and laboratory in such a way that it could be used for science teaching.
(f) Imperative need for economy.

Organization of Laboratory:

For organised teaching of physical sciences, the laboratory should have a preparation room, store room, science room and dark room. In the preparation room of laboratory such apparatus are collected which are to be used in the laboratory or 'Science room'. In this room apparatus for daily experiments are kept. The laboratory assistant or the teacher can prepare the experiment in the 'preparation room'. In this various apparatus like-nails, rings, screws, glass tubes, jars, ropes, pipes and various tools are kept. In the store room (which is generally inside the laboratory) Physical Science related apparatus and articles are stored. This room should be kept locked, there should be one door opening in the 'science room'. The articles should be properly arranged in large glass almirahs. The various articles should be labelled. There should be proper light and ventilation. In the 'science room' the teacher demonstrates the practical/experiment. The seating arrangement in this room should be such, so that all the students can watch the experiment clearly. The seats should be as in theatre i.e. in ascending order lower in front to higher at the back. There should be proper arrangement of light. The windows should have dark curtains so that the room can be darkened as and when required. The teacher's table should be big enough to place all the apparatus in front of the students. There should be a blackboard at the back or towards the left, which the teacher can use whenever required. There should be pictures of scientists on the walls. The 'dark room' is permanently dark but ventilated.

Types of Physical Science Laboratories in Schools

Various types of laboratories are presented through the following diagrame:-



Laboratory for High Schools:

There are three types of science labs prevailing at high school level in our country. They are:-

(1) Lecture-Room-cum-laboratory

(2) All purpose laboratory

(3) Lecture Theatre-cum-laboratory.

1. Lecture-Room-Cum Laboratory

Lecture-room-cum-laboratory plan was originally suggested by Dr. R. H. Whitehouse (Formerly Principal Central Training Institute, Lahore) and now it is adopted as one of the standard plan for High schools. It is an economical plan and very much suitable to our conditions. It is more beneficial in developing science climate as well as more convenient for the students & teachers.

Details of this plan are given below: –

(1) The Lay Out:

In this plan, it is suggested to have a room of 45' x 25' for a class and it should be partitioned into two equal compartments, one of which may be used as the lecture-room and the other, for laboratory purpose. This lecture room can accommodate 40 to 50 students, and in the laboratory 20 to 25 students can work for the science practicals.

(2) Walls & Floor:

Walls & floor of the lecture room-cum-laboratory should be quite tough & durable. It is suggested to have the thickness of the walls equal to $1\frac{1'}{2}$ feet. The walls should be well-plastered and painted upto a height of 90 c.m. and rest be white washed or distempered. The floor should be cemented or tiled with a proper drainage system. There should be round corners between the wall & floor to avoid dirt lodging. A slight slope in the floor is better as the water may be swept easily.

(3) Doors:

The rooms should have doors facing north for getting more sunlight and fresh air. There should be two doors, one near the lecture room and another near the laboratory. These should open outwards as it saves the space and also convenient for emergency exist. One door may be used for entrance and another for exit. Whatever plan is adopted, a rigid observance of the rules of entrance & exit is a must. There can also be a door connecting both the apartments i.e. lecture room and laboratory.

(4) Windows:

On the side opposite to the doors three windows each 6' x 8' x 8' should be provided. Out of these, one should be near the practical benches and two of these should be near the seating accomodation. The windows be open outwards so that inner sills of the windows may be used as shelves.

Wire gauze screens be fitted to avoid flies and mosquitoes etc. Provision should be made for the window blinds for darkening the room required for various experiments. Proper ventilation is necessary and for this, adequate arrangements for ventilations be made.

The windows and doors should have glass panes to bring sky-light in the laboratory.

(5) Furnishing:

There should be a blackboard of $10' \times 4'$ size. Teacher's table should be at a distance of about three feet. The size of the table should be $6' \times 2'$ high, so that it may also be used as a demonstration table. No raised plateform is required for the table.

The lecture room should have a seating arrangement for 40 students. There should be 20 dual tables of $3\frac{1}{2}' \times 1\frac{1}{2}' \times 2'$ high with two students on each table. The top of the table should be flat. The chairs or stools may be of wood or iron, are $1\frac{1}{2}'$ high. The area allowed for dual tables and two chairs be $3\frac{1}{2}' \times 3\frac{1}{2}'$ with a passage way of $1\frac{1}{2}'$ for single file and a space of $2\frac{1}{2}'$ to $3\frac{1}{2}'$ at the sides. Thus, the total area needed for 40 students is $18\frac{1}{2}' \times 17\frac{1}{2}'$. The dual tables should be placed at a distance of 9cm. to 120 cm. from the walls.

(6) Laboratory:

A black board of $10' \times 4'$ should also be provided in the laboratory. There should be a provision of 6 big plain-tables (systematically arranged) for conducting experiments. There should also be one smaller table for the use of the teacher near the black board, which may also be used for keeping the apparatus & other material required for the experiment. It may also act as the demonstration table.

The six big tables (referred above) should have a shelf along the working sides for placing books and papers. The top of each table is waxed or may be fixed with sheets of aluminium or glass to act as acid resistant. The size of the table should be $6' \times 3\frac{1}{2}' \times 3'$. Each table accommodates 4 students. No sinks be provided with the laboratory tables. However, three sinks should be fitted one for teacher, and two for the students (one fitted in the window recess and another in the recess in the wall) Each sink is provided with a straight down pipe leading to a bucket. A drainage board be provided

to drip water over the sink. Beakers cylinders, flasks etc. may be invested on it for drying and draining off water.

The recesses in the walls should be 1 wide and at a height of $3\frac{1}{2}'$ feet from the ground where balances can be placed.

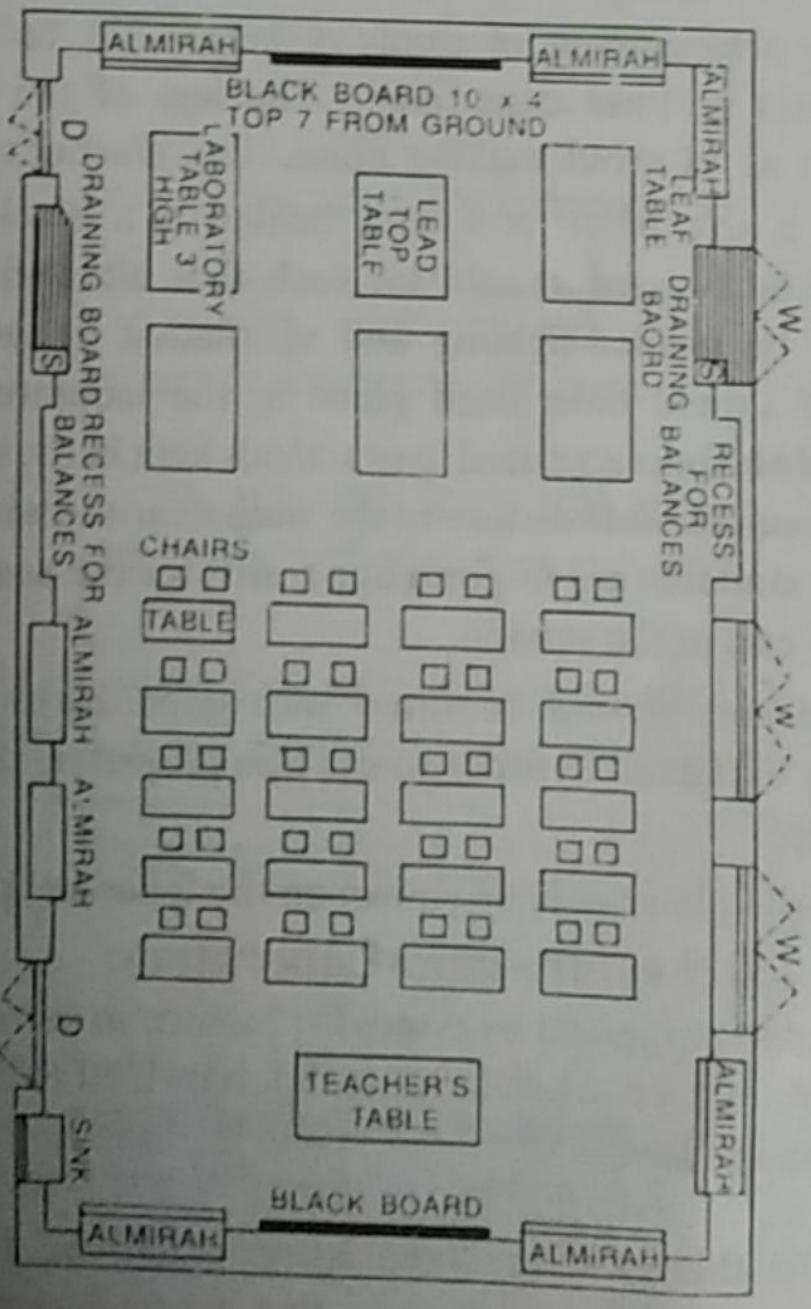
There should be 8 almirahs, each of 7′ high and 5′ wide and $1\frac{1}{2}'$ deep and 6′ projected in the room are provided for storage accommodation.

Notice boards and bulletin boards may find place between the windows or just inside the doors.

For the laboratory, proper arrangement should be made for water supply and electricity.

This lecture room-cum-laboratory plan is being presented on the following page.

Diagrame-Lecture room-cum-Laboratory Plan



(b) All Purpose Laboratory

This type of laboratory may serve the dual purpose of practic as well as theory work. It is also known as integrated plan of bo physical and life sciences.

For seating 30 to 32 students a laboratory of an area $45' \times 25'$ is sufficient. There can be placed around 16 tables and o each table 2 (two) students can work. The size of the table is generall $6' \times 2'$ but if the table is required for four (4) students then the siz of table is $6' \times 4'$. In between the tables there should be a tap fron where the student can take water easily. The tables should have polish so that they are not spoiled by water acid or alkali. A cupboard is also arranged for each student to keep the articles for experiments. There should be a tap, gas burner etc on the seat of each student. There should be arrangement of stools of height $22''$ to $262''$ for the students to sit and perform experiment. The legs of the stool should be rubberised so as to avoid making noise. The teacher's table in the laboratory is of a size of $10' \times 4'$ and behind it a black-board. The position of the black-board should be such that all students can see it. There should be proper lighting and ventilation in the laboratory. Every equipment should have fixed place in the laboratory.

There should be books related to practicals kept in the alimarhs. The tables of the students should be close to the walls near the windows to give proper light. The students are to given apparatus for the session and collected back at the end of the session.

All the windows should be fitted with good blinds so that the laboratory may be darkened in order to use film projecter, slide projecter and epidiascope etc.

Audio-Visual Aids in Science

In order to make the lesson interesting and understandable it is necessary that the education should have a relationship with maximum organs of perception. Keeping in mind this objective, these days the use of audio-visual aids is being made in abundance. The use of audio-visual aids in teaching of science is compulsory. The theoretical, oral and uninteresting topics can be made more natural, entertaining and useful with the use of teaching aids. It is a factual truth that audio-visual aids, sharpen the senses of sight and hearing and open up the avenues of learning.

Althogh the teacher is himself an audio-visual aid because he makes the lesson easy and tries to explain it properly, still he is not complete in himself. The use of audio-visual aids is not only desirable but necessary.

Audio-visual aids can be defined as **"Audio-Visual Aids are those tools and devices by the use of which communication of ideas between persons and groups in various teaching-training situations is helped."**

Objectives of Audio-Visual Aids :

1. To develop the lesson and create interest of the students towards the lesson.
2. To impart factual knowledge to the students in an interesting manner.
3. Improving the power of retention.
4. To make the students more active.
5. To develop the interest towards learning.
6. To have desired effect on the earnest desires/interests.
7. To impart education to the dull and intelligent students according to their capabilities.
8. To make the teaching material clear, easy and understandable.
9. To keep the attention of the child-centred towards the lesson.
10. To develop the power of observation of the students.
11. To make inanimate objects animate.

Characteristics of Audio-Visual Aids :

The audio-visual aids are useful in teaching due to the following characteristics –

1. The audio-visual aids help in learning and understanding permanently.
2. It reduces verbalism.
3. It imparts knowledge through experience.
4. It gives knowledge through narration.
5. It saves time and increases interest.
6. It gives a flow to the thoughts.
7. Helps the teacher in useful and proper teaching.
8. Eliminates language related problems.
9. Makes use of variety of media.
10. The students remain more active and learn the lesson easily.
11. Develops scientific attitude.
12. The students start considering themselves as efficient, resourceful, self-dependent as they start working themselves.
13. They develop curiosity towards exploration of various subjects.
14. They get a chance to see the things apparently.
15. They get a chance of comparative study of natural and artificial things.
16. The students learn the methods of use of apparatus.
17. The audio-visual aids explain the intricate matters easily, precisely and develop the imaginative and thinking power of the students.
18. The sense of perceptior. is inspired and the students obtain precise knowledge.
19. The lesson becomes interesting.

Classification of Audio-Visual Aids :

The audio-visual aids can be classified in various manners. But the following classification is very popular and commonly used –

Classification of Audio-Visual Aids

1. Visual Aids
   - Model
   - Picture and Poster
   - Blackboard
   - Magic Lantern
   - Epidiascope
   - Real Objects
   - Sketch and Diagram
   - Map
   - Album or Scrap Book
   - Graph
2. Audio Aids
   - Gramophone
   - Radio
   - Tape recorder
   - Lingua phone
   - Headphone
   - Dictaphone
3. Audio-Visual Aids
   - Picture
   - T. V.
   - Video
   - CD's

Chart
Film strip
Text-Books
Bulletin Board
Tours and Excursions
Museum
Computer/Internet

1. Visual Aids : The knowledge is perceived by the use of audio- visual aids. If a student is being told about the various parts of a machine then he should actually be shown that machine. The students take more interest in what they see and show more curiosity.

2. Audio Aids : By the use of this type of aids the student gains knowledge through the sense of hearing. The chief examples are radio and tape recorder. By the use of these apparatus the students listen to the new discoveries and scientific inventions and life histories of Scientists and gain knowledge.

3. Audio-Visual Aids : In the use of these aids the eyes and ears work together. The child sees with his eyes and listens with his ears and tries to memorize the teaching points. The knowledge bestowed by these aids should have the quality of being precise, real, thematic and have comprehensibility. In the absence of these the audio-visual aids lose their usefulness.

In science the Audio-Visual Aids can also be classified in the following manner :

1. Projected Aids : In this type of aids all those aids are included which are projected e. g. film strips, films etc.

2. Non-projected Aids : In this type of the aids like charts, pictures, models, are included.

Useful Audio-Visual Aids in Physical Sciences

In Teaching of Physical Sciences mainly the following types of audio-visual aids are used.

1. Chalk or Black-Board.
2. Objects.
3. Models.
4. Science exhibitions & Science fairs.
5. Film strips and Films.
6. Charts, graphs and maps.
7. Pictures and Diagrams.
8. Magazines.

9. Telescopes
10. Science Museums.
11. Projectors.
12. Science kits.
13. Tape recorder.
14. Television and radio.
15. Bulletin and Flannel Board.
16. Epidiascope.
17. V. C. P. & V.C.R
18. Computer & teaching machines.
19. Science excursions & visits.

(1) Black-board chalk board and chalks:

The black-boards and chalks are as important to the teacher as the weapons to a soldier. An efficient teacher always makes use of these. But how to use the black-board correctly, this technique is known to few teachers. In a poor country like India, this is a common teaching aid generally used in all schools. Evein in the villages, where there is no provision of audio-visual aids, black-board is available.

Effective use of black-board : Some views have been expressed regarding the effective use of black-board so that teaching can be made more effective. While writing on the black-board care should be taken to write the sentences in a straight line. Unevenly written sentences have a bad effect on the eyes of the children. They also look awkward. The black-board contents should be clear and readable, otherwise:

(i) The students will trouble the teacher by asking repeatedly.
(ii) It will not give rise to clear understanding.
(iii) Some students will completely ignore the Black-Board work thinking it to be incomplete.
(iv) The writing on the black-board should be bold so that the students sitting on the back-benches can also read. The teacher should keep the fact in mind that whatever he is writing on the Black-Board is for the students.
(v) After writing on the black-board the teacher should face the class and teach because he has to teach the students not the black-board. But if the teacher has to give some information and explain it then the teacher can do so while writing but his voice should be loud so that the whole class can hear it easily. Similarly ,the teacher can explain the figures while pointing out towards the black-

board. It has been rightly said that while teaching the teacher should make use of the sense of hearing and sight of the students.

(vi) While writing on the black-board it should be written in a manner so that all students can see. While writing the teacher should not stand in a manner so as to cover what he has written.

(vii) The subject and the title of the lesson should be written on the black-board but it is not necessary that unit duration, class section or date be written as the information is for the students and they already know it. The supervisors can know about it from the lesson plan, thus writing this, is considered to be waste of time.

(viii) While drawing the diagrams, coloured chalks should be used, they look more effective and draw the attention of the students.

(ix) Before leaving the classroom the black-borad should be erased so that the other teacher will not have to clean it and you will also get a clean black-board. It has been said "Leave the black-board as you want it."

Personality in Relation to Black-Board Work :

The black-board reflects the personality of the teacher. When the teacher writes on the black-board then how he stands, how he finds solution to the problems and draws the result, how he teaches, how he accomplishes black-board work are all deciding factors of his personality. The teacher should pay more attention to the black-board. It is true that **"Hand-writing is the symbol of personality and character."** The black-board tells us about the teacher and his/her personality. The good work on the black-board, organised form and compact matter, clear and beautiful handwriting indicate towards a good personality of the teacher. Thus, the teacher should use the black-board carefully and properly so that his/her personlity can become more impressive. Effectiveness is an essential quality of a teacher.

Aims of Black-Board Summary :

The teacher makes use of the black-board to achieve the following aims :

1. Main points for retention.
2. Printing of facts on mind without cramming.
3. Audio-visual aids.
4. Helping weak students.

Precuations in Black-Board Work :

The teacher should take the following precautions while making use of the black-board :

1. The rough work done to explain and the black-board work should not be mixed. The rough work should be erased after the accomplishment of the task or should be done separately.
2. It the teacher has to draw diagrams on the black-board in front of the class, then he should first decide on how much portion of the black-board he has to draw, how much portion to be used to describe it and which and how much portion to be used for rough work.
3. The teacher should not start teaching while the students are busy in copying the black-board matter. When the children have noted down the summary then only the teacher should start the teaching work.
4. After completing the black-board work, useless gestures to draw the attention of the students should be avoided *e.g.* playing with the chalk, moving the duster here and there etc. This type of gestures distract the students from studying.
5. Free movement is permitted.
6. While writing on the black-board such atmosphere should be avoided which gives the feeling of artificiality or the students will not be able to study properly. While explaining the various pictures, charts etc. on the black-board, a pointer should be used.
7. If the picture or diagram is complicated then the help of a roller board should be taken. To make the picture more effective, outline should be drawn beforehand and the rest should be developed in the classroom.
8. While writing on the black-board wrong words, sentences or information should not be written.
9. Black-board matter should be prepared in advance.

(2) Real Objects :

The real objects are very important in the field of science. On the basis of perception of objects the student gets an apparent experience. Objects like rocks, soils, minerals, etc. can apparently be shown in the class. To show the object apparently and to make this process more natural the students can be taken for excursions. Seeing the objects face to face the students get familiarised with these objects. That is why, these objects are considered very useful and lively means of teaching.

(3) Models :

If due to some reasons it is not possible to show the real objects to the students in the class then they are shown the models of these objects. These models should bear a close resemblance to the objects so the students perceive a true picture of it. The teacher should use the models of different

types of scientific apparatus & scientific processes. These models can also be prepared by the students, with guidance from the teachers.

(4) Science Exhibitions and Science fairs :

These are also very important aids for science teaching. Students learn many things and skills through these aids. Teacher & students, both have to play an important role and have to work hard for the use of science exhibitions and science fairs.

The details of science exhibitions & science fairs are given in another chapter. Students are advised to refer this chapter

(5) Film strips and Films :

Knowledge about various functions, discoveries and other information related to science can be imparted with the help of film strips and films. The students take a lot of interest in these and can study the various scientific functions in an apparent manner. In the films and film strips each subject is given in systematic sequence and in detail and gives a clear knowledge of the subject, thus the knowledge imparted through this medium is effective and permanent. In India, now the films and film strips, on various subjects are being prepared commercially. Education Department, Government of India, N. C. E. R. T. and other institutes are producing vaious films related to science and have published their list. The interested teachers can procure the necessary films and show them to the students and then return them.*

(6) Charts, Graphs, Maps, Pictures and Diagrams :

When the models of objects are not available the teacher can make use of charts and graphs etc. With the help of the charts, the teacher can explain the various functions, topics and information of science with ease. The advantage of the chart is that the picture which cannot be drawn quickly on the black-board, its chart can be prepared in advance and knowledge can thus be imparted. One chart should have a single objective. These should be colourful and have matter related to the topic. The chart should be artistic in shape and size. The chart should be clear, true and impressive. The teacher can draw various pictures and diagrams and explain the topic clearly. The figures drawn by the teacher should have a correct ratio. If the teacher is not able to draw the pictures quickly and correctly, then he should make use of the charts prepared in advance. The following charts and pictures can be used in the field of Physical Sciences :—

1. Chart depicting various laws and formulae.
2. Pictures of prominent scientists.

3. Pictures related to the developments in Physical Sciences.

4. Charts and pictures depicting the use of science in daily life.

5. Structure of atom & molecules.

6. Charts showing different chemical processes.

(7) Magazines :

Knowledge of various topics of science can be imparted through the medium of newspapers and magazines by relating these topics to daily life. Facts can be made clear to students by taking examples from the articles published in newspapers and magazines. General knowledge can be given about different experiment & inventions which has been published. This way the students can be made active.

(8) Telescope :

Telescope is used in studying distant objects. The students can have an idea of distant objects on earth with essential details with the help of terrestrial telescope. They can also be acquainted with heavenly bodies like galaxies, stars, Moon & planets etc. using astronomical telescope.

(9) Apparatus and Material :

These are very essential for all science subjects. Without these no real science teaching is done. Demonstrations & experiments are very useful and they make use of apparatus & material. The students can learn the skill in proper handling and using apparatus and material.

(10) Science Museum :

In a museum, we preserve substances, material & apparatus etc. These provide quite useful information for many topics of physical sciences. In a school, establishing science museum should be a prime necessity.

Advantages of Museum :

1. It makes the teaching easy, interesting and nearer to the truth.

2. By this direct, clear and permanent knowledge of certain things can be obtained.

3. Students get first hand experience.

4. By seeing strange things curiosity is aroused and a rapport between students and school is formed.

5. The observation power of students is developed.

6. The natural instinct of students collective things is developed.

Organization :

Place : A safe long gallery or room is best place for a museum where audience can get a good view of objects. There should be arrangement of glass almirahs and showcases, etc.

Collected Articles :

In the museum following types of science related articles should be kept :

1. Various types of small gadgets of electrical & mechanical nature.
2. Instruments & apparatus used in various processes.
3. Charts, pictures & models explaining the principles of Physical Science.
4. Various types of substances and material.
5. Various chemicals alongwith their written properties.

While collecting various articles for the museum, students' co- operation should be sought.

The students can collect articles from the following places :

1. Tours or education trips or excursions.
2. Markets.
3. Science exhibitions.
4. Science fairs.
5. Science books.
6. Scientific Institutes.
7. Newsletters and Magazines.
8. Technical Institutes.

Charts, pictures etc. should be preserved with D. D. T. or Napthalene powder.

Exhibition or Decoration of Museum :

In the Museum :

1. All articles should be kept in a planned and systematic manner.
2. All articles related to Physics should be kept on one side and those related to Chemistry on the other.
3. All almirahs and bottles should be labelled bearing the name of article, date of receipt and place of procurement.
4. Clear instructions should be written so that no one touches the articles. *e.g.* 'Do Not Touch.'
5. A list of all articles should be prepared and the management of the museum should be given to the science club or students of higher classes, under the closed supervision of the science teacher.

(10) Projector :

The teacher can show the students slides, film strips and films and make the teaching interesting with the help of the projector.

(11) Tape Recorder :

The teacher can make use of the tape recorder to make his teaching interesting. Sounds of different animals and birds, lectures of prominent scientists and specialists can be taped and can be reproduced before the

students when required. The audio-visual section of N.C.E.R.T. has collected various tapes and established a 'tape-library.'

(12) Televison and Radio :

The national channel of Doordarshan (DD1) and the All India Radio are relaying many education related programmes. In these many experiments are conducted, lectures are relayed and life histories of scientists are highlighted. Teaching by a good teacher and a specialist's lecture, the students can listen to and watch on the radio and T. V. while sitting at home.

(13) Bulletin Board and Flannel Board :

The Bulletin Board is very useful for giving information and news relating to science topics, exhibiting strange pictures and information about the lesson being taught in the class. Cuttings from various newspapers and magazines etc. can be put up on the Bulletin Board.

In the classroom, the flannel board is fixed near the black-board. The teacher uses this board for exhibiting life history of scientists etc. with the help of the paper cuttings etc. When various procedures or its steps are compiled on the board, it becomes an interesting activity for the students. The ideal size of the board is 60 x 75 cm. The parts to be shown on it should have sandpaper fixed under it because sandpaper sticks on flannel by slightly pressing it over and can be taken out easiy.

(14) Epidiascope :

With the help of the epidiascope printed figures, pictures, diagrams etc. can be enlarged and projected on the screen. This is a boon for the teachers who cannot draw proportionate pictures on the black-board.

It combines the benefits of showing transparent as well as opaque objects. It helps to deal with a large class and students are motivated as the monotony of the class teaching is broken up.

(15) Science kits :

'Science kit is an answer to the new challenges posed by compulsory science teaching, remote single-teacher-village schools, and the problems of science teachers'.

Science kits serve the purpose of laboratory. **"Science kit is a device of preparing folded apparatus and material and then to arrange them in a box, which may serve as the demonstration table."**

Why to use science kits ?

(1) These are economical.

(2) It provides a systematic knowledge and understanding of the fundamentals of science.

Field Trips

'Field trips' are rich sources of true education. Field trips not only provide educational knowledge but also give them a chance to make use of actual or real knowledge. Their power of observation is developed. As regards to its importance it is said that, "Field trips when properly conducted, satisfy two main concepts of Educational Theory, motivation of the desire to learn and the actual learning.

Objectives

1. The objective of the field trip is to provide first hand observation and experience. Knowledge as regards to all those things can be provided, which cannot be shown in the classroom easily.
2. To create interest in the students about different subjects.
3. To draw conclusions from the exercises conducted in natural environment.
4. To exhibit relation between theoretical and practical knowledge.
5. To develop the desire among students to understand responsibility and fulfil it.
6. To develop the observation power of students.
7. To develop the students to make proper use of vacation.

Advantages–

1. The students obtain actual knowledge in natural surroundings.

2. They undergo similar experiences which they can utilize to acquire new knowledge.

3. They get a chance to observe, to get5 real experience and to describe them.

4. They develop the quality of mutual co-operation.

5. They learn a lot of things which may help interchanging their attitudes.

6. Field trips, provide larger interaction and widen the horizons of learning.

7. It helps in acceptance of progressive methods and developing healthy attitude towards them.

8. It gives an opportunity to the students to perform practicals independently which come under theoretical knowledge.

9. It teaches the students with the needs and the problems of a group and find solution of them.

Limitations–

1. At least a whole day is required for the field trip. It is not possible to conduct it in few hours.

2. Co-operation is required between teacher and students for its success.

3. here can be accidents during Field-Trip.

4. There should be enough finances fro Field Trips.

Adjustment in Field Trips

Organising field trips is a responsible job. All the jobs should be distributed equally in a congenial atmosphere. All the information should be given to the students before the commencement of the journey. It is very helpful if a 'Route-guide' is prepared in advance.

SCIENCE FAIRS OR EXHIBITION

Science fairs are now becoming popular day by day. NCERT, SCERT and state department of education are joining hands, for the promotion and encouragement of science fairs at the district, regional or state levels by providing essential financial aids, guidance, and all other official assistance. These fairs may prove a good platform, forum and means for the display of all the activities whether formal or informal in nature undergoing in the field of science education in different schools. These also provide healthy competition among the students of different schools for bringing out their talents in the study and improvement to science and prove a source of great inspiration and encouragement for making the science popular, interesting and useful among the people of the community.

Exhibits Displayed in the Science Fair

The exhibits in science fairs are ordinarily of the following nature :

1. Objects and specimens collected by the students.
2. Graphic material like charts, pictures, graphs and diagrams on various topics and events related to different branches of science.
3. Charts depicting the processes and functioning of various inventions and discoveries related to science.
4. Scientific models prepared by students individually or collectively.
5. Apparatus or any other scientific instruments made by students themselves.
6. Scientific toys either electrical, mechanical or magnetic made by the students.
7. Improvised apparatuses showing some innovation brought out in the existing ones.
8. Industrial and technological use of certain scientific principle demonstrated through the arrangement of some apparatus or innovative design of a process depicted through charts.

9. Articles of scientific use entirely and exclusively prepared by the students.

10. Display of several projects successfully completed by the students.

11. Good science text-books, general and reference books, news bulletins and journals.

12. Good aids for the teaching of different topics in physical and life sciences.

Other Activities Undertayken in the Science Fairs

Apart from organizing exhibitions and displaying the objects, the following types of programmes and activities may also be undertaken in a science fair :

1. Holding debates, declamation and paper reading contests on different topics of scientific interest.

2. Holding essay competition on the topics of scientific interest.

3. Holding group–discussions, seminars and workshops related with the study, research and development of science.

4. Arranging lectures and talks of the science teachers and educators on useful scientific topics.

5. Holding the science quiz contests.

6. Organizing competition in the field of aids used for teaching science.

7. Organizing film shows and plays on the topics and themes related to the development, study and application of science.

Purposes and Objectives of the Orgainsation of Science Fairs

Science fairs are seen to serve some of the following purposes and objectives :

1. Science fairs prove a good media and means to the science students for trying out theory into practice.

2. Science fairs afford opportunity to the students as well as members of the community to understand the practical application and utility of science.

3. From these fairs the students get opportunity to see the individual or collective performance of other students for being encouraged and inspired to work hand in the pursuit of science.

4. Science fairs interest in the students for science and thus may help in making the study of science a joy in itself.

5. These fairs provide opportunity to the talented or creative students for the nourishing and nurturing of their creative talents.

6. Such forum helps in bringing out the future scientists into lime light and thus may prove quite helpful in catching them young for being trained as a skilled and teachnical personel and inventors for the growth of the society, nation and mankind.

7. Science fairs help in providing satifactory forum and opportunity for the healthy competition on the individual and the institutional level.

8. Science fairs bring the schools quite close to community and the society. The guardians of the students derive pleasure and satisfaction on seeing the performance of their wards. They are also acquainted with the utility and service of science in their day to day life.

9. Science fairs may help in knowing about the methods, teahniques and aid material developed by the individual teacher, students or institution and deriving benefit by coming into contact with each other.

Organisation of Science Fairs

Science fairs are organised by the individual institution not only for their own students but these may also be organised in the shape of inter-schools, inter-district, inter-state levels. For their effective orgainsation at any level, the science teachers have to play a significant role in terms of the planning as well as execution. In general the following things are to be kept in mind by them for the organisation of these fairs :

1. The science teacher (incharge) should seek the cooperation of the head of the institution and also of his colleagues and the students before undertaking the task of organizing science fair in his school. Moreover, it is also necessary for him to ensure the active cooperation and help from the participating institutions and terms for the effective organisation of science fair.

2. The major problem concerning the availability of the finances for the organisation of science fair can be solved by seeking due cooperation from all corners. Besides the contribution from the host club and financial assistance from NCERT SCERT, and State Government, the participant teams should also contribute in the form of entrance fees and bearing expenses in setting up of their exhibits and participating in the competitive activities.

3. In the matter of the selection of site, proper spacious site is to be selected as to provide maximum facility for the successful organisation of the fair.

4. Proper allocation of space should be provided to each participant team according to their needs and requirements.

8.7 COLLABORATIVE LEARNING APPROACH (CLA)

One of the most important goal of education is to prepare learners for the world of work. Requirement for the world of work are exploring and developing one's own ability to:

- work collaboratively;
- communicating effectively and convincing others with one's own idea; and
- critical thinking and problem solving skills.

In the traditional way of teaching-learning, teacher passes on the information to learners, who passively listen, mechanically jot down the notes and vomit out the received information in the examination. In CLA, learners take responsibility of their own learning. It promotes self learning skills in them. They have to discuss their ideas with their group members, relating it to their previous experiences. Teacher facilitates situations for active participation in teaching-learning process by encouraging collaboration among the learners. She communicates the goal to be achieved within a limited time frame realising and respecting diverse needs of the learners and their different styles of learning. **Collaborative learning approach develops both academic and social skills in learner in an integrated manner.**

In the construction of knowledge, social aspect is also involved in the sense that knowledge needed for a complex task can reside in a group situation. In this context, collaborative learning provides room for negotiation of meaning, sharing of multiple views and changing the internal representation of ideas to the external reality. In the collaborative set-up, each learner individually and socially constructs meaning as she learns. Collaborative learning enhances motivation to learn and increases depth of understanding. In the group setting, learners develop a positive attitude towards the learning and materials on which they work on, as they contribute to it. Learning is more effective as students themselves take care to resolve any conflicting observation and opinion. It also gives them opportunity to apply the concepts in real-life situation and to learn to solve a problem through multiple ways. Disinterested students readily learn from their peers as their learning problems and issue are better appreciated by the peers.

Working in a group, students move beyond the caste, creed, region and get opportunity to develop friendship with each other. Students learn the qualities of doing collaborative and team work, patience, persistence of effort, completing the task within a set time frame, and sense of belongingness to the group as well as to their learning. They get to know who they are in the opinion of others and identify their

8.7.1 Steps of collaborative approach

- Problem, issue or concept is identified to be dealt within a group situation. It may be small or big, simple or complex, depending upon learning environment and teaching-learning process.
- Formation of groups (say 3 to 6 students) is facilitated by the teacher. Students are also facilitated to take up the task of their choice.
- There is exchange of ideas, discussion on the issue at hand or performance of activities or experiment to clarify the concept in group situation. Sharing of ideas facilitates visiting and revisiting the concepts.
- Teacher facilitates their interactions directed towards the set goal within stipulated time frame.
- Learning evidences are assessed throughout the teaching-learning process and feedback is provided to all groups of the learners.

8.7.2 Ensuring meaningful learning through CLA

- Ensure that the group is heterogeneous. There should be learners learning with different paces and styles in a group.

- However, keep grouping pattern flexible and consider the choice of learners also.
- Every time keep on changing the members of the group.
- Facilitate them to form group rule. If there is a disagreement, consensus should emerge.
- Make it a point that group leader will facilitate the work of the group and keep them organised. The leader should not dominate over other members.
- Tell one student of the class to pass on the name of group members and group leaders on a piece of paper for your record.
- While assessing, you may give same grade to all members of the group as far as possible. This will prompt the learner learning with greater pace to motivate other learners to perform.
- It will be convenient for you if you start this approach after 2–3 months the session starts. It will give you enough time to identify academic and social skills of all the students and help you to facilitate them in forming the group.
- Ensure that members of all groups should be made responsible for their work. All members should remain open to each other's idea and get equal opportunities to share their ideas and work (Fig 8.3).
- All members should be given liberty to express their ideas freely and work cohesively towards achieving the goal.

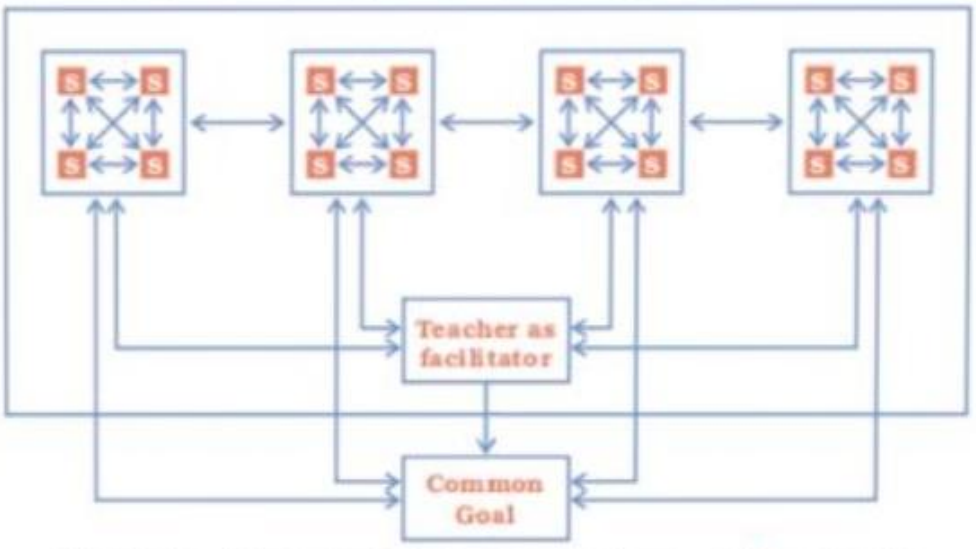


Fig 8.3 *A collaborative learning set up in classroom (- student)*

- Students are helped to realise that there exists a problem, solution of which is to be inquired.
- Different groups work on the same problem and may come up with different hypothesis, solutions and conclusion.
- In order to get involved in the inquiry, learners may discuss, share their ideas, derive the equations, perform an activity, experiments and solve numericals.

Example: How would our life be affected if force of friction suddenly vanishes?

Skills developed: Problem solving skill, inquiry skills, analysis, synthesis and evaluation.

(iv) Tutorial group

- Teacher facilitates formation of group according to students' ability.
- A concept is identified by the teacher which can be learned in a group setting.
- A student having good understanding of the concept is identified as group leader by the teacher. Opportunity should be provided to various students in turn.
- The group leader is assigned the job of facilitating learning to all members of her group.
- The group leader asks questions with the members and encourages them to discuss their learning difficulties with her.

Example: Determine unknown resistance using a metre bridge.

Skills developed : Basic competencies related to a concept develop in all members.

There is a difference between cooperative learning and collaborative learning. In the former set-up, the centre of authority is the teacher, the group is held responsible for collective learning. However, the collaborative learning encourages self-governance, shouldering responsibilities according to one's interest and skill. Each member is accountable for the task. It is convenient to use former setting when a task can be done by one way only, e.g. learning formuale or writing or chemical equation as given in the textbook. Solving a problem, doing experiment/activity/project demands collaborative set-up.

8.7.4 Limitation of collaborative learning approach

- Teacher's dominance is reduced. The control is passed onto the students themselves. As a result, some teachers may feel like loosing control.
- If work of the groups is not properly monitored, misconception and naive concepts may breed in the thinking of learners.
- A few shy students may not participate actively in the group. Interaction of all members need to be continuously monitored.
- It may be difficult to check and recheck the work of all the groups working at one time for an inexperienced teacher.
- Very meticulous planning is required for meaningful learning to take place. Various aspects need to be considered—needs, interest and abilities of each student, scope of the activity/concept to be discussed in the group and classroom management, group dynamics of the class, etc.

i. Floppy Discs: Most computers come with a 3.5inch disc drive. The 3.5inch is used to transfer small amounts of data between computers. Before data is stored on a disc, the disc needs to be formatted. This creates a magnetic map of the disc surface to enable the data to be either read from the disc or written onto the disc, very quickly.

ii. CD-ROM (Drives): CD-ROM drives use the same technology as music CDs and CD players. The data is stored on the disk digitally and a laser beam is used to read the data off the disc. Because light is used to read the disc, the data may be packed closely and the disc therefore has a large capacity. Because of their huge storage capacities they are useful for distributing software, storing clip art and use in multimedia systems. CD-ROMS are read-only discs, which mean that you can read data off the disc but not alter it or store new data. A CD recordable (CD-R) drive has a read/writes capability. Standard CD-R discs can be written only once, but there is a type of disc called CD-RW that within a suitable drive can be written, erased and rewritten.

iii. E-Learning: An innovative application of computer in the teaching and learning process is e-learning. E-learning may be network-based, Internet-based which includes text, video, audio, animation and virtual environments. E-learning may be stated in the following ways:

a. E-learning is learning on Internet time.

b. E-learning uses the power of networks, primarily those that rely not only on Internet technologies but also satellite networks, and digital content to enable learning.
c. E-learning is the use of network technology to design, deliver, select, administer, and extend learning.
d. E-learning is internet-enabled learning. Components can include content delivery in multiple formats, management of the learning experience, and a networked community of learners, content developers and exports.

E-learning provides faster learning at reduced costs, increased access to learning, and clear accountability for all participants in the learning process. The following are the important features of E-learning.

a. E-learning is dynamic.
b. E-learning operates in real time.
c. E-learning is collaborative.
d. E-learning is individual.
e. E-learning is comprehensive.

E-learning has definite benefits over traditional classroom training. While the most obvious are the flexibility and the cost savings from not having to travel or spend excess time away from work, there are also others that might not be so obvious.

7.16 ROLE OF INTERNET IN TEACHING.

1. Learning may take place 'anytime and anywhere'.
2. The approach ensures equality of opportunities in higher education for all.
3. A strong foundation is laid for the creation of a 'learning society'.
4. Learners would in course of time, become independent learners.
5. Learners need not be dependent on a single or a few books only for their learning.
6. 'Authentic' learning materials, materials based on real life experiences are provided to them through the net.

WHAT IS A UNIT?

A unit includes the procedure of presentation of the subject-matter. It is both a block of content as well as method. According to Preston : "A unit is as large a block of related subject-matter as can be over-viewed by the learner." **Samford** says that a unit is an "outline of carefully selected subject-matter which has been isolated because of its relationship to pupils' needs and interests."

Formerly, the use of teaching units was also called 'unit method' to distinguish it from other methods of teaching, distinction exists between teaching unit and other methods. The unit plan with teaching unit may include the use of other methods like laboratory, project recitation methods etc.

COMPOSITION OF TEACHING UNIT

A syllabus is divided into small workable sections which include related topics, which makes it easier for the students to follow and he motivated to work more for the other units. These units serve a useful purpose to sustain the comprehension and the interest of the students who also understand the procedures used in developing a particular unit.

Phases of Composition

During the introductory phase, the pupils know the purpose and get ready for the work. During the presentation stage, they acquire many useful experiences and present the new material. During the concluding phase, the pupils organise and review the learnings.

Nature of units

The teaching units are not just a collection of unrelated topics or lessons but are integrated ones. A number of lessons may be required

to complete one teaching unit. Each lesson is a part of the whole unit and leads to the development of next lesson in the unit. A single lesson may serve for getting the pupils ready for a new experience, for presenting a new experience and finally helping the pupils assimilate the learning. Due care should be taken with regard to the nature of subject matter, the conditions under a unit is to be taught, and the needs of the pupils etc.

CRITERIA OF A GOOD UNIT

1. It should keep in view the needs, the capabilities and the interests of the pupils.
2. It should permit a variety of field trips, experiments, demonstrations and projects etc.
3. It should take into account the previous experiences and background of the pupils.
4. It should provide for new experiences which the students have not done before.
5. The length of the unit should be such as to maintain the interest of the students upto the last.
6. The material of the unit should consist of familiar and related topics, and not as remote and strange one.
7. It should be flexible so as to allow the above average pupils to go beyond the limits of the unit.
8. It should be related to the social and physical environments of the pupils.
9. It should help anticipate and satisfy some of the future needs of the pupils.
10. It should be a part of a sequence that permits growth from year to year.
11. It should be the result of the co-operative planning of teacher and pupil as far as possible.

STEPS INVOLVED IN DEVELOPING A TEACHING UNIT

1. Preparation or motivation—The pupils are motivated to achieve the purpose. The motivation should not be forced from outside by the teacher. It should be natural and self-directed. The students should also overview the unit and find out the scope of the material. Motivation is required in the beginning as well as throughout the lesson.

2. **Knowing the previous experiences**—The background can be found out by questioning or by preparing an inventory. "Start with the pupils where they are". Know their background so that neither there is duplication of what they already have, nor any danger of having anything in the unit which is above their comprehension.

3. **Presentation**—Now some new experiences are given to the students which may be direct or vicarious, though efforts should be made to provide opportunities for direct experience. Only that much amount of new experience should be given which the students may easily assimilate.

4. **Organisation of learning**—The students should get opportunities to bring their learning together so that they may establish relationships between the new experiences and assimilate them. This organisation may be written or verbal.

5. **Summarization**—Organisation and summarization go together. Usually this is done at the close of the teaching unit to bring together all the learning. It may also be done at intervals during the progress of the unit.

6. **Review and drill**—During the progress of the teaching unit, some part of it may be forgotten and some may not be completely comprehended. For this is required review or reteaching or just revision of the new experience taught during presentation. Some learning experiences require repetition or repeated review called 'drill'. Review and drill may also be required at a number of places during the lesson.

7. **Evaluation**—This is made to know what the students have achieved and where they have failed to achieve. Evaluation should be mainly self evaluation in the form of oral or written tests after short intervals, say after a week or fortnight. They may also be in the form of performance tests, interviews, self-check test, puzzles, etc. The final test at the unit is given to give grades to the pupils and also to evaluate the effectiveness of teaching.

MERITS OF THE UNIT APPROACH

1. It is based on Gestalt Psychology which emphasises the 'Wholeness' nature of learning.
2. Since the subject-matter is divided into small units, it leads to easy comprehension.
3. In the unit approach, learning does not remain just 'memorisation'. It develops understanding.
4. On account of the delimitation of the learning contents and specification of the unit objectives, teaching and learning becomes more objective.
5. Division of the learning material into small units and sub-units makes the task of teaching-learning easy, interesting and simple.
6. All the steps in the unit approach are directed to achieve the desired mastery.
7. This approach encourages the habit of independent and self-study among the students.
8. By providing adequate opportunities to the students to remain active, this approach leads to healthy interaction between the students and teachers.
9. Learning process becomes organised, systematic and sequenced.

LIMITATION OF UNIT APPROACH

1. The present day syllabus is very heavy and with unit planning it is very difficult to complete the entire syllabus in time.
2. Unit approach is time consuming.
3. This approach is more suitable in the case of intellingent students.
4. This approach puts heavy demands upon teachers.

"A lesson plan is not a blue print that one has to adhere to it at all costs. It is, rather, a guide, an index of sequence of class-room activities, a list of important teaching points; suggestions for procedures that may be followed during the period. The teacher may and should modify the plan or change any part of it whenever necessary." A lesson plan is the systematic preparation done in a scientific manner. Without a lesson plan, even the most competent of the teachers is unsuccessful. There may be differences among the scholars regarding the form of the lesson plan but there cannot be two views regarding its need. There is a description of the acquired knowledge, new knowledge, question method, means, materials etc. in the lesson plan. In reality the lesson plan can be called the heading of that description which tells about what achievements of the teacher, and by the help of what means and class activities they can be achieved within an hour.

In the beginning, the detailed lesson plans should be prepared. After that the teacher should organize the subject-matter and make a shorter lesson plan. The lesson plans are for use of student-teachers. Thus, they should be prepared in such a manner that they can make maximum use of these in their teaching.

ADVANTAGES OF LESSON PLANNING

1. It stimulates the teacher to think in an organised manner.
2. It helps the teacher to understand the objectives properly/fully.
3. It helps in creating the interest of students towards the lesson.
4. A proper correlation is established between the new and old lesson.
5. It provides guidance to the teacher as to what and how he should teach.

6. It compels the teacher to think about and use of teaching aids.
7. It helps the teacher to choose the best teaching method.
8. It inspires the teacher to ask proper and important questoins.
9. It helps the teacher to teach, keeping in mind the individual differences.
10. The teaching matter is organised in a time frame.
11. It takes care to consider the level and previous knowledge of students.
12. It develops self-confidence in the teacher.
13. It helps the teacher in evaluating his teaching.
14. It clarifies the outlook of the teacher.
15. It lays stress on instructional material.
16. It brings definitness and regularity in the thinking of the teacher.
17. It inspires the teacher to improve the further lessons.

CHARACTERISTICS OF GOOD PLAN

(1) It makes the objectives of teaching lesson quite clear to the teacher.
(2) It helps teacher to be systematic in the presentation of subject-matter, in arranging sequential and appropriate teaching activities, in deciding questions to be asked and problems likely to arise during teaching.
(3) It helps teacher to decide motivational techniques and teaching aids.
(4) It should be flexible.
(5) It is always written, and
(6) It works as a guide-line for content, method, activities, aids etc.

LIMITATIONS OF LESSON PLANNING

1. It traps/entangles the teacher. In the traditional instructional colleges as there is no flexibility, the teacher finds himself helpless in new situations.
2. It obstructs the independence of the teacher.
3. It complicates simple matters. The teaching process becomes more difficult.

What is Pedagogical Analysis?

In its simple meaning the term pedagogical analysis (a composition of two words pedagogy and analysis) stands for a type of analysis based on pedagogy. For its further understanding let us now try to get acquainted with the term analysis and pedagogy.

Analysis as a term stands for a process of breaking or separating a thing into its smaller parts, elements or constituents. Water can be analysed into its constituents or elements, hydrogen and oxygen through

a process of analysis known as electro-analysis. We break a teaching unit into its constituents — Sub-units, topics or single concepts etc., through the process of unit analysis. Similarly we can break the contents of the prescribed course in a subject into its various constituents — major and minor sections and sub-sections, units and sub-units, major concepts and minor concepts, topics and sub-topics etc., by carrying out a process of content analysis.

Regarding the meaning of the term pedagogy, we find that in the available dictionaries it has been briefly defined as science of teaching.

Accordingly the analysis of a given content material in the subject Physical Sciences carried out well in the spirit of the science of teaching (pedagogy) is known by the term pedagogical analysis of the contents in Physical Sciences.

Distinction between Content Analysis and Pedagogical Analysis

The prescribed syllabus or course in any subject of the school curriculum contains a body of subject matter and learning experiences well in tune with the objectives of teaching that particular subject in a particular class. This subject matter is available in the form of its sub-divisions into major and minor sections, major and minor concepts, units and topics etc. Similarly while teaching a particular unit or topic, a teacher tries to break the contents related to that unit or topic into its constituent sub-units/sub-topics or single concepts etc. Such sort of simple breaking the subject matter or contents of a course, unit or topic into its constituents or parts with a sole objective of its proper organisation into sequential and meaningful order is termed content analysis of the given subject material or contents. However, when such analysis is carried out more methodically and scientifically in the true spirit of the science of teaching (pedagogy), it is termed as pedagogical analysis of the contents of a subject. In this way pedagogical analysis of the contents represents a quite advanced stage in the process of analysing the given contents in comparison to the meaning and purpose served by a simple process of content analysis.

What is Science of Teaching or Pedagogy?

Now question arises, what is the science of teaching? Does our teaching need some sort of science for its effective functioning and better output? In this connection, it is true that in our daily life we usually feel the need of the services of science for making the things simpler and more workable for our living, prosperity and existence. As a result we can save our time and energy in accomplishing our task and try to get

maximum output with the help of minimum input. Therefore, anything referred to as science of teaching is also expected to help a teacher in his task of teaching in the same way as science helps in doing a task related to our day to day life and world of work. Hence by utilising the services of a functionary named as science of teaching one must be able to teach in a quite effective way by putting the least input in terms of the men-material resources. As a conclusion the *term science of teaching stands for the ways and means provided to or utilised by a teacher for managing his task of teaching as smoothly and effectively as possible by involving his least efforts for drawing the maximum possible better teaching outcomes.*

The Role Played by Science of Teaching or Pedagogy in a Teacher's Teaching.

In the light of what has been already said above, the science of teaching or pedagogy is found to serve the following two main objectives in the scheduled task of a teacher's teaching.

(*i*) Teaching should be carried out as smoothly as possible.

(*ii*) It should result into the maximum output in terms of the expected better teaching outcomes.

What is suggested by science of teaching or pedagogy for the realization of its above said two main objectives now carries a wide significance at this stage. Let us briefly describe it.

A teacher has before him the content material and learning experiences related to the subject for being used as a tool for the realization of the set objectives of teaching subject in a particular class. In this way his success in his teaching task depends on the extent to which he is successful in the realization of the teaching or instructional objectives. He can go on smoothly in his teaching task only if he is helped by suitable method, devices, techniques and aid material etc., for providing the fruits of his teaching to his students. How properly is he proceeding in his teaching task and how well he is trying to achieve the set teaching objectives, that now needs the help of a continuous system of testing and measurement known as evaluation of teaching outcomes. The results of such evaluation provides an appropriate feedback to the teacher for bringing desirable modification in his methods and materials of teaching including justifying the need of bringing alteration in the setting of instructional objectives. In this way science of teaching or pedagogy advocates a total mutual relationship and interdependence among the following four pillars of the teaching-learning process for attaining best possible results in the task of teaching.

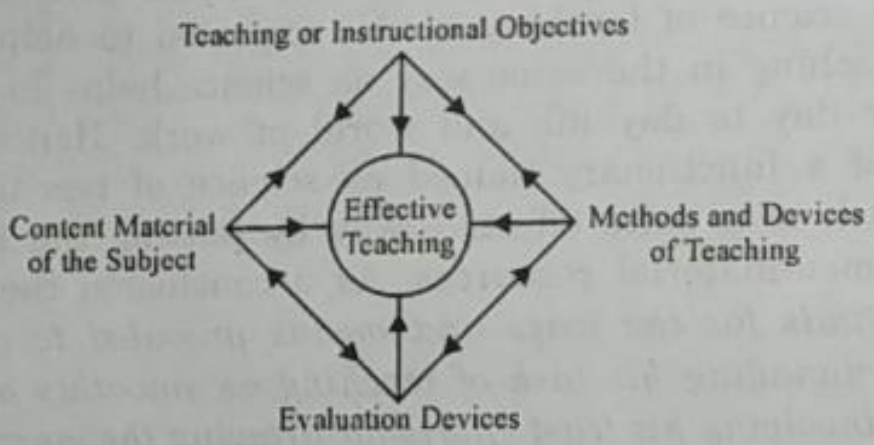


Figure 4.1

Science of teaching or pedagogy in this way lays down the above mentioned four essential pillars along with their inherent mutual relationships and interdependence for being considered essential in the realization of the desired success in a teaching task. It is this message and spirit of the science of teaching or pedagogy that needs to be properly carried out in any scheme of the analysis of the content material to a subject and then only such analysis of the content material may be termed as pedagogical analysis of the given content material.

In the light of what has been said above, a teacher of mathematics may proceed in the way given below for analysing the contents of the syllabus of his subject as well as the contents of the topic to be taught in the classroom by preserving the spirit or message conveyed by the science of teaching or pedagogy.

1. The contents of the subject mathematics should be got analysed properly into major and minor sections/units/concepts etc., and sequenced as well as organised as methodically as possible.
2. Only a desirable amount of the content material enabled to be covered properly in the scheduled subject period should be taken into hand at a time in the shape of a topic to be taught by the teacher for his scheduled classroom teaching.
3. This topic in hand should also be analysed properly in the form of major and minor concepts/single concepts etc.
4. The teacher should now clearly lay down the teaching or instructional objectives related to the topic in hand by writing them into specific behavioural terms.

   (For writing these objectives readers are advised to go through the relevant pages of the chapter three of this text.)
5. How can these stipulated instructional objectives be achieved properly by teaching the contents of the topic in hand should

now be made a point of consideration for proceeding further on the path of pedagogical analysis. Definitely in this situation it needs better employment of men-material resources by the teacher. Science of teaching (pedagogy) can help him here to think about the best possible methods, strategies, tactics and techniques to be employed, aid material and likewise resources to be utilised for the teaching of the topic in hand in the existing teaching-learning situations. All such possible things and factors helpful in the teaching of the topic in view of the proper realization of the teaching objectives should be analysed and classified in any of the schemes of pedagogical analysis of the topic or contents of subject physical sciences.

6. Lastly, there arises a need of exercising proper control over the different components of the teaching-learning process. Such control can only be possible through a well organised scheme of evaluation well in tune with the contents of the topic in hand, stipulated teaching objectives and methods and material employed for teaching. For this purpose an appropriate evaluation scheme should also find a place in any scheme of pedagogical analysis of the topic or content material of the subject physical sciences.

Components and Operations Involved in the Task of Pedagogical Analysis

Looking in this way, by the term *Pedagogical Analysis of the contents in physical sciences we certainly* aim to carry out the task of analysing the prescribed course material or a particular unit/sub unit/topic/single concept of the subject physical sciences being taught to a particular class by systematically executing the following four operations in a close interactive style.

(*a*) Content analysis of the unit/topic/single concept being taught by the teacher in the subject physical sciences.

(*b*) Setting of the teaching or instructional objectives of the content material of the topic in hand by writing them in specific behavioural terms.

(*c*) Suggesting methods, techniques, teaching-learning activities, aids and equipments helpful for the teaching learning of the topic in hand quite in tune with the realization of the set instructional objectives.

(*d*) Suggesting appropriate evaluation devices in the form of oral, written or practical activities and test questions etc., for evaluating the outcomes of the teaching-learning process carried out in relation to the teaching of the topic in hand.

In the light of the relationship and interdependence existing among the above mentioned four components of the pedagogical analysis, operations of the content material in the subject physical sciences may then be properly illustrated through the following diagram.

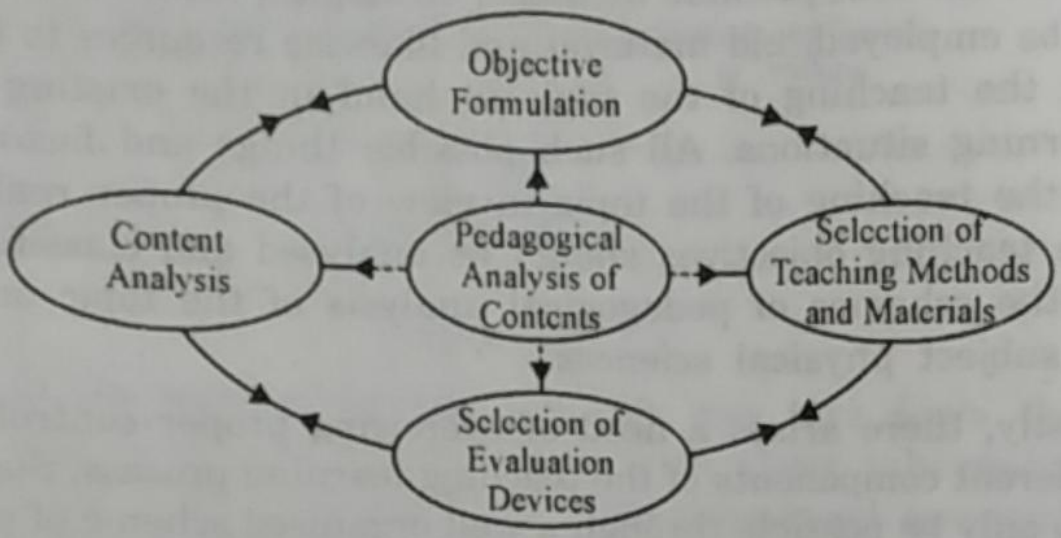


Figure 4.2 : Components of the Pedagogical Analysis of the Content Material

Summarising in this way when a teacher of physical sciences is asked to perform pedagogical analysis of the contents of a subject/unit or topic to be taught in the class he has to go through the cycle of the above mentioned four components namely (*i*) content analysis, (*ii*) objectives formulation, (*iii*) selection of the teaching methods and material, and (*iv*) selection of the evaluation devices.

Let us illustrate this task of pedagogical analysis now by taking some selected units/topics from the contents of the prescribed syllabi of high school classes.

The task of pedagogical analysis of any content material essentially requires a thorough grasping of the content material prescribed in the syllabus. A textbook of present nature should therefore try to put down the necessary content material for carrying out the desired task of pedagogical analysis.

Pedagogical Analysis of the Content Material — Energy and its Types

A. Content Analysis of the Topic — Energy and its Types (as included in the syllabus of class IX) incorporating major and minor concepts as under:

1. What is Energy?
2. Forms or Types of Energy:
   - (*i*) Mechanical Energy
   - (*ii*) Energy types other than the mechanical energy.

(*i*) Mechanical Energy — Types and forms:

- (*a*) Kinetic energy
- (*b*) Potential Energy

(*a*) Kinetic Energy:

- (*i*) What is kinetic energy?
- (*ii*) Computation of kinetic energy.

(*b*) Potential Energy:

- (*i*) What is potential energy?
- (*ii*) Types of potential energy:
  - — Gravitational potential energy
  - — Elastic potential energy
- (*iii*) Computation of potential energy

(*ii*) Energy Types other than the mechanical energy

— Muscular energy

— Heat energy

— Light energy

— Sound energy

— Magnetic energy

— Electrical energy

— Chemical energy

— Wind energy

— Hydro energy

— Solar energy

— Nuclear energy or Atomic energy.

3. Transformation of Energy

— From potential to kinetic and vice versa

— From one form of energy to others

4. Conservation of Energy.

B. Objective Formulation (Listing of Behavioural Outcomes). Students of class IX after going through the teaching of the contents related to the topic "Energy and its Types" are expected to demonstrate the following types of behavioural outcomes:

1. They define the term energy.
2. They explain the term energy.
3. They provide examples of the term energy.
4. They name the unit used for the measurement of energy.
5. They name the two important forms of mechanical energy as kinetic and potential.
6. They define the term kinetic energy.
7. They provide at least two examples of kinetic energy
8. They provide formula for the computation of kinetic energy.
9. They compute kinetic energy of a moving body of a given mass and velocity.
10. They define the term potential energy.
11. They differentiate between kinetic energy and potential energy.
12. They define and explain the term gravitational potential energy.
13. They define and explain the term elastic potential energy.

14. They give at least two examples each of gravitational and elastic potential energy.

15. They recall the formula for the computation of potential energy.

16. They compute potential energy by making use of the relevant formula.

17. They name at least six other forms or types of energy available in the objects besides the mechanical energy.

18. They define and explain muscular energy/heat energy/light energy sound energy/magnetic energy/electrical energy/chemical energy wind energy/hydro energy/ solar energy/nuclear energy.

19. They differentiate between the terms nuclear fusion and nuclear fission.

20. They name the four famous nuclear power stations of our country.

21. They explain the mechanism of transformation of energy from potential to kinetic and vice versa.

22. They cite at least six instances or examples for the transformation of energy (other than the kinetic and potential) from one form to another.

23. They define and explain the term conservation of energy.

24. They state the law of conservation of energy as brought out by the German scientist Robert Mayer.

C. Listing Teaching methods, devices, activities and materials etc.

1. Methods and devices used:

Methods: Lecture method and demonstration method.

Devices: Narration device, explanation device, illustration device, experimentation and observation device.

2. Activities and materials employed.

(*i*) While using lecture method, narration, explanation and illustrative devices, help of blackboard writing and sketching will be taken.

(*ii*) In certain situations use of transparencies or slides will be made and the main points, examples etc., will be demonstrated through them by making use of the slide as well as overhead projectors.

(*iii*) Charts and pictures may also be utilised for the presentation of concepts, facts and principles related to energy types.

(*iv*) Difference between kinetic and potential energy of the objects will be explained through day to day examples and instances. It can also be demonstrated through actual objects and the work done by them in their moving as well as stationary positions.

(*v*) Students may be asked to drive a nail into a wooden block with the help of a hammer for illustrating the concepts of gravitational potential energy. Similarly the concept of elastic potential energy will be explained to them by actually throwing the arrow with the help of the string of a bow.

(*vi*) The various forms of energy like heat, sound, light, magnetic, electrical, chemical, wind, hydro, solar and nuclear energy etc., will be well illustrated through charts, pictures, slides and transparencies.

(*vii*) Transformation of energy from the potential to the kinetic and vice versa will be explained to the students with the help of the experiments performed through the swinging of the pendulum.

(*viii*) The transformation of potential energy into kinetic energy and vice versa will also be demonstrated through a free fall of a body under the influence of gravity only and also through the mechanism of throwing a body upward.

(*ix*) Help of a well prepared chart, transparency or slide will be taken for explaining and illustrating energy transformation from one form to another along with the device used for such transformation in our day to day life.

(*x*) The concept and mechanism of conservation of energy will be explained through examples and demonstration of experiments.

D. Listing of evaluation procedure, devices etc. Oral, practical and written (involving essay type, short answer type and objective type questions) mode of testing and evaluation will be employed for evaluating the teaching-learning outcomes of the concept "Energy and its types". As a teacher-made evaluation device, the following items will be used for evaluation purpose :

(*a*) Essay Type Questions:

1. Explain the meaning of the term energy with the help of some suitable examples.

2. What is mechanical energy? What are its two different types? Explain and illustrate with examples.

3. What do you mean by kinetic and potential energy of an object? Illustrate with examples.

4. Compute the kinetic energy of a moving object of mass 1 kg moving with a speed of 10 metres per second.

5. Explain and illustrate the concepts of gravitational and elastic potential energy with the help of examples or demonstrable experiments.

6. Compute the potential energy at the highest point of a body of mass 200 kg falling from a height of 10 metres.

7. Name and discuss about at least six energy types other than the mechanical energy.

8. Distinguish between the term nuclear fission and nuclear fusion.

9. Explain and illustrate how directly or indirectly, sun is the ultimate source of all forms of energy available on the earth.

10. Explain and illustrate how transformation of energy from potential to kinetic and vice versa takes place in nature as well as in our day to day life.

11. What do you mean by the term conservation of energy? Explain with the help of suitable experiments or illustrations.

(*b*) Short Answer type Questions :

1. Define the term energy.

2. Name the unit for the measurement of energy.

3. Define the term kinetic energy.

4. Distinguish between the terms kinetic energy and potential energy.

5. Provide the formula for the computation of kinetic energy and potential energy.

6. What is gravitational potential energy?

7. What is elastic potential energy?

8. What is muscular energy?

9. What is hydro energy?

10. What is nuclear or atomic energy?

11. Name the four famous nuclear power stations in our country.

12. State the law of conservation of energy as brought out by the German scientist Robert Meyer.

(*c*) Objective Type Questions :

1. Fill in the blanks:

(*i*) Capacity of doing work is called _____

(*ii*) Capacity of a body to do work by virtue of its _____ is called its kinetic energy.

(*iii*) Capacity of a body to do work by virtue of its _____ is called its gravitational potential energy.

(*iv*) Capacity of a body to do work by virtue of change in its _____ is known as elastic potential energy.

2. Match the following :

Column I	***Column II***
(*i*) Potential energy	(*a*) $\frac{1}{2} mv^2$
(*ii*) Kinetic energy	(*b*) mgh
(*iii*) Steam engine	(*c*) energy transformation from electrical to mechanical
(*iv*) Microphone	(*d*) energy transformation from sound to electrical
(*v*) Photo cell	(*e*) energy transformation from heat to mechanical
(*vi*) Electric fan	(*f*) energy transformation from light to electrical

3. Write true (T) or false (F) against each of the following statements:

(*i*) In throwing a cricket ball in the air we transform our muscular energy into kinetic energy of the ball.

(*ii*) Energy can be created as well as destroyed.

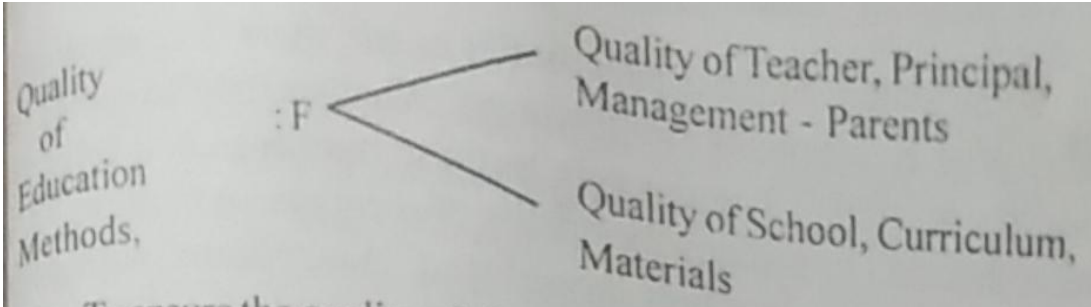
(*iii*) Doubling of the velocity of the body results in the doubling of its kinetic energy.

(*iv*) Infra-red rays of the sun possess a distinctive property of heating objects on which they fall.

Note. Help of prescribed textbooks and NCERT Teachers Guide will be taken for more comprehensive evaluation as per demands of the situation.

16.2 QUALITY

A definition on quality has two dimensions. One is concerned with the removal of undesirable factors and dealing with problems that be set an expanding education system. The other, is concerned with what we wish our education system to become, what we consider to be the purpose of quality education. For strengthening the education the quality of education needs to be concentrated. Quality of education is the product of two fold factors:



To ensure the quality of all above mentioned factors, it is very essential to restructure the educational set up, redefine and remodel the roles and responsibilities of teachers, principals, management and parents. The classrooms need restructuring as well.

When we are entering in 21st century, no school or parent can afford to take risk of allowing the future citizens to be in the hands of low quality teaching staff, monotonus and non-creative teacher's leadership, non-stimulating classrooms, unchallenging educational programmes and set up. Now it is the time to hunt out alternate methods/ means of teaching and practices so that the children find it enough interesting and challenging to attempt to and etc. sustain with. The unhealthy race of quantitative achievement ideology of over emphasising product needs to be replaced by the qualitative appreciation of process aspect through brain storming as only cognitive achievement will not fulfill the ultimate objective of education. The objective of education is to prepare the mind of the learner to face the challenges of society through wholistic and comprehensive development of the learner.

The learner is a social being has to live in very given, society and has to survive with given only. The learner cannot afford to be individualistic or self-centered, he/she has to be with rest of the world emotionally, socially and of course intellectually. So far as the quality of education is concerned, there should be no compromise or reservations about anything. There need a reorientation about education to be one and all.

16.3 QUALITY CONCERNS:SOME ISSUES IN SECONDARY EDUCATION

1. **Education should be Life Related:** It is difficult to provide services/govt. service to all. But education needs to be given to all in such a way that the basis of knowledge and skills achieved he/she can be self-employed. Question is how far our curriculum caters to these needs? Is it diversified? Is it uniform? What steps have been initiated? Where is the need to strengthen the same? We can think and discuss about it.

2. **Education should Sharpen Thinking:** Education should create curiosity and help the learners to sharpen their thinking ability and empower them to take decisions. Does our secondary education is geared

towards development of these capabilities or still there is a mechanistic approach? Who is responsible for the same? What are the alternatives for achieving these goals? The answers to these questions will solve the problems related to improving the quality of secondary education.

3. **Classrooms:** Over populated classrooms with poor infrastructure facilities in schools. In most of the schools, the ideal number of teachers/student ratio is 1 : 35 to 1 : 40. Hardly, today one may fulfil this idea. The class size remaining the same, the number of students accommodated is being increased.

4. **Examination System:** The examination system is making education burdenful. There is a strong need of continuous classroom evaluation and cumulative record cards so that examination programmes can be reformed. Much is to be done for burdenless and joyful learning.

5. **Use of Information Technology:** In Twenty First Century, overall system needs gearing towards future challenge of globalisation and information technology, entering into community life through various media of T.V., Radio, Internet, etc. Use of these media and its proper utilisation also provide challenge to future of secondary education management, teacher training and teaching methods.

6. **Guidance and Counselling:** There is problems of integration of values, affect and knowledge explosion fort the learners, a sound programme for guidance and counselling to develop proper self-concept, confidence and courage is needed.

7. **Organisational Management:** The school unit, school complete and idea of institutional planning involving the members in achievement of the goals of secondary education can make the system work. Even the size of the institution, geographical status, community involvement all these together to may help in quality strengthening.

Indicators of Quality learning

1. **Emphasis on the Socio-Economic well being, Competence and Creativity of the Individual:** The secondary education should aim at developing physical, intellectual and aesthetic development of personality. It must develop a healthy attitude to dignity of labour and hard work. Due care should be taken for the inculcation of self-confidence to innovate and face unfamiliar situations.

2. **Proper Control and Training of Emotions:** Developing proper emotions and controlling them is very essential objective of education during secondary schooling. Control of emotions is essential. Control accepted and reitereated by most of the commissions on education appointed after independence. Even the defects pointed out by Mudaliar Commission in 1954, appear to be significant even today: "The education was too bookish and mechanical, stereotyped and rigidly uniform and did not cater to pupils of different aptitudes and nor did it develop those basic skills and qualities of discipline, co-operation and leadership which were calculated to make the function as useful citizens."

Secondary Education was regarded as the weakest link between primary and higher education and it has remained so, even now. The solution of the problem thus, is in making the secondary education diversified, imparting technical, vocational trade oriented courses and make it a real termination for those who are entering the world of work or continuing education to join higher studies.

For the vast majority of our students formal education stops at the secondary school level, therefore, as the country is concerned, the primary objective of the secondary schooling control does not mean repression bat it means learning to approach a social situation with rational attitude and repression of those emotions which are socially unacceptable. The teachers should change their attitude towards students. They should provide proper environment for the expression of pent-up feelings. For treatment, sympathy, co-operation and freedom of action within a reasonable limit should be given to students and unnecessary restrictions should not be imposed. Teach the students at secondary school stage by providing opportunity for hobbies, curricular activities, free discussion and dramas etc.

3. **Develop thé Qualities of Citizenship:** India is a democratic country. The success of democracy depends on ideal citizens. The citizens are educated to behave according to the accepted social ideals. Qualities of tolerance, knowledge of one's rights and duties, respect of the views

of others and spirit of social service should be developed in the students during secondary school education.

4. **Introducing Vocational Point of view in Secondary Education:** In the modern age, the vocational point of view is considered very important. Special emphasis should be placed on scientific and technical education so that the country is able to progress with a sound technical base. The order to keep the students engaged in constructive activities, we should pursue vocational courses in education. While vocationalising secondary education this concept should be kept in view not only for the development of the student but for the development of the nation as well.

5. **Developing the Sense of World Citizenship:** Today, due to scientific and industrial revolution needs a mutual contact between different countries. The citizens of a country are coming into contact with others in one respect or the other. Therefore, the need of varied knowledge of the world with an open mind, shinning a narrow outlook is felt. Therefore, secondary education should aim at developing a sense of world citizenship in the students.

6. **Moral and Ethical Upgrading:** Now India is a land of culture, ethics and saints is considered as one of the most dishonest nations of the world. Though a number of factors are responsible for this degradation. At the same time education cannot wash its hands and drawn the responsibility of moral and ethical downgrading. During recent years, the growing indiscipline, the lack of ideals and the weakening of social and moral values in the younger generation have caused grave concern in many countries.

Therefore, emphasis should be made while framing aims of secondary education on the religions and moral education. It will help in removing selfishness, natural indiscipline, violence etc. Secondary education should be so reoriented as so give the students a proper sense of direction by a kind of systhesis of democratic ideals moral and spiritual values.

7. **Identification of Talent:** A modernized society like ours, needs a large number of talented men to occupy positions of responsibility in different fields of activity. This would be done only by the organization of an extensive programme for identification of talented children. It is at the secondary stage that this identification of talent really begins.

8. **Due care to the Special Interests of Students:** A great care should be taken to locate special interests and aptitudes of students during secondary school education. They should be provided with learning

experiences and opportunities for participation in co-curricular activities. Their trust of curosity, wondering and adventure should be quenched through mountaineering, excursion, N.C.C., scientific exploration etc. The love for humanity and ideals should be utilized in social services and community services in the neighbourhood and disbursed areas. By doing so they will make proper use of leisure time.

Concept of Test, Measurement and Evaluation

You may have heard or undergone through the instruments like achievement tests, aptitude tests, intelligence tests etc. Each of these instruments consists of a standard set of questions needed to be answered by you. Out of the responses given by you, we obtain a measure/score *i.e.*, a numerical value of the characteristic possessed by you in relation to your performance in a subject, intelligence or aptitude etc. In this way you can understand a test simply as a measuring instrument consisting of a standard set of questions for being answered by the individual student with regard to one or the other characteristics of his behaviour. Mind that the use of the term 'test' is only limited to the use of some or the other specific set of questions and 'testing' as a process of making the students answer that set of questions. Upto this extent no process or act of measurement is involved. It begins with the work of assigning numbers to the test results according to a specific rule like counting correct answers and assigning one mark each for every correct answer.

Measurement in this way is a one step ahead of the process of testing. When the work of testing ends, measurement comes into picture for assigning numerical values to the test results. However, the process

of measurement does not necessarily rest on tests and testing. It is quite a broader concept. Both testing (like achievement tests and intelligence tests etc.) and non-testing devices (like observations, rating scales etc.) may be used in the process of measuring a characteristic *i.e.*, obtaining information in a quantitative form. We may derive scores or obtain numerical description of the degree to which you as an individual possess a particular characteristic. In this way how much potential you possess in a particular aspect of your behaviour (*i.e.*, knowledge, understanding, skills and applications of mathematical facts and principles etc.) may be adjudged quantitatively with the help of the product and process of measurement. Let us make the meaning of the term measurement more clear with the following definitions :

1. *Carter V Good.* Measurement may be understood as "the comparison of a quantity (exhibited in a particular case) with an appropriate scale for the purpose of determining (within the limits of accuracy imposed by the nature of the scale) the numerical value on the scale that corresponds to the quantity to be measured."

—(1959, pp. 337-38)

2. *Remmers, Gaze and Rummel.* Measurement refers to observations that can be expressed quantitatively and answers the question "how much."

—(1960, pp. 7-8)

3. *Mahesh Bhargava.* "Measurement is the process of assigning symbols or numerals to observations, objects or events in some meaningful or consistent manner according to rule."

(1987, p. 53)

4. *Gronlund and Linn.* The term measurement is limited to quantitative description of pupils; that is, the results of measurement are always expressed in numbers (*e.g.* Mary correctly solved 35 out of the total 40 arithmetic problems). It does not include qualitative descriptions (Mary's work was neat) nor does it imply judgement concerning the worth or value of the obtained results.

(1990. p. 6)

The analysis of above definitions may clearly reveal that measurement is nothing but a process of quantification *i.e.*, assigning units of measurements or numeral values to the types of characteristics observed in the behaviour or nature of an individual or object during some observation or testing. For example, when we say that the height of an individual is 160 centimetres or his score on a unit test of mathematics is 8 (correctly answered 8 out of the 10 objective type questions), we are definitely resorting to the process of measurement. A centimetre and score of one both here represent the respective units of measurement

and the individuals are assigned different units on the basis of the performance exhibited by them during observation or testing. In fact, we try to assign numeral values or express the results of our observations or testing in a quantitative term through the process of measurement as precisely and objectively as possible.

Now coming to evaluation, we will soon realise that it is a quite comprehensive and broader term than measurement and testing. A glimpse of the following definitions may reveal the meaning and nature of the term evaluation.

1. *Carter V. Good.* Evaluation is the process of ascertaining or judging the value or amount of something by use of a standard of appraisal. (1959, p. 209)

2. *Stufflebeam and others.* "Evaluation is the process of delineating, obtaining and providing useful information for judging decision alternatives." (1971, p. 25)

3. *Remmers, Gage and Rummel.* "Evaluation is not just a testing programme. Tests are but one of many different techniques such as observation, checklists, questionnaires, interviews etc. that may contribute to the total evaluation programme." (1960, p. 6)

4. *Wrightstone.* "Evaluation is relatively new technical term introduced to designate a more comprehensive concept of measurement that is applied in conventional tests and examination ..... the emphasis is upon broad personality changes and major objectives of educational programme. These include not only subject matter achievements but also attitudes, interests, ideals, ways of thinking, work habits and personal and social adaptability." (1956, p. 8)

4. *Indian Education Commission (1966).* "It is now agreed that evaluation is a continuous process, forms an integral part of the total system of education and is ultimately related to educational objectives. It exercises a great influence on the pupil's educational achievements but also improves it."

5. *Quillen and Hanna.* "Evaluation is the process of gathering and interpreting evidences on change in the behaviour of the students as they progress through school."

An analysis of the above definitions may clearly reveal the following facts about the nature and characteristics of the term evaluation.

- Evaluation is more comprehensive term than measurement or testing.
- It represents a continuous process and overall efforts for knowing about the progress of the learner.
- It provides quantitative as well as qualitative description of the outcomes of a teaching-learning process.
- It helps in knowing about the changes in behaviour related to the domains of the learner's behaviour as a result of the process of teaching-learning.
- It provides greater scope and flexibility for the use of variety of means and techniques rather than limiting itself to certain tests or conventional examinations.
- It represents a comprehensive plan of better testing and measurement for inquiring into the quality of the output in the light of the set objectives.
- It provides sufficient value judgement about the progress of the learner, teacher's efforts and effectiveness of the instructional programmes.

How Evaluation Differs from Measurement?

Measurement	Evaluation
1. Its scope is limited. Only few aspects of personality are being tested here.	1. Its scope is wider. Total personality of the child is being tested here.
2. Comparative study is not possible here.	2. Comparative study is possible here.
3. It is a means, not an end in itself.	3. It is an end in itself.
4. No clear-cut opinion about the student is formed.	4. Clear-cut opinion may be formed about the student.
5. Its job is to collect evidences.	5. Its job is appraisement of evidences.
6. Less labour and time is needed here.	6. More labour and time is needed here.
7. It is content-centred.	7. It is objective-centred.
8. It may not be an essential part of education.	8. It is an entire part of education.
9. It is one-dimensional in relation to environment (Isolated from environment)	9. It is multi-dimensional in relation to environment. (Not-isolated from environment)
10. Measurement answers the question, How much? Vibha got 70% marks, it is measurement.	10. Evaluation answers the question 'What-Value'? Getting 70% marks, Vibha got Ist position, it is evaluation.
11. It can be done at any time.	11. It is a continuous process.
12. No significant prediction may be made here.	12. Significant predictions may be made here.
13. It is quantitative in nature.	13. It is quantitative as well as qualitative both.
14. Measurement describes a situation.	14. Evaluation judges its worth or value.
15. Formal process is planned here.	15. Formal and informal processes both are planned here.
16. Its functions are prognosis, diagnosis and research.	16. Its functions are are selection, grading, guidance, prediction and diagnosis.
17. Here equal interval and ratio scales are used.	17. Here nominal, ordinal, equal interval and ratio scales are used.

Examination and Evaluation

More often these two terms are used interchangeably. But in spite of the fact that both aim at the same thing or things, they differ in so many ways. Evaluation is relatively a new term in the field of education. It has a more extensive scope and is definitely more valid, objective and purposeful than examination. The relative difference can be summarized as under :

Examination	*Evaluation*
1. It refers to a system where students are tested just at the end of a definite period of instruction.	1. The changes brought in the behaviour of the students through education are continuous. Evaluation helps in the continuous appraisal of such changes.
2. It limits itself to the testing of knowledge and skills of subject matter.	2. Through evaluation it is possible to test the overall changes brought in the behaviour and personality of the children.

Evaluation as a continuous and comprehensive process

In comparison to the terms tests, measurement and examination (used for appraisal of the performance of the students and outcomes of the teaching-learning process) evaluation is regarded as most comprehensive term involving continuity in its use throughout the teaching-learning process. Let us weigh the truth of this assertion.

Comprehensiveness of Evaluation

We have already discussed about the comprehensive nature of the term evaluation while distinguishing it from test, measurement and examination. However, it may be re-stated as under:

1. Evaluation is quite comprehensive in terms of the employment of tools for carrying out its task. It is not limited to the use of tests and measuring devices providing quantitative information and results but extends its scope for providing valuable qualitative information without using testing and measurement devices. Thus every type of appraisal measure providing quantitative, qualitative or both types of information or results in a formal or non-formal way may be used in the process of evaluation.
2. Evaluation is more comprehensive in terms of its output on account of the following reasons:

(*i*) It goes beyond the state of presenting appraisal results in quantitative and qualitative forms by passing value judgements over their desirability and worthwhileness.

(*ii*) The planned changes in behaviour of the students through a teaching-learning process or educational efforts may be well adjudged in all the three domains of behaviour *i.e.*, cognitive, conative and affective with the help of evaluation tools.

(iii) The value judgements may be passed about the desirability and worthwhileness of all the involved components of a teaching-learning process like

— Suitability of the set teaching-learning objectives.

— Suitability of the curriculum, subject matter and organisation of learning experiences.

— Suitability of the methods and strategies of teaching-learning.

— Suitability of the teaching-learning environment.

— Suitability or worth of the efforts of the teacher and the student himself.

3. Evaluation is more comprehensive in terms of its purposes and objectives served as well as in providing feedback to a number of persons involved in the processes and products of a teaching-learning process or educational activities for bringing needed modifications in their ways of working. Teacher, students, curriculum framers, educational technologists, audio-visual aid manufacturers, multimedia experts, administrators, guidance personnel, research professionals, all may make use of the valuable qualitative and quantitative data coupled with adequate value judgements through the means and ways of evaluation. Evaluation in fact may work as a driving engine as well as a controlling agency for the proper upkeep of an instructional or educational system by providing proper feedback to the input, processes and output of these systems.

Continuity of Evaluation

Besides known for its comprehensiveness evaluation is also regarded as a quite continuous process in any process of teaching-learning and educational endeavour. The truth value of such assertion may be supported on the following grounds.

1. During a teaching-learning session a teacher may resort to evaluation of the performance of his students as and when he feels a need to do so. He is not forced for its carrying out after the expiry of a fixed period as happens in the cases of daily, weekly, fortnightly and monthly tests, or terminal and annual examinations.

2. Evaluation is intended to make value judgements over the results of a teaching-learning process *i.e.*, the planned changes in the behaviour of the students. The changes occurring in the cognitive, conative and affective domains of the pupils' behaviour are non-stopping and continuous. They may occur at any time well in

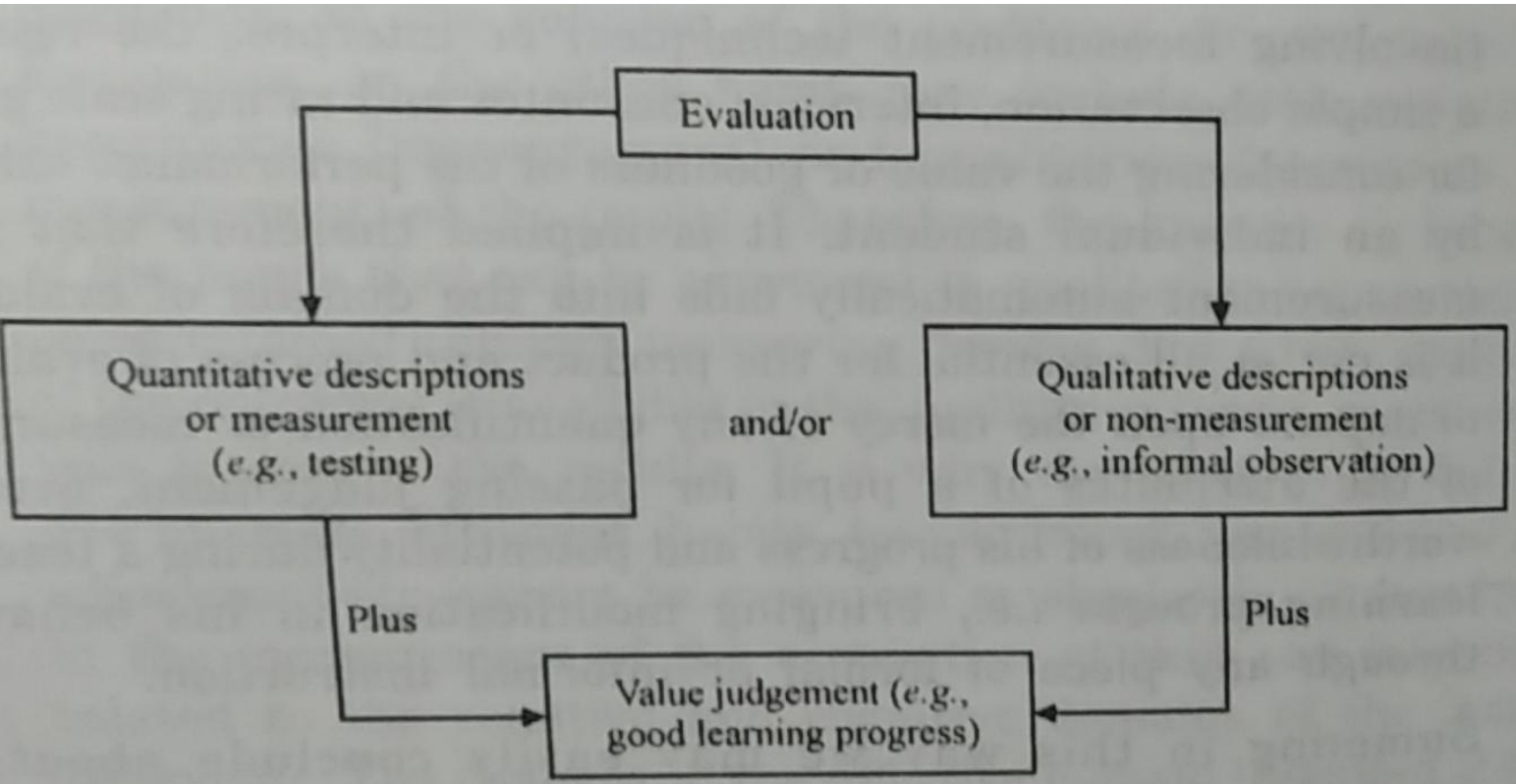


Figure 14.1: Comprehensive Nature of Evaluation (Source: Gronlund and Linn, 1990, p.6)

Types of Evaluation

While teaching mathematics, teachers may resort to three major kinds of evaluation—diagnostic, formative and summative in order to help themselves for taking wise decisions at the three stages of the teaching-learning process *i.e.*, pro-active, inter-active and post-active. Let us know something about these three types of evaluation.

1. *Diagnostic Evaluation.* Such evaluation task if performed prior to teaching may help in providing information what the students know about a certain topic, contents or area of learning which is going to be taught to them. In this way it may help the teacher to plan his instructional programme suiting the needs, interest and abilities of the students. Strategies used for such evaluation may be both informal (like observation and discussions) and formal (like pretest, inquiry, questionnaire). However, diagnostic evaluation does not limit itself to the pre-stage or beginning of the instruction. One can make its use throughout his delivered lesson or unit of teaching for diagnosing his students understanding and interest. Making use of evaluation for such ongoing assessment of the teaching-learning outcomes during teaching pushes it near the formative teaching or some specially designed remedial teaching programmes and measures for the students who are diagnosed as suffering from serious learning problems. The main objective of diagnostic evaluation in mathematics thus is to find out the nature and causes of the persistent learning problems and to formulate a plan for seeking suitable remedial actions.

2. *Formative Evaluation.* The type of evaluation is conducted well during the teaching-learning process. When a teacher has taught some content or some unit or provided some learning experiences he has a need to determine the outcome. Similarly, students also need to know about their progress in the path of learning. The formative evaluation helps in this task by providing useful information to both teacher and students about the strengths and weaknesses of their teaching and learning. In the light of this information, they may plan and engage for the mid course corrections in pace or content and methodology of instruction. The formative evaluation may be carried out both in formal (like checklists, quizzes, question-answers, assignments and tests) as well as informal (like observations, listening to students comments and conversations) way. The essential characteristics of such evaluation may be briefly summarized as under.

- It is administered during the lesson taught or instruction imparted.
- It helps in informing the students about their progress chiefly about the amount they have yet to learn before achieving the set objectives.
- It is useful to the extent it remains informative, closely related to the things being taught, timely and frequent.
- It helps the teacher by providing him qualitative and quantitative data for bringing necessary modification in his teaching.
- It proves very useful in guiding the students, planning remedial instruction and prompting them to ask for necessary help.
- It should in no way be used by the teacher against the students, just as for making comparison among the students or making a certifying judgement. The results of such evaluation should not necessarily appear in any official record.

3. *Summative Evaluation.* Such type of evaluation is carried out at the end of a piece of instruction lesson or unit. Actually it represents a final test or measure of the student's progress or gains made by him as a result of a course of learning. Both formal as well as informal techniques may be used for conducting such evaluation. The formal techniques may include tests—standardized as well as teacher made, questionnaires, interviews, rating scale, work assignments, projects etc. In the informal techniques, we may include observations, discussions, comments and feedback given by the students etc. Such type of evaluation is chiefly characterized as following.

- It summarizes the final progress of the students as a result of a course of learning unit or lesson.

- It is carried out less frequently than formative evaluation, usually at the end of a unit or course of instruction
- The results of such evaluation may be safely used for making comparison among students, placing them in order of merit or taking decisions about their promotion and awarding degree or diploma. It is this characteristic of summative evaluation which enables it to be called as certifying evaluation.

QUALITIES OF AN ADEQUATE TEST

There are certain essential qualities which should be there in a good test. A good test should have the following characteristics.

Good Test

Technical Criteria	Practical Criteria
(1) Validity	(1) Ease of Application
(2) Reliability	(2) Time
(3) Objectivity	(3) Cost
(4) Discrimination	(4) Purpose
(5) Standardization	(5)Meaningfulness of Test scores
(6) Norms	(6) Acceptability
(7) Items	(7) Ease of Scoring
(8) Comprehensiveness	(8) Ease of Interpretation

(1) Validity - The test should be valid. A test is said to be valid when it measures what it needs to measure. The extent to which a testing device is said to be accurate or perfect in judging or testing a thing is usually referred to its validity. For example, if a test is meant to test the application skill of a student, it should really measure that skill and nothing else.

(2) Reliability - A test is said to be reliable when it tends to put the same results even after its repetition at number of times. It refers to a faith that can be put in the usuability of a test. A test is said to be reliable to the extent to which it can remain consistent in terms of its functioning or performance for the assessment or the measurement of the learning outcomes of the examinees. In case, different examiners award almost the same score to an examinee by going through its examination answer-book, we can conclude that the examination device or test paper is quite reliable.

(3) Objectivity- A test is said to be objective if it is not influenced by the personal opinion, views, impressions, interest or attitude of the examiner. If the questions are set in such a way that the examinces give different answers to the same questions that means it is vague and subjective. As far as possible, the answers requied to be produced by the students should be short and objective.

(4) Discrimination - A good test is that which can differentiate between good and bad student. The test should have difficult questions which can be solved by the brilliant students, and it should also have easier questions which can be solved by the weak and normal students.

(5) Standardization- Standardization implies uniformity of procedure in administering and scoring the test. If in a test, the comparative study is to be of different individual scores, then it is necessary that the conditions for testing for each individual should be similar.

According to Croanbach "A standardized test is one in which the procedure, apparatus and scoring have been fixed so that precisely the same test can be given at different times and at different places.

(6) **Norms-** The norms signify the normal or average performance. No psychological test presents a predetermined standard of pass or fail. The scores of any one individual are evaluated in the terms of comparison of scores of the other individual.

(7) **Comprehensiveness -** Comprehensiveness of the test refers to its length and extensiveness as to cover the complete course or learning experiences to be tested. It should be competent enough to test all the stipulated objectives in terms of knowledge, understanding, skills, abilities, interests and attitudes etc.

(8) **Ease of Application (Administration) -** A good test should be quite easy and simple in terms of administration. It should not provide opportunity to the examinees for creating administrative problems such as copying, cheating and talking to one another at the time of administration of the test.

(9) **Ease of Scoring -** According to Ross ease in scoring is dependent on three elements viz. objectivity, adequate key and full scoring directions. The scoring of the test should be done with ease and speed and in a desirable manner.

(10) **Ease of Interpretation -** The test should be easily interpretable i.e. the scores resulting from its use can be interpreted in terms of a common base that has natural or accepted meaning.

Construction of Test - There are four main steps involved in the construction of the test :

(1) Planning the test
(2) Preparing the test
(3) Try out of the test
(4) Evaluating the test

(1) Planning the test - In planning the test following aspects should be kept in mind :

(i) Content - The test should emphasize that curriculum material upon which stress is laid at the time of construction. The syllabus which is to be tested should be specified.

(ii) Objectives - In constructing the test attention should also be directed towards the purpose which the test is required to serve. Questions covering knowledge, understanding and skill objectives should be specified.

(iii) Number of test items - The total number of test items in the test should be finalized before starting to prepare the test.

(iv) Distribution of Weightage - When the content, objectives and the total number of test items have been determined, it is important to give the different objectives and the units in the content due weightage

to ensure proper coverage of each.

(2) Preparing the test - The actual construction of a test is done at the second step. In this connection, the following principles are to be kept in mind.

(i) The preliminary draft should be prepared as soon as possible. In this draft, all these steps must be included which ought to be included in the test.

(ii) Include more than one type of items.

(iii) All items of similar type should be placed together.

(iv) The instruction should be clear, complete and concise.

(v) Arrange items in ascending order of difficulty.

(3) Try out of the test - After the preparation of the first draft of the test, it must be sent for preliminary try out. In the try-out the following points should be specially paid attention to-

(i) The first try out should be on a sample. This sample should be so chosen that it represents the total population to which the test has to be administered.

(ii) During administration, the same conditions should exist for all.

(iii) The time for administering the test should be properly selected.

(iv) The instructions should be brief, clear and easy.

(v) In scoring, the simplest method should be used. The scoring of each individual should be done in accordance with the key prepared for the test. The average of the total scores of all the individuals should be obtained and the standard deviation be calculated. If half or one-third of the items involve chance factor, then by the following formula the scoring should be improved-

$$S = R - \frac{W}{N-1}$$

S = Corrected Score

R = The number of correct responses.

W = The number of wrong responses.

N = Number of responses given each time.

(a) Item Analysis - After the preliminary try out, item analysis is done. The item analysis means that each item is analysed in the light of the percentage of correct responses given by the total number of the students in order to decide its suitability for inclusion in the test. In its analysis, the discriminating value is calculated. It can be found out by arranging the scores of students highest to lowest. Then papers of 1/3rd of students who got the highest scores and 1/3rd who got the lowest scores are taken and it is found out whether the item discriminates the poor student from the good student or not.

(b) Internal Validity - After obtaining the difficulty value the internal validity of an item is calculated. For this, the following formula

is used :

$$E = \frac{(S_1 + S_2) - (S_5 + S_6)}{N/3}$$

E = Internal Validity

N is the number of testees.

S_1, S_2, S_5 and S_6 are those piles in which score books or cards are distributed. After finding out internal validity the final decision about the inclusion of the item in the final tests is taken.

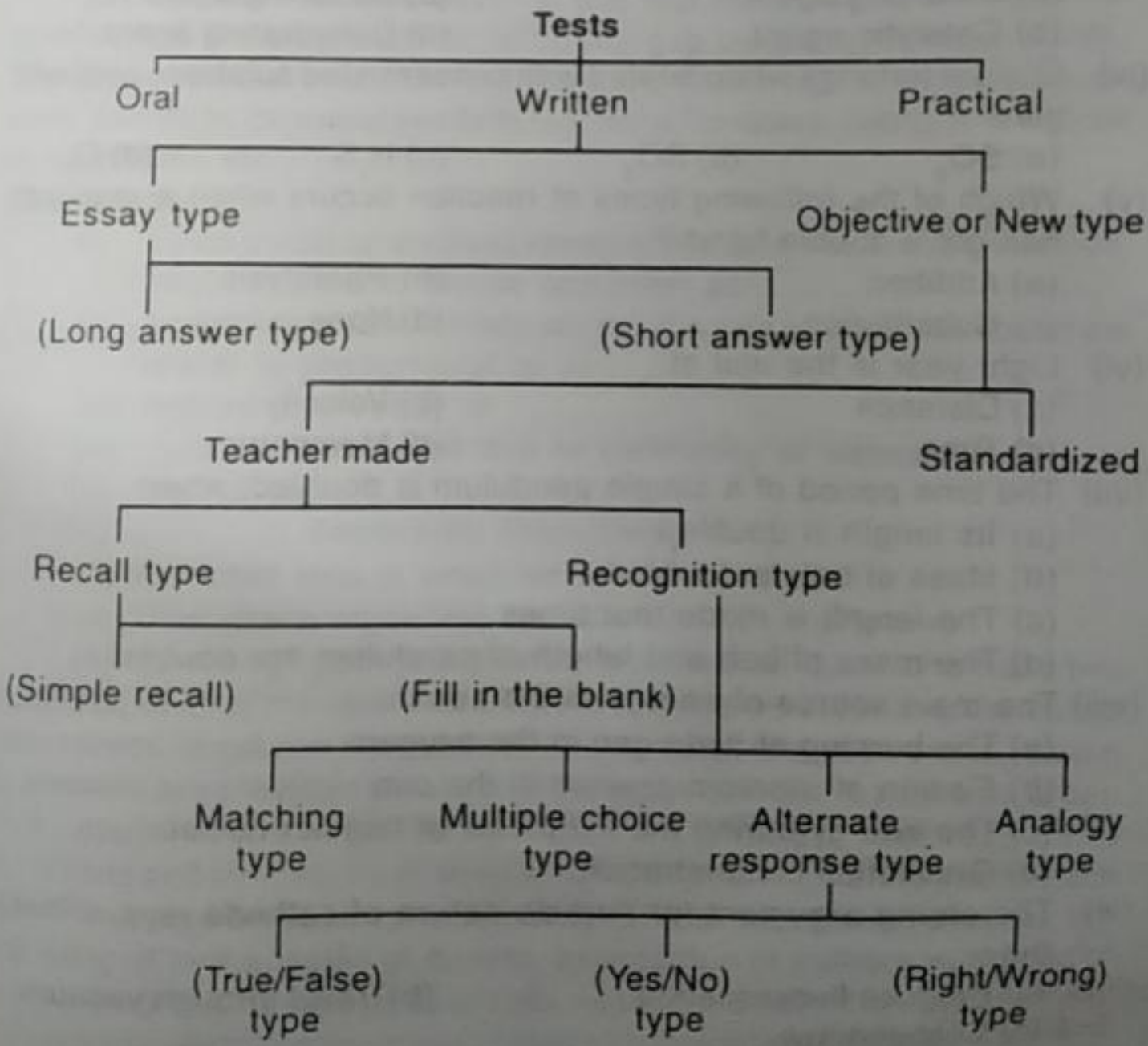
(c) Final Selection - Following laws should be kept in mind, for the final selection of the items-

(i) Those items should be included whose difficulty value is from 40-60% and internal validity is 0.5.

(ii) In selecting an item, the deciding factor should be that if a difficulty value curve is drawn, it should be a normal curve.

In this way, a test is constructed which can easily be used in the school.

Forms of the Techniques of Testing



Construction of an Achievement Test

Construction of an achievement test is a serious job for a teacher. It requires adequate planning before hand. Usually this work can be properly accomplished by following the undermentioned steps:

1. *Setting Objectives*. The first and the most important step is to make clear oneself about the objectives for which one is going to frame the test. In all situations the objectives of the test should be properly decided and defined in terms of specific behaviour changes expected in the pupils.

2. *Coverage of the syllabus or contents*. The contents which have to be covered in the test are directly dependent upon what has been taught by the teacher. The teacher should keep an outline of the learning experiences given by him. Although no major unit or subtopic of what has been taught should be left, it is not essential at all to ask for each and everything discussed by the teacher in the class. In other words,

a reasonable coverage of various aspects of the learning experiences given to the students should be the goal.

3. *Decision about the types of items or questions.* Decision about the types of questions to be set in the test paper is also an essential aspect of its construction. As pointed out earlier, all the three forms—Essay type, short answer type and objective type—should find place in a good achievement test.

4. *Decision about the time.* The total time given to the students for giving responses to the items of test should also be decided.

5. *Preparation of the Blue-Print.* This is the most crucial step in the planning of the test. Blue-Print is a sort of the design for the test paper in which we present a detailed question-wise distribution of marks over specific objectives, topics and forms of questions. Therefore, all the factors mentioned in the above four steps, *i.e.* objectives to be tested, contents to be covered, types of questions to be asked, and total time to be given, should be kept in mind while preparing the blue print or design of the test.

How the blue print is prepared can be understood through the following illustration.

Unit Test In Physical Sciences

Class : VII — Time : 40 minutes

Topic/Unit : Acids, Bases and Salts — Max Marks : 25

Blue Print

Objectives →	*Knowledge*			*Understanding*			*Application*			*Total*
Forms of Items → / *Sub units ↓*	*E*	*S*	*O*	*E*	*S*	*O*	*E*	*S*	*O*	
1. Acids	1 (2)	2 (2)	1 (1)	–	1 (1)	2 (2)	–	1 (1)	1 (1)	10
2. Bases	1 (2)	2 (2)	1 (1)	–	1 (1)	2 (2)	–	1 (1)	1 (1)	10
3. Salts	–	1 (1)	1 (1)	–	1 (1)	1 (1)	–	–	1 (1)	5
Sub Total	2 (4)	5 (5)	3 (3)	–	3 (3)	5 (5)	–	2 (2)	3 (3)	
Total	(12)			8			5			25

Notes.

(*i*) Figure within brackets indicate the marks while figures outside the brackets indicate number of questions.

(*ii*) *E* = Essay Type Questions, *S* = Short Answer Type Questions, *O* = Objective Type Questions.

Summary	*Type*	*No. of Questions*	*Marks*	*Scheme of option*
	Essay (*E*)	2	4	Nil
	Short Answer (*S*)	10	10	Scheme of Sections
	Objective (*O*)	11	11	Section *A*. Objective
	Total	23	25	Section *B*. Essay and Short Answer type.

6. *Organising and arranging the items or questions.* The items or questions to be included in the test require proper organisation and arrangement. The following points may prove helpful in this direction:

(*i*) Essay and objective items should be kept in two separate sections with separate time limit for each. Short answer questions can be tagged on to either of these two sections according to their nature.

(*ii*) Each section should have separate instructions common to both the sections.

(*iii*) Items should be arranged in order of difficulty from the easy to the more and more difficult.

(*iv*) In objective type items it is advisable not to use too many different forms of items or questions as it involves some waste of time over reading instructions etc. As far as possible multiple choice items should be preferred as they are more reliable, valid and objective in comparison to other forms of items.

7. *Writing items and finding their difficulty value.* After planning as suggested above, the teacher may start writing items or questions. It is better to have 20% items in excess so that in the final review the excess items may be left out. As a rule the test paper as a whole should neither be too stiff nor too easy. For this purpose the difficulty level of the items should also be considered by the teacher. For finding out the difficulty value of each item the teacher should administer the test to a group of students. The analysis of this test result, showing the percentage of students passing each item, can enable him to obtain a

numerical index of the difficulty of the items. The higher the percentage of students passing, the easier the item. On the basis of such analysis the level and range of difficulty of items or questions in the test can be determined. In the light of such findings, the unsuitable items can be deleted from the test or some other items can be included for making it more suitable.

8. *Preparation of a scoring key.* To ensure objectivity in scoring, it is advisable to have a pre-determined way of scoring. It is not only the objective type items that require an advance preparation of a scoring key but also in case of essay and short answer type questions the answer and procedure for scoring should be pre-determined.

Having proceeded along the above steps a teacher can manage to prepare an achievement test for the evaluation of the lesson/unit taught in the subject Physical Sciences.

Grading System

Grading system calls for providing letter grades to the students for their educational achievements instead of declaring them passed or failed or assigning numerical marks on a 100 point scale. It is preferred to the old system of percentage marking on account of the following reasons.

(*i*) It is simple to assign grading than the exact numerical marking involving no biases and subjectivity.

(*ii*) Examiners do differ in their marking on account of the subjectivity and standard of their marking. Grading reduces the subjectivity and unreliability on the part of the examiners.

(*iii*) In the old system, there is a provision of pass-fail or assigning divisions 1st, 2nd or 3rd for a certain percentage of marks obtained by the students. Grading makes it more wider by providing more graded categories. There is a practice in the old system of bunching the marks at the end for declaring pass or assigning particular divisions. Grading system helps in removing this evil.

(*iv*) Usually different subjects have different ranging marks, and combination of such heterogeneous scores as an aggregate or total marks for pass-fail or division is quite unsound and inaccurate from statistical as well as mathematical angles. Grading system provides good alternative for removing this defect.

(*v*) Grading system provides scaling of the evaluation on a uniform basis for the better comparison and combination of the evaluation outcomes in the different subjects and by the different examiners.

Methods of Grading. Generally two types of letter grades are assigned, one is to assign A, B, C, D, or E and the other consists of assigning O, A, B, C, D representing outstanding, very good, good, poor or very poor level of performances. For assigning such letter grades generally two methods known as absolute grading method and relative grading method are employed. Let us discuss these ways.

Absolute Grading Method. In such grading method a pre-determined level or standard is fixed for assigning letter grades. It can be carried out in two ways.

(*i*) A pre-established percentage scores required for a given grade is fixed. In other words, we fix different ranges of percentage marks for assigning them grade letters like given below :

Grade	*Scores Percentage*
O	80% and above
A	70-79%
B	60-69%
C	50-59%
D	Less than 50%

(*ii*) The other form of the absolute grading is known as criterion referenced grading. Here the criterion performance standard is fixed by the teacher or authorities in advance in the light of the difficulty level of the test and the standard or quality of learning performance needed from the learners. In other words, the decision is taken well before examining or testing the students that what performance (in terms of the changes in their behaviour) will help them to earn various letter grades. The performance level and letter grades can be represented as below:

Grade Performance Level. (In relation to the achievement of pre-determined objectives)

O	Outstanding (Excellent)
A	Above Average (Very good)
B	Average (Good)
C	Below Average (Poor)
D	Inadequate (Very poor)

Relative Grading Method. In this method grades are provided on the basis of the comparative or relative positions (ranks) of the students in their class or group. In usual practice, relative grading follows the 'normal curve' distribution for the allocation of grades. The assumption is that in general, the distribution of marks over a population of students follows the distribution pattern of a normal curve. The area under the normal curve may be statistically divided into equal segments helping us to mark the percentage of cases falling in each segment. This further helps us to take the decision as given below:

Grade	*Percentage of cases for being assigned the given grade*
O	Top 7% of a class or group.
A	Top-Middle 24% of a class or group.
B	Middle 38% of a class group.
C	Bottom Middle 24% of a class or group.
D	Bottom 7% of a class or group.

The decision about the top 7%, the next 24%, middle 38% and so on may be taken on the basis of numeral scores earned or performance level shown by the students on any evaluation measure. The students' roll numbers may then be arranged in descending order on the basis of their numerical scores or performance ratings. Top 7% are then assigned grade O, next 24% grade A, next 38% grade B and so on.

(1) Multiple choice Tests - This type of test is most popular because these require reasoning or involve cause and effect relationship. They are suitable for measuring knowledge, comprehension, application, analysis, synthesis and evaluation. In these questions there is a stem in the form of question and 4-5 alternative answers are given and the student is required to select the most correct answer or option.

Examples

(i) The process in which oxidation number increases is known as-

(a) Oxidation (b) Reduction

(c) Auto oxidation (d) None of the above

(ii) Sodium reacts with water more vigorously than Lithium because it-

(a) Has higher atomic weight (b) Is more electro-negative

(c) Is more electro-positive (d) Is a metal.

(iii) In the preparation of chlorine from HCl, MnO_2 acts as-

(a) Oxidising agent (b) Reducing agent

(c) Catalytic agent (d) Dehydrating agent.

(iv) Copper turnings when heated with concentrated sulphuric acid will give-

(a) SO_2 (b) SO_3 (c) H_2S (d) O_2

Selection of the Appropriate Evaluation Technique

The decision about adopting a particular evaluation technique or combination of techniques depends upon so many factors like:

- objective or objectives of the teaching-learning.
- contents or the learning experiences provided to the learner.
- the methodology and strategies adopted for carrying out the process of teaching-learning.
- the behavioural domain, cognitive, conative or affective in which behavioural changes are to be measured or assessed.
- the purposes like diagnostic, formative or summative or providing information, feedback, incentive etc. served by the evaluation.
- emphasis on mastery learning, acquisition of required level of performance or reliable comparability and grading etc.
- the level, memory and understanding reflective of the organisation of teaching-learning.
- the nature of the evaluation technique or techniques suitable for serving some particular or required purposes.

Remedial Teaching

What is Remedial Teaching?

The term 'remedial teaching' as the name suggests stands for the teaching or instructional work carried out to provide remedial measures for helping the students (or individual student) in getting rid of their common or specific weaknesses or learning difficulties diagnosed through diagnostic testing or some other measures carried out for such diagnosis.

Diagnosis thus provides a solid base for hypothesising the general and specific causes underlying the weakness or learning difficulties of the students of a class/group (or a particular students). It is thus true that as the diagnosis so is the remedy for the removal of the difficulty.

Thus depending upon the general or specific nature of the weaknesses or learning difficulties of the students. We have to take appropriate steps for the organization of remedial teaching for the needy students.

Organization of Remedial Teaching in Science

Remedial teaching in the science can take various forms like below :

1. Class teaching
2. Group tutorial teaching
3. Individual tutorial teaching.
4. Supervised tutorial teaching.
5. Auto-instructional teaching.
6. Informal teaching.

Let us discuss now all these forms and aspects of remedial teaching.

Class Teaching In this system or schedule of remedial teaching, the usual composition and structure of the class is not disturbed. The teacher here teaches a particular lesson/unit, emphasises a point again and again, repeats the experiments or uses some specific teaching aid in order to remove the difficulties and deficiencies of the learners in terms of the acquisition of the desired learning experiences. The class as a whole is benefitted through such type of remedial teaching. It proves particularly useful in the removal of the weaknesses and learning difficulties of the general nature.

Group Tutorial Teaching Here the students of the class are divided into some Homogeneous groups called **tutorial groups** on the basis of their common learning difficulties and identical weaknesses or deficiencies in the acquisition of the learning experiences in some or the other areas or aspects of the subject. These groups are then taught separately by the same teacher or different teachers according to the nature of the difficulties and deficiencies. The tutor incharge of a tutorial group then tries to solve the difficulties of the learners however, collectively on a group basis. The weak area or aspects of the curriculum identified through diagnostic testing are properly attended by the teacher according to the needs and requirement of the pupils of the group. In case, it is related to particular work, due care and proper attention is now paid by the teacher over his own demonstration work as well as on the practical and project work done by the students in their respective group.

The group tutorial teaching proves advantageous over the class teaching in many aspects. Here the students who have common problems and difficulties in their learning are more helped in overcoming their difficulties and deficiencies. It makes the task of teaching - learning quite interested and goal oriented in class teaching there remains a lot of chances that the time and energy of many of the students who do not suffer with a certain learning deficiency or difficulty will go in vain by attending to the remedial teaching not at all needed by them. Moreover, the number of students in group tutorial teaching is comparatively reduced. It results in making the task of the teaching more convenient, and effective for providing better coaching and practice in terms of the needed remedial education.

Individual Tutorial Teaching In this schedule, every learner, who feels learning difficulty of one or the other nature,is attended individually for overcoming his deficiencies or weaknesses. It is one to one coaching, help and guidance that is rendered by the teacher to the learner as and when needed by him in order to actualise his potentialities to the maximum. Therefore, in this type of remedial teaching, maximum consideration may be provided to the principle of individual difference in the direction of the best results in the task of teaching and learning. Here the students may progress according to their own pace, abilities

and capacities and get adequate help, individual attention and reinforcement for coping up with their deficiencies and difficulties on the path of learning.

Supervised Tutorial Teaching In this schedule of remedial teaching, the responsibility of overcoming the learning difficulties and removing deficiencies in some learning areas is handed over to the learners themselves. They have to work at their own for removing their difficulties and deficiencies. The role of the teacher is confined to observe and supervise the learning activities and provide as much help as necessary to carry on them on their path of self-learning and self-correction. This type of supervision can be made on the individual as well as tutorial group levels. The students may opt to work in the group or individually for solving their difficulties and over coming their learning deficiencies.

Auto-Instructional Teaching This type of remedial teaching consists of auto-instructional programmes and activities. Here the learner is provided with basic auto-instructional and self-learning material and equipments like programmed learning text books and packages, auto-learning modules, teaching machines and computer assisted programmed instructions, etc. This material helps the pupil to gain sufficient practice and drill work in the areas of his weakness and acquire necessary confidence in overcoming his difficulties and deficiencies through the well programmed self-instructional material.

Informal Teaching Informal science education and teaching suitable planned and assimilated with the formal science education of the school may go in a big way to act as a source and means of remedial education to the needy students. The activities connected with such informal education in the form of excursions or trips, collecting material for the science museum, improving science apparatus, working on useful scientific projects, engaging in the scientific hobbies, establishing aquarium, vivarium, terrarium, botanical garden, zoo and nature study corner in the school campus and participating in the science club activities, etc, make the study of the students and provide unique and special opportunities to learn and practice the facts and principles of science. The learning difficulties arrived out of the lack of interest, non-availability of direct and first hand learning experiences, deficiencies in the methodology of teaching, psychological needs and problems of the learners and host of other reasons may be easily overcome through the organization of useful formal activities of sciences or scientific interest in the schools.