M.A. 4th Semester

Course Code: EDUGE 302
Course Type – Generic Elective

PEDAGOGY OF SCIENCES

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Course Code: EDUGE302

Course Title: PEDAGOGY OF SCIENCES

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Unit 1:

FOUDATIONS OFSCIENCE EDUCATION

Place of Science in School Curriculum and Relationship of Science with other School

- Science: Meaning, Nature and Importance of Sciences in Life.
- Aims and Objectives of Teaching Science Subjects.
- Formulation and Classification of Objectives in Behavioral Terms with reference to Cognitive, Psycho-motor and Affective Domains

Unit 2:

CURRICULUM AND LEARNING RESOURCES IN SCIENCE

Curriculum in Sciences: Concept, Principles of Curriculum Construction in Sciences

- Learning Resources in Science: Need and Importance of Science Laboratory
- Selection and Organization of Content, Factors affecting Change in Science Curriculum. Importance of Various Teaching Aids in Science and Uses of Smart Classroom in
- Organization of Science Club, Science Exhibitions and Science Fairs, Qualities of a Good Textbook in Sciences
- Teaching of Sciences

UNIT - 3 TEACHING METHODS AND TECHNIQUES

- Methods and Techniques of Teaching Science: Meaning, Types of Methods/Approaches: Lecture, Demonstration, Problem Solving,

- Project Method, Laboratory Method, Heuristic Method
- Techniques and Strategies of Teaching Sciences: Drill and Practice, Brain Storming, Quiz
- Play way Technique, Activity-Based Technique, Ways of Developing Scientific Attitude and Aptitude among Children.

UNIT - 4 PLANNING FOR TEACHING AND EVALUATION IN SCIENCES

- Unit and Lesson Planning in Sciences: Meaning, Need, Importance and Principles.
- Steps in Unit and Lesson Planning in Sciences
- Evaluation in Sciences: Meaning and Types; Formative, Summative and Diagnostic Evaluation
- Continuous and Comprehensive Evaluation: Concept and Techniques with reference to Sciences.

PEDAGOGY OF SCIENCES
Course Code: EDUGE 302
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Unit-1

MEANING AND NATURE OF SCIENCE, IMPORTANCE OF SCIENCE IN LIFE

STRUCTURE

1.0 Learning Objectives

1.1 Introduction

1.2 Meaning of Science

Self Check Exercise-1

1.3 Nature of Science

Self Check Exercise-2

1.4 Importance of Science in Everyday Life

Self-Check Exercise-3

1.5 Summary

1.6 Glossary

1.7 Answers to Self-Check Exercise

1.8 References and Suggested Readings

1.9 Terminal Questions

1.0 Learning Objectives:

After reading this unit, you will be able to

- Understand the meaning, nature & importance of General Science
- Understand the importance of science in life

1.1 INTRODUCTION:

Today science is advancing at an amazing speed and everything of our life has changed beyond recognition. It constitutes an attempt to conquer the forces of nature and aims to give man increasing power over his surroundings. In the daily life of a man science is visible. For instance, he can now travel much faster and more comfortably than in the past Bullock carts in villages and horse carriages in town are being replaced by tractors, trucks auto-carriages in and cars.

Invention of steam engine revolutionized travel Similarly quick means of communication have brought the peoples of the world together We can talk to any person through telephone and mobiles. Electronic mail (email) has made the transmission of any message across internet to any person in this world Science has played a tremendous role in our lives during the last century and is now changing our entire existence in such important aspects as health, communication transportation and power to visualize what science has done for man, it simply necessary to sit in a modern room and look around. There you will find nothing which the hand of science has left untouched. The curtains and carpets are tinted with dyes which no plant could have produced. The chemists have produced these out of the black and sticky coal tar from the same coal tar has been manufactured the Bakelite fountain pen and the ink in it. The artificial silk fabric of the chairs covers has been made from wood pulp. The electric light TV VCR the artificial graphite in the pencil, the nickel-plated door fitted is all feats of science. The invention of television is one of the most important events in human history It enables men to see peoples, images thousands of miles away from them.

Cinematography is also a unique gift of science The talkies have definitely taken the place of the theatre and a large-scale cinema industry has sprung up.

"Every comfort will be made to extend science to the vast numbers who have remained outside the pale of formal education "National Policy on Education (1992)

1.2 MEANING OF SCIENCE:

Science has been derived from Latin word Scientia", which means knowledge. It has been defined in different fashions by different persons Commonly speaking

- 'Science is a systematized body of knowledge'.
- 'Science is organized common-sense'.
- 'Science is a heap of truth.'

The term science & general science are used synonymously Einstein defines science as "An attempt to make the chaotic diversity of our sense experience correspond to logically uniform systems of thought."

According to the Columbia dictionary "Science is an accumulated & systematized learning in general usage restricted to natural phenomenon."

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 of modification in the light of further empirical observation. Science is both a body of knowledge & the process of acquiring & refining knowledge."

According to Griggs. In the literal sense science means the pursuit of knowledge but it has a wider connotation for our purpose, and can be said to mean knowledge of nature in the widest possible form on the basis of these definitions of science we can say that

- Science is a study of natural phenomenon

- It is organized & systematized learning
- It is a body of cumulative & ordered observations
- It is the knowledge based on observations, experiments.
- Science is a process as well as the product.

Self Check Exercise-1:

Q-1: Discuss the word science.

1.3 NATURE OF SCIENCE:

Humans have always been curious about the world around them. The inquiring and imaginative human mind has responded to the wonder and awe of nature in different ways One kind of response from the earliest times has been to observe the physical and biological environment carefully, look for any meaningful patterns and relations, make and use new tools to interact with nature, and build conceptual models to understand the world This human endeavor is science.

Science is a dynamic expanding body of knowledge covering ever new domains of experience. How is this knowledge generated? What is the so-called scientific method? As with many complex things in life, the scientific method is perhaps more easily discerned than defined But broadly speaking, it involves several interconnected steps observation, looking for regularities and patterns, making hypotheses, devising qualitative or mathematical models, deducing their consequences, verification or f. fiction of theories through observations and controlled experiments, and thus arriving it the principles, theories and laws governing the physical world There is no strict or in these various steps Sometimes, a theory may suggest a new experiment, at other times an experiment may suggest a new theoretical model Speculation and conjecture also have a place in but ultimately, a scientific theory, to be acceptable, must be verified by relevant observations and/or experiments The laws of science are never viewed as fixed eternal truths Even the most established and universal laws of science are always regarded as provisional subject to modification in the light of new observations, experiments and analysis.

The methodology of science and its demarcation from other fields continue to be a matter of philosophical debate Its professed value neutrality and objectivity have been subject to critical sociological analyses Moreover, while science is at its best in understanding simple linear systems of nature its predictive or explanatory power is limited when it comes to dealing with non-linear complex systems of nature Yet, with all its limitations and failings, science is unquestionably the most reliable and powerful knowledge system about the physical world known to humans.

How do we ensure that science plays an emancipative role in the world? The key to this lies in a consensual approach to issues threatening human survival today This is possible only through information, transparency and a tolerance for multiple viewpoints.

In a progressive forward-looking society, science can play a truly liberating role, helping people out of the vicious circle of poverty, ignorance and superstition. In a democratic political framework, the possible aberrations and misuse of science can be checked by the people themselves Science tempered with wisdom, is the surest and the only way to human welfare. This conviction provides the basic rationale for science education.

But science is ultimately a social endeavor Science is knowledge and knowledge is power. With power can come wisdom and liberation? Or as sometimes happens unfortunately power can breed arrogance and tyranny Science has the potential to be beneficial or harmful, emancipative or oppressive. History particularly of the twentieth century is full of examples of this dual role of science.

How do we ensure that science plays an emancipative role in the world? The key to this lies in a consensual approach to issues threatening human survival today This is possible only through information, transparency and a tolerance for multiple viewpoints in a progressive forward-looking society, science can play a truly liberating role, helping people out of the vicious circle of poverty ignorance and superstition in a democratic political framework, the possible aberrations and misuse of science can be checked by the people themselves Science, tempered with wisdom, is the surest and the only way to human welfare. This conviction provides the basic rationale for science education.

Nature of Science is a term that refers to various topics related to sociology, philosophy, and history of science It is a metacognition about science's products in an interdisciplinary analysis of these areas of knowledge, together with specialists in didactics of science and scientists Also, the NoS seek recognition of the values implicit in the development of theories and statements, given that science is not neutral and it is subject to constant review This leads to consider science beyond of the concept of an unalterable body of knowledge referred to in the scientific method.

In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of scientific knowledge. Many of these intrinsic ideas are lost in the everyday aspects of a science classroom, resulting in students learning skewed notions about how science is conducted.

The main ideas regarding the nature of science are:

1. Scientific knowledge is tentative. Although scientific knowledge is supported by a wealth of data from repeated trials, it is not considered the final word. Scientific knowledge is at the same time stable and malleable Scientists continually test and challenge previous assumptions and findings. After all, science is a human endeavor, and we know human perspective is limited and fallible. This idea of fundamental uncertainty is vital to scientific studies and is the basis of great scientific discoveries.

2. **Nature of facts/hypotheses/theories.** Some key words in science are often misinterpreted.

Facts:

Students often think of the pieces of scientific knowledge they learn as "facts" As mentioned in the last section, we should not refer to scientific knowledge as fact because that would tend to perpetuate the idea that scientific knowledge is inalterable Scientific facts are observable phenomenon in a particular situation "Dinosaurs were cold-blooded" is not a scientific fact because this phenomenon cannot be observed "The caterpillar is 26 cm in length" is an example of a fact, because the phenomenon was observed in a particular situation.

Hypotheses:

If you ask a student to tell you what a hypothesis is, you will likely receive the following response "A hypothesis is an educated guess" Although a hypothesis is partly a "guess" in the sense that it is an idea, this inevitable definition is not adequate A hypothesis is a statement, based on previous observations that can be tested scientifically. The idea that a scientific hypothesis must be testable often eludes students.

Theories:

In the colloquial, theories are often ideas that have not been validated in science, a theory has a much stronger meaning Scientific theories are broadly based concepts that make sense of a large body of observations and experimentation Because theories successfully be together such a huge amount of information, they are among the most important ideas in science.

3. **Scientific methods.** In the first chapter of most science textbooks, there will be a section laying out "the scientific method," a step-by-step process that apparently must be followed in order to conduct scientific studies The danger in this approach is not only that learning the scientific method is a bummer to but that it is also quite restrictive in its scope. Scientists usually do not walk through the method sequentially. They often bounce around, perhaps forming a new hypothesis during experimentation. Studies in which no experimentation is performed are also valid scientific studies, but do not follow the scientific method. For example: Jane Goodall observed the behavior of the apes in Africa and did not experiment on them, yet her research is still considered science. This butterfly study is a good example of an observational study which does not follow the scientific method, yet students record scientific data and create scientific conclusions.

4. **Observations and inferences.** It is important for students to understand the difference between observation and inference However, this knowledge in itself is not enough Students should also learn to make good observations and inferences and understand the role that observations and inferences play in the development of scientific knowledge.

Observations:

When we describe an environment based on our five senses, it is called an observation. For example, "Upon magnification, the painted lady eggs appear bluish and barrel-shaped" Observations are direct enough that most would make the same observation in the same situation.

Inferences:

When we bring our past experience into making a judgment based on an observation, it is an inference. For example, "The caterpillar appears as if it is about to form its chrysalis" is an inference, because you are interpreting observations according to knowledge from past experience. Inferences are important in science in making explanations, but one must be careful not to confuse observations with inferences when conducting a study.

5. **Human error.** Although we take steps not to make errors in observation or experimentation, scientists are still human and make mistakes It is important to challenge students to view their mistakes or unexpected results as potentially helpful Scientific studies are most often riddled with problems that must be addressed Often, scientists do not find the answer they expect, but if they do not allow their expectations to cloud their judgment, they may be able to approach the problem in a more appropriate manner.

Self Check Exercise-2

Q-1: Discuss the term nature of science.

1.4 Importance of Science in Everyday Life:

Today science is advancing at an amazing speed and everything of our life has changed beyond recognition. It constitutes an attempt to conquer the forces of nature and aims to give man increasing power over his surroundings. In the daily life of a man science is visible. For instance, he can now travel much faster and more comfortably than in the past. Bullock carts in villages and horse carriages in town are being replaced by tractors, trucks auto-carriages in and cars. In every generation and in every century there always exist a number of people, who are afraid of everything that is related to possible changes. In various epochs they are called differently luddites, anti-globalists, ecologists and so on, but their nature is always the same They hate progress and strive to preserve the status quo without seemingly realizing the fact that the same very kind of people hated progress and strived to retain the status quo a hundred years ago, and now they use all the things that were denounced by their spiritual ancestors Science always has to fight against heavy odds, for it always tries to show how useful something may be to people who don't want to listen, knowing that the very moment they will be persuaded, they will use a yet another product of science against what has created it. It wouldn't be an exaggeration to say that a scientist is the hero of modern day, and not a politician or a social activist Invention of steam engine revolutionized travel. Then came the sensational invention of aero-planes Similarly, quick means of communication have brought the peoples of the world together We can talk to any person through telephone and mobiles Electronic mail (email) has made the transmission of any message across internet to any person in this world Further, it has made the use of radio both as a means of information and recreation In times of distress, wireless telegraphy renders extraordinary service A plane or ship in danger can at once contact on wireless the

nearest aerodrome or port and get timely help. The importance of science in our daily life are discussed as below:

Science has invaded every branch of modern life. It is the noise of machines, cars. mills and factories, etc. which awakens us every-day in the morning The food we eat, the clothes we wear, the books and papers we read, the recreations we enjoy the games we play-all have something or other to do with the application of science.

Every person feels the effects of science in every sphere of life It is not merely the electric light or the electric fan, the radio or the cinema that displays the power of science in our life, but everything we do or is done to us is in some way or another connected with science.

The things that we use in our daily life are mostly due to science. Our forefathers put on clothes woven by hand. Our clothes are made in large factories where scientific methods are used. We get so much paper to write on only because the piper mills can turn out huge quantities of it. Cloth and paper we had even before science came on the scene but no one could then think of the huge quantities in which they are produced now.

Science has conquered time and distance. We can travel from one place to another with a quickness which our forefathers could not have dreamt of. In the morning, we get news of events that happened yesterday in all parts of the world Why should we talk of yesterday? With the help of the radio, we can listen to an American speaking. It would seem that he is before us and we are part of his audience. If we want to send a message to a person in America, we can send an email and he will get it in a few hours if we want to speak to our friends far from us, there is the telephone that will connect us.

Effect of science on human life: It is, indeed, true that science has added tremendously to the comforts and conveniences of mankind. Unless one is an ascetic, one has no reason to reject the things science offers. By conquering time and distance science has brought mankind together and so far made life richer. By inventing medicines, it has made our day-to-day existence relatively free from disease, and has, indeed, added to our length of life.

Examples of use of science in everyday life: This fan and light works from the application of electricity. Electricity is one of the wonders of modern science. The bus which has an engine works with petroleum. The train is driven by the power of coal. This is possible only because of the application of science. My doctor gives certain injections and the patient soon well enough to come here medical science is another achievement of modern science, the marvel of medicine.

Contribution to our health and wellness: The invention of medicines for severe diseases is a significant contribution of science in the field of health and wellness Plague, small-pox, cholera, leprosy typhoid and even tuberculosis are no long terrible disease now.

Human body has been thoroughly studied and most of the diseases are controlled by life-giving medicines and miraculous surgery Plastic surgery can make an ugly woman a beautiful lady.

Science makes our life possible - today a human being cannot imagine his or her life without all the many thousands of little and big things, created by science in the course of millennia. And the people who denounce it for meddling with the things that we do not understand, just don't see that is no way to study a thing that you don't understand without, well, studying it Of course science always prevails in the end for life is stronger than death. But it is really embarrassing to see how hard it has to fight.

Self-Check Exercise-3

Q-1 Which of the following statement best describes the nature of science?

a) Scientists are totally objective in their work

b) The scientific method is the only guide for conducting research

c) Science is a system of beliefs

d) Science is social in nature

Q-2 The values of science for nature are:

a) Possibility

b) Reality

c) Interim

d) Uncertainty

Q-3 Science has been derived from Latin word Scientia", which means knowledge.

True/False

Q-4 Science has been derived from Latin word Scientia", which means……...

1.5 Summary:

It cannot be denied that there is some truth in the above criticism. But we cannot now go back to the old days. We should have all the comforts and conveniences, and we should try to improve upon them. But we must try to be masters of scientific appliances and not their slaves. We should make use of machines, but our life must not be mechanized. The broadest concept of science and society relates the achievements of science to human welfare and to human values, blending and integrating in disciplines. This couples science to operational applications within our society by using its concepts to attack persistent problems of human experience and stressing its potential for improving the "quality of living". This goal changes forms of the established laws and concepts of science.

1.6 Glossary:

Significant- Important or large enough to be noticed

Phenomenon- A fact or an event in nature or society, especially one that is not fully understood

Magnification: A comparison between the size of the image formed by a lens with respect to the size of the object.

1.7 Answers to Self-Check Exercise:

Self-Check Exercise-1

Ans-1: "Science is a cumulative and endless series of empirical observation which result in the formation of concepts & theories with both concepts & theories being subject of modification in the light of further empirical observation. Science is both a body of knowledge & the process of acquiring & refining knowledge."

Self-Check Exercise-2

Ans-1: Nature of Science is a term that refers to various topics related to sociology, philosophy, and history of science It is a meta cognition about science's products in an interdisciplinary analysis of these areas of knowledge, together with specialists in didactics of science and scientists Also, the NOS seek recognition of the values implicit in the development of theories and statements, given that science is not neutral and it is subject to constant review This leads to consider science beyond of the concept of an unalterable body of knowledge referred to in the scientific method.

Self-Check Exercise-3

Ans-1 Science is social in nature

Ans-2 Reality

Ans-3 True

Ans-4 knowledge

1.8 References and Suggested Readings:

- Das R.C. (1989) Science Teaching in Schools, New Delhi: Sterling Publishers.
- Kohli, V.K. (1998) How to Teach Science, Ambala Vivek Publishers.
- Kumar, Amit (2002) of Physical Sciences, New Delhi: Anmol Publications.
- Mangal. S.K. (1997) Teaching of Science, New Delhi: Arya Book Depot.
- Mohan, Radha (2002) Innovative Physical Science Teaching Methods. New Delhi: P.H.I.

1.9 Terminal Questions:

1. Science has always responded to the needs of society. Comment.
2. Discuss the significance of physical science relating it to the surroundings around you.

3. Science helps in bringing all countries together. Justify this statement.
4. Discuss in detail the place of science in school curriculum.
5. What is the importance of science in our daily life?

Unit-2

PLACE OF SCIENCE IN SCHOOL CURRICULUM AND RELATIONSHIP WITH OTHER SUBJECTS

STRUCTURE

2.0 Learning Objectives
2.1 Introduction
2.2 Place of science in school curriculum
Self-Check Exercise-1
2.3 Relationship of science with other subjects
Self Check exercise-2
2.4 Summary
2.5 Glossary
2.6 Answers to Self-Check Exercise
2.7 References and Suggested Readings
2.8 Terminal Questions

2.0 Learning Objectives:

After reading this unit, you will be able to

- Explain the science in school curriculum:
- Explain the relationship of science with other subjects

2.1 INTRODUCTION:

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 of modification in the light of further empirical observation. Science is both a body of knowledge & the process of acquiring & refining knowledge."

There you will find nothing which the hand of science has left untouched. The curtains and carpets are tinted with dyes which no plant could have produced the chemists have produced these out of the black and sticky coal tar from the same coal

tar has been manufactured the Bakelite fountain pen and the ink in it. Today science is advancing at an amazing speed and everything of our life has changed beyond recognition. It constitutes an attempt to conquer the forces of nature and aims to give man increasing power over his surroundings. In the daily life of a man science is visible. For instance, he can now travel much faster and more comfortably than in the past Bullock carts in villages and horse carriages in town are being replaced by tractors, trucks auto-carriages in and cars.

Invention of steam engine revolutionized travel Similarly quick means of communication have brought the peoples of the world together We can talk to any person through telephone and mobiles. Electronic mail (email) has made the transmission of any message across internet to any person in this world Science has played a tremendous role in our lives during the last century and is now changing our entire existence in such important aspects as health, communication, transportation and power. To visualize what science has done for man, it simply necessary to sit in a modern room and look around. The artificial silk fabric of the chairs covers has been made from wood pulp. The electric light TV VCR the artificial graphite in the pencil, the nickel-plated door fitted is all feats of science. The invention of television is one of the most important events in human history It enables men to see peoples, images thousands of miles away from them.

Cinematography is also a unique gift of science The talkies have definitely taken the place of the theatre and a large-scale cinema industry has sprung up.

"Every comfort will be made to extend science to the vast numbers who have remained outside the pale of formal education "National Policy on Education (1992)

2.2 PLACE OF SCIENCE IN SCHOOL CURRICULM:

The fore-going discussion reveals that man's future is stubbornly linked to scientific advances and the development of productive activity Obviously, therefore, science must find a respectable place in the school curriculum All the words over this feeling is being generated.

In India, through the efforts of National Council of Educational Research and Training (NCERT), science has been made a compulsory subject through the school stage.

The views of Kothari Commission, UNESCO's International Commission on the development of Education and National Policy on Education, in this connection are worth considering.

Kothari Commission (1964-66):

The Commission stated that—

"We lay great emphasis on making sciences an important element in the school curriculum We, therefore, recommend that science and mathematics should be taught on a compulsory basis to all pupils as a part of general education during the ten years of schooling In addition, there should be provision for special courses in these subjects at the secondary stages, for the students of more than average ability."

UNESCO'S International Education Commission (1972):

In line with the strategy of Kothari Commission, UNESCO'S International

Education Commission recommended as under;

"Science and technology must become essential component in any Educational enterprise, they must be incorporated into all educational activity intended for children, young people and adults, in order to help the individual to control social energies as well as natural and productive ones thereby achieving mastery over himself, his choices and actions and finally they must help a man to acquire a scientific turn of mind so that he becomes able to promote science without being enslaved by it."

Regarding the shape of science and its relation with humanities this commission hoped that:

The natural sciences will one day incorporate the science of man, just as the science of man will incorporate the natural sciences, there will be a single science."

National Policy on Education (1992);

The National policy has made science as a compulsory subject at school level. It goes further saying that science education may be given even out of the school youth and adolescents. The policy recommends as under;

"Every effort will be made to extend science education to the vast numbers who have remained outside the pale of formal education."

Science is vitally important in our daily lives as it provides us with an understanding of how the universe behaves Physical Science explains the measure of the different physical quantities that play a vital role in our daily life, such as volume, weight, mass, distance, etc. By these standard units of measurement, we can organize our daily activities and this has united human activities all over the world. Physical Science can solve many of the crises facing the world, such as global warming, waning energy, overpopulation, natural disasters, and the slow poisoning of our planet. We can discuss the Importance of physical sciences as a subject of the school curriculum on the basis of its value in different spheres such as:

1. **Intellectual Value.** The Science has introduced us to new ways of thinking and reasoning Scientific knowledge helps to sharpen our intellect & promotes intellectual honesty The science education can develop the positive attitudes like open mindedness such positive is helpful to an individual to understand, evaluate and solve many problems faced in life.
2. **Vocational Value.** In present age all the vocation need the knowledge of science more ever there are large no of vocations for which study of science is compulsory requirement examples: Medicine, Engineering Computers Para medicines, agriculture etc. The study of science at a school level is the basis of many vocations & other productive activities in the latter of students.
3. **Aesthetic Value.** Knowledge of science develops in man a passion for truth & thus he has a passion for beauty The English Poet Keats has said.

Truth is Beauty Science is basically unfolding of the mysteries of nature & nature is a store house of all the beautiful things Thus teaching of science is necessary for developing aesthetic sense in an individual.

4. **Utilitarian Value.** Scientific principles & laws find a large number of applications in our everyday life. For proper utility of such applications knowledge of science is necessary Electronics, Electricity Communication, transport etc all integral part of our life is strongly influenced & advanced due to advancement in science Thus teaching of science is necessary from utilitarian point of view.

5. **Cultural Value.** Science has played an important role in determining the culture & civilization of a country from time to time. It has affected our way of thinking & way of living Science has a direct influence in dispelling many traditional beliefs Science has made us more aware of the universe we live The scientists take an equal responsible part in the vital issue of our country so as to bring about consideration & integration of scientific developments & our cultural heritage.

6. **Moral Value.** Knowledge of science develops in us truthfulness & reasoning. These qualities are desirable in all human beings. These qualities make the life worth living. This could be possible with the teaching of science.

7. **Psychological Value.** Teaching of science is essential for developing scientific attitudes & scientific temper The principle of learning by doing is the main basis of the teaching of science & satisfies the instincts of curiosity, creativeness, self-assertion, self-expression etc of the pupils.

8. **Adjustment Value.** Science develops in us a scientific attitude It also develops in an individual a problem-solving attitude. These attitudes help to solve any problems in life successfully. A person having scientific attitude lives a peaceful & successful life.

9. **Leisure Time Value.** Science has helped us to overcome the problem of passing our leisure time & to make best use of it. Science has provided us with a large number of devices such as television, radio, cinema etc which are the source of entertainment to all of us They also serve as source of knowledge & are used for spread of mass education & making the community aware of dangers of various is Science has also provided large number of hobbies which we can pursue in our leisure time.

Self Check exercise-1

Q-1: Discuss the role of science to enhance intellectual value.

2.3 Correlation of science with other subjects

It often happens that the various aspects of a topic are dealt with by different teachers from the point of view of their own subject.

The impact of these lessons on a people is much greater when they are discussed about the same time by different teachers instead of separating them by long

intervals Teachers therefore must strive for some degree of correlation Science can be correlated with almost all subjects. A few of them are as discussed below;

1. **Science and mathematics:** Mathematics is probably the sole language of science and therefore a real understanding of science is impossible without adequate knowledge of mathematics Algebraic equation, graphs, geometry, co-ordinate geometry, calculus, simple statics are some of the useful tools of science. Science and mathematics teachers should co-operate in the consideration of such matters as following;
    a. Can scientific data be used for illustrating mathematical problems?
    b. Can exercise on measurements, finding volume, area be transferred to mathematics side?
    c. Can mathematics teacher teach and give practice in certain mathematical operation before science teacher use it in the class?
2. **Science and Geography:** Subjects like meteorology, rocks and soil, distribution of plants and animals' life etc. bring the two subjects very close to each other The question arise who would deal with these subjects first, science teacher or geography teacher? The actual recording of atmospheric pressure, temperature, wind direction, humidity and rainfall, the study of recording instruments are science Geography interprets the results got by science in terms of climate and its effects on land and man. The way in which the breaking down of different types of rocks produces different types of soil is nothing but science Geography lessons on these subjects will, therefore be better understood and appreciated if they have already been discussed in the science class Again the topic like relationship between plants and animal distribution, the density and activities of human population, the occurrence and composition of clay, hills and coral reefs concerns both geographer and the scientists Thus one subject can very well help the other.
3. **Science and language:** language and composition teacher may occasionally be requested to look at a set of science essay, or descriptive accounts of experiments so that both teacher and taught feel that there is close cooperation for a good descriptive style Language teacher may suggest essays on scientific topics Passage from original and historical scientific works may be used for translation Science books on natural history and biography are valuable contribution to literature and provide excellent reading material.
4. **Science and history:** It is useful to mention events in the world history which coincide with important scientific discoveries. Certain important discoveries and inventions took place in the reign of certain famous kings who patronized the scientists. German gained scientific leadership in the early years of the century and her monopoly of the manufacture of many scientific instruments paved the way for the World War 1. Correlation between science and history is very prominent in topic like the story of the

man, the story of the earth, and the story of the wheel. The story of man endeavors to fight disease may be correlated with the work in history such as leprosy and plague in the east, scurvy and small pox in Europe, the ideals of health in time of Greeks, parliamentary acts for the better sanitation and living condition etc.

5. **Science and Social Studies:** Science and social studies are very much inter- dependent. There is great impact of science on our way of thinking, behaving eating and living Science is an important factor in determining our faith and beliefs. Development of scientific attitudes and training in scientific methods the major goal of science teaching, have revolutionized our outlook and way of looking upon world problems.

   The teacher of social studies should not ignore or under estimate this impact of science and try to bring active and living correlation between science and social studies. On the other hand, the science teacher should also emphasis to his students how faith and beliefs are being shattered and conception of man, God, and life are changing.

6. **Science and craft:** Correlation between the science department and department of Work Experience or SUPW of a school can result in a good deal of improvisation and construction of useful science apparatus. Students can construct a piece of apparatus and models of scientific interest during craft period. The making of useful and serviceable model of scientific interest by a student has a lot of educational value.

7. **Science and Art:**

   1. A good drawing in the biology is impossible unless the student get a good deal of practice in art lesson.
   2. By learning to draw plants and animals, students can learn not only the form but the habits of these living things.
   3. Drawing in physics and chemistry though much simpler still need the knowledge of some art.
   4. Bad lettering often spoils a good drawing Lettering should be done in script. Even simple lettering requires practice.
   5. Chart and diagrams to be displayed in the laboratory should be of more permanent nature.

8. **Science and Music:** The knowledge of resonance, vibrating system in string s and air column, reverberation, music scales etc. can be very helpful to the students of music The production and reproduction of sound, the gramophone, sound films, tape recorders and other phonetic instruments are all based on the principle of science.

Self Check exercise-2

Q-1: How will you correlate science with mathematics?

Q-2: The continuous and comprehensive evaluation in science means:

a) Summative and formative evaluation

b) More frequent test and examination

c) Routine activities and exercises to assess

d) Evaluation of all aspects of science

Q-**3**: The first step of scientific method is:

a) Forming a hypothesis

b) Making an observation

c) Conducting an experiment

d) Predicting the result of experiment

Q-4 Science and social studies are very much inter- dependent. **True/False**

Q-**5** Mathematics is probably the sole language of …….

2.4 Summary:

The teacher of social studies should not ignore or under estimate this impact of science and try to bring active and living correlation between science and social studies. On the other hand, the science teacher should also emphasis to his students how faith and beliefs are being shattered and conception of man, God, and life are changing.

It cannot be denied that there is some truth in the above criticism. But we cannot now go back to the old days. We should have all the comforts and conveniences, and we should try to improve upon them. But we must try to be masters of scientific appliances and not their slaves. We should make use of machines, but our life must not be mechanized. The broadest concept of science and society relates the achievements of science to human welfare and to human values, blending and integrating in disciplines. This couples science to operational applications within our society by using its concepts to attack persistent problems of human experience and stressing its potential for improving the "quality of living". It is useful to mention events in the world history which coincide with important scientific discoveries. Certain important discoveries and inventions took place in the reign of certain famous kings who patronized the scientists.

2.5 Glossary:

Improvisation: The art of composing, uttering, executing, or arranging anything without previous preparation.

Self-expression: The expression of one's feeling, thoughts, or ideas, especially in writing, art, music, ordnance.

Cinematography: The art, technique, or science of filmmaking, which includes the process of shooting and the development of a film.

2.6 Answers to Self-Check Exercise:

Self-Check Exercise-1

Ans-1: The Science has introduced us to new ways of thinking and reasoning Scientific knowledge helps to sharpen our intellect & promotes intellectual honesty The science education can develop the positive attitudes like open mindedness such positive is helpful to an individual to understand, evaluate and solve many problems faced in life.

Self-Check Exercise-2

Ans-1: Mathematics is probably the sole language of science and therefore a real understanding of science is impossible without adequate knowledge of mathematics Algebraic equation, graphs, geometry, co-ordinate geometry, calculus, simple statics are some of the useful tools of science. Science and mathematics teachers should co-operate in the consideration of such matters as following;

a. Can scientific data be used for illustrating mathematical problems?

b. Can exercise on measurements, finding volume, area be transferred to mathematics side?

c. Can mathematics teacher teach and give practice in certain mathematical operation before science teacher use it in the class?

Ans-2 Routine activities and exercises to assess

Ans-3 Making an observation

Ans-4 True

Ans-5 Science

2.7 References and Suggested Readings:

- Das R.C. (1989) Science Teaching in Schools, New Delhi: Sterling Publishers.
- Kohli, V.K. (1998) How to Teach Science, Ambala Vivek Publishers.
- Kumar, Amit (2002) of Physical Sciences, New Delhi: Anmol Publications.
- Mangal. S.K. (1997) Teaching of Science, New Delhi: Arya Book Depot.
- Mohan, Radha (2002) Innovative Physical Science Teaching Methods. New Delhi: P.H.I.

2.8 Terminal Questions:

1. Science has always responded to the needs of society. Comment.
2. How will you correlate science with other subjects?
3. Science helps in bringing all countries together. Justify this statement.
4. Discuss in detail the place of science in school curriculum.

5. What is the importance of science in our daily life?

Unit-3

AIMS AND OBJECTIVES OF TEACHING SCIENCES, TAXONOMY OF EDUCATIONAL OBJECTIVES

Structure:

3.1 Introduction

3.2 Learning Objectives

3.3 Aims as Objectives of teaching Science

Self Check Exercise-1

3.4 Meaning of the learning objectives

Self Check Exercise-2

3.5 Taxonomy of the educational objectives

Self Check Exercise-3

3.6 Summary

3.7 Glossary

3.8 Answers to Self-Check Exercise

3.9 References and suggested readings

3.10 Terminal Questions

3.1 Introduction

Bloom identified six levels within the cognitive domain, from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which is classified as evaluation.The objectives of science teaching have gone under a tremendous change during the course of last few decades. The subject of science has acquired its place as an independent subject a few years ago only. The development of science and technology and their expansion have influenced the educational objectives. According to the NCERT in its Evaluation and Examination Score towards which action is taken, it is that systematic change which is realized by activity for which we all work. Objective is that final point of educational process whose realization is achieved by planned activities of teaching. Objectives are determined by from psychological and philosophical point of view. These Objectives are realized by the teaching of different subjects in school. Teaching objectives curriculum and methods are selected on the basis of subject Objectives are of great importance in class teaching. Educational objectives are achieved by teaching of a subject. Educational objectives keep changing as per the needs of life philosophy, country and community.

3.2 Learning Objectives:

After studying this chapter, the students will be able to:

- Know about the Aims as Objectives of teaching Science
- Meaning of the learning objectives
- Taxonomy of the learning objective

3.3 Aims as Objectives of teaching Science:

Generally, the term 'aims and objectives' are used synonymously where as in reality there is a lot of difference in the two terms.

AIM is general declaration of intent which gives direction to a teaching program OBJECTIVE is small objective, helps required in achieving a specific aim which makes the study of sciences more useful and helps in bringing about the desired behavioral changes in the students. The following table helps in making these differences clear/evident.

Difference between aims and objectives

Sl.	**Aims**	**Objectives**
1.	Aim is a general declaration of intent which gives direction to a teaching program.	Objective is a particular point in that direction.
2.	Aim is the answer to the question of why a subject is taught.	It is an answer to the question of what will be achieved after the teaching of that topic.
3.	They are indefinite and vague.	They are generally definite and clear.
4.	These are close to the ideals which cannot be fully achieved.	They can be achieved.
5.	School, society and nation are responsible for their fulfillment.	Mostly the teacher is responsible for their fulfillment.
6.	A lot of time is taken for their achievement.	Time is not much. The achievement of objectives can be verified along with the teaching of the lesson or after the completion of the lesion.

We teach science for the Knowledge and understanding of science, nurturance of the process skills, development of scientific attitude and scientific temper, nurturance of the natural curiosity, creativity and aesthetic sense, imbibing values, developing

problem- solving skills, and relating physical science education with natural and social environment, technology and society. Many of the above aims are common to all educational processes. It has also been emphasized+ that achieving aims of physical science should be a continuous effort of the teachers.

The aims of science teaching are discussed as below:

1. To provide practical knowledge of the subject matter/content.
2. To provide the latest knowledge.
3. To provide the broad objectives of sciences i.e. skill, knowledge, interest appreciation, application and understanding etc.
4. To provide fundamental skills and processes for proper understanding of the subject matter.
5. To give students broad genuine appreciation of what development of sciences means to modern life.
6. To satisfy the natural interest in things and forces of nature with which men are surrounded.
7. To contribute specific ideals like concepts of accuracy, truthfulness, honesty, open mindedness, ordered system, neatness and accuracy to etc.
8. To stimulate spirit of study, investigation and invention.
9. To educate them regarding the application of science in their social and physical environment.
10. To develop their observation capacity.
11. To encourage them to read the life stories of great scientists.
12. To develop the capacity to solve day to day problem.
13. To develop economic efficiencies.
14. To develop scientific attitude, scientific appreciation and scientific temper among students.

The objectives of science teaching are to affect all-round development of a student in order to make him an efficient and able citizen. This wide objective of science teaching directs class teaching. A student's behavior is changed suitably by class teaching. Therefore, an objective of science teaching is to effect behavioral change in a student. The objectives of science teaching have gone under a tremendous change during the course of last few decades. The subject of science has acquired its place as an independent subject a few years ago only. The development of science and technology and their expansion have influenced the educational objectives. In the beginning, emphasis was laid on the knowledge of facts. Gradually attention was paid towards planning and generalization. In the third and fourth decade of the nineteenth

century, a science committee was appointed to determine teaching objectives of science, which in its report attached importance to practical and experimental aspect of science. A revolutionary change occurred in the objectives of science teaching after the Second World War. Besides knowledge of scientific facts and theories, importance now came to be given to scientific attitude, experimental work and problem solving. The main objectives of science teaching are given as below:

- Know the facts and principles of physical science and its applications, consistent with the stage of cognitive development.
- acquire the skills and understand the methods and processes that lead to generation and validation of scientific knowledge,
- develop a historical and developmental perspective of physical science and to enable her to view physical science as a social enterprise,
- Relate to the environment (natural environment, artifacts and people), local as well as global, and appreciate the issues at the interface of physical science, technology and society.
- acquire the requisite theoretical knowledge and practical technological skills to enter the world of work
- Nurture the natural curiosity, aesthetic sense and creativity in science and technology.
- imbibe the values of honesty, integrity, cooperation, concern for life and preservation of environment, and
- Cultivate scientific temper objectivity, critical thinking and freedom from fear and prejudice.

Self Check Exercise-1

Q-1: What do you mean by the term aim?

Q-2: What is the main objective of science teaching?

3.4 MEANING OF LEARNING OBJECTIVES

Teachers are entrusted with the responsibility to provide learning experiences and opportunity to each learner, so that the learner can learn to the best of her ability and develop her full potential of learning Identifying certain perceptible changes in terms of remembering, understanding, applying and analyzing, etc. that need to be brought out in the learner before transacting a particular topic/unit in the class helps a teacher to discharge this responsibility. These desirable strands of remembering, understanding. applying and analyzing for a particular topic/unit in terms of perceived learning are broadly known as learning objectives This desirability should be viewed from the perspective of the existing knowledge and background of the learners, not of the teachers.

In other learning objectives are the statements in specific and observable term that tell what the learner is expected to achieve as a result of engaging her in teaching-

learning process. For example, writing three properties of vector product mathematically.

Learning objectives of physical science should be consistent with the aims of physical as well as cognitive abilities of the learners. Obvious all the scientific facts principles and theories of science cannot be learnt by all learners and there may be a qualitative hierarchy in different aspects of learning of a particular learner. For example, a learner may be very good in experimental skills, but not so in solving numerical problems. You have to keep in mind the nature of science in general and the topic in particular, the scope of the content to be transacted to the learners, the context in which learning is taking place and needs, abilities and learning difficulties of the learner.

Understanding how to develop learning objectives will help you to structure teaching-learning and assessment processes and optimize learning. Furthermore, classifying the objectives will help you to focus on various aspects of student's learning in their knowledge and cognitive process dimension about which we shall discuss in the next section. Learning objectives should be aligned with three major components of teaching-learning process the objective, assessment and teaching learning activities. Whether the objectives are realized or not is known by assessment of learners. Accordingly teaching-learning activities are modified to realize the objectives. Thus, the three components are consistent with each other If three components are congruent, teaching-learning is meaningful.

3.5 TAXONOMY OF EDUCATIONAL OBJECTIVES

Learning Taxonomy - Bloom's Cognitive Domain

"Bloom's Taxonomy is designed to be a classification of the student behaviors which represent the intended outcomes of the educational process. It is assumed that essentially the same classes of behavior may be observed in the usual range of subject-matter content of different levels of education (elementary, high school, college), and in different schools. Thus, a single set of classification should be applicable in all these circumstances.

What we are classifying is the intended behaviors of students the ways in which individuals are to think, act or feel, as a result of participating in some unit of instruction. (Only such of those intended behaviors as are related to mental acts of thinking are included in the part of the Taxonomy developed in the handbook for the cognitive domain).

It is recognized that the actual behaviors of the students after they have completed the unit of instruction may differ in degree as well as kind from the intended behavior specified by the objectives That is the effects of instruction may be such that the students do not learn a given skill to any degree.

We initially limited ourselves to those objectives referred to as knowledge, intellectual abilities, and intellectual skills. (This area, which we named the cognitive domain, may also be described as including the behavior, remembering, reasoning, problem solving. concept formation, and to a limited extent creative thinking)"

Bloom identified six levels within the cognitive domain, from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which is classified as evaluation.

Self Check Exercise-2

Q-1: Discuss the main function of Blooms taxonomy.

Cognitive learning is demonstrated by knowledge recall and the intellectual skills comprehending information, organizing ideas, analyzing and synthesizing data, applying knowledge, choosing among alternatives in problem-solving, and evaluating ideas or actions		
Level and Definition Illustrative	**Verbs**	**Example**
Knowledge is defined as the remembering of previously learned material. This may involve the recall of a wide range material, from specific facts to complete theories, but all that is required is for the student to bring to mind the appropriate information. Knowledge represents the lowest level of learning outcomes in the cognitive domain.	arrange, describe, duplicate, identify, label, list, match, memorize, name, order, outline, recognize, relate, recall, repeat, reproduce, select, state	Memory of specific facts, terminology, rules, sequences, procedures, classifications, categories, criteria, methodology, principles, theories and structure. Recite a policy. Quote prices from memory to a customer. Know the safety rules. Describe the painting.
Comprehension is defined as the ability to grasp the meaning of material. This may be shown by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing) and by estimating future trends (predicting consequences or effects). These learning outcomes go one step beyond the simple remembering of material, and represent the lowest level of understanding.	classify, convert, defend, describe, discuss, distinguish, estimate, explain, express, extend, generalize, give examples, identify, indicate, infer, locate, paraphrase, predict, recognize, rewrite, report, restate, review, select, summarize, translate	Stating problem in own words. Translating a chemical formula. Understanding a flow chart. Translating words and phrases from a foreign language. Explains in one's own words the steps for performing a complex task. What is the subject or theme?

Application refers to the ability to use learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws, and theories. Learning outcomes in this area require a higher level of understanding than those under comprehension.	apply, change, choose, compute, demonstrate, discover, dramatize, employ, illustrate, interpret, manipulate, modify, operate, practice, predict, prepare, produce, relate, schedule, show, sketch, solve, use, write	Taking principles learned in math and applying them to figuring the volume of a cylinder in an internal combustion engine. Use a calculate manual to an employee's vacation time. If you could interview the artist, what questions would you ask?
Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of the parts, analysis of the relationships between parts, and recognition of the organizational principles involved. Learning outcomes here represent a higher intellectual level than comprehension and application because they require an understanding of both the content and the structural form of the material.	analyze, appraise, break down, calculate, categorize, compare, contrast, diagram, differentiate, discriminate, distinguish, examine, experiment, identify, illustrate, infer, model, outline, point out, question, relate, select, separate, subdivide, test	Discussing how fluids and liquids differ. Detecting logical fallacies in a student's explanation of Newton's 1st law of motion. Recognize logical fallacies in reasoning. Gathers information from department a and selects the required tasks for training. Explain what you think the artist is trying to say about the subject matter.
Synthesis refers to the ability to put parts together to form a new whole. This may involve the production of a unique communication (theme or speech), a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information). Learning outcomes in this	arrange, assemble, categorize, collect, combine, comply, compose, construct, create, design, develop, devise, design, explain, formulate, generate, integrate, manage, modify, organize, plan, prepare, propose, rearrange, reconstruct,	Writing a comprehensive report on a problem-solving exercise. Planning a program or panel discussion. Writing a comprehensive term paper. Integrates training from several sources to solve a problem. What ways would you render the subject differently?

area stress creative behaviors, with major emphasis on the formulation of new patterns of structures. Integrate.	rearrange, reconstruct, relate, reorganize, revise, rewrite, set up, summarize, synthesize, tell, write	
Valuation is concerned with the ability to judge the value of material (statement, novel, poem, research report) for a given purpose. The judgments are to be based on definite criteria. These may be internal criteria (organization) or external criteria (relevance to the purpose), and the student may determine the criteria or be given them. Learning outcomes in this area are highest in the cognitive hierarchy because they contain elements of all of the other categories, plus conscious value judgments based clearly defined on criteria.	appraise, argue, assess, attach, choose, compare, conclude, contrast, defend, describe, discriminate, estimate, evaluate, explain, judge, justify, interpret, relate, predict, rate, select, summarize, support, value	Making judgments based on internal evidence or external criteria. Evaluating alternative solutions to a problem. Detecting inconsistencies in the speech of a student government representative. Explain and justify a new budget. Hire the most qualified candidate. What is your opinion of the painting? Why?

Self -Check Exercise-3

Q-1 Which option is false in reference to Bloom's taxonomy?

a) It deals with the classification of learning objectives within education

b) It was published in 1966 AD.

c) It contributes the children's mental development

d) It was named after Benjamin Bloom, the education psychologist

Q-2 Which of the following is not an affective domain?

a) Receiving

b) Analyzing

c) Valuing

d) Organizing

Q-3 "Bloom's Taxonomy is designed to be a classification of the student behaviors which represent the intended outcomes of the educational process. **True/False**

Q-4 Bloom identified …. Levels within the cognitive domain.

3.6 Summary:

A student's behavior is changed suitably by class teaching. Therefore, an objective of science teaching is to effect behavioral change in a student. The objectives of science teaching have gone under a tremendous change during the course of last few decades. The subject of science has acquired its place as an independent subject a few years ago only. The development of science and technology and their expansion have influenced the educational objectives. In the beginning, emphasis was laid on the knowledge of facts. As a result of scientific and technological development, extensive change has occurred in the objectives of science teaching. Now, together with the attainment of knowledge, importance is also attached to concepts, abilities, aptitudes and skill development in science teaching Whatever may be the aims of teaching science (as they change with requirements of time) the basis of their formation should be child, society and subject matter Apart from these aims discussed, the most important function of science education should be development of all dimensions of child's and this can only be possible if we shift our focus from acquisition of knowledge to development of scientific attitude, reflective thinking, skills, desirable habits, interest in scientific literature and impact of subject on their daily life, provide work for leisure, training for better living, providing opportunities and facilities for specialization for vocation etc. Learning objectives of physical science should be consistent with the aims of physical as well as cognitive abilities of the learners. Obvious all the scientific facts principles and theories of science cannot be learnt by all learners and there may be a qualitative hierarchy in different aspects of learning of a particular learner. For example, a learner may be very good in experimental skills, but not so in solving numerical problems.

3.7 Glossary:

Objective: A form of category by which we can make a desired change in the behaviour of students

Comprehension: An exercise that tests how well you understand spoken or written language

Methodology: A way of doing something based on particular principles and methods

Nurturance: Emotional and physical nourishment and care given to someone

3.8 Answers to Self-Check Exercise:

Self-Check Exercise-1

Ans-1: AIM is general declaration of intent which gives direction to a teaching program OBJECTIVE is small objective, helps required in achieving a specific aim which makes the study of sciences more useful and helps in bringing about the desired behavioral

changes in the students. The following table helps in making these differences clear/evident.

Ans-2: The objectives of science teaching are to affect all-round development of a student in order to make him an efficient and able citizen. This wide objective of science teaching directs class teaching. A student's behavior is changed suitably by class teaching. Therefore, an objective of science teaching is to effect behavioral change in a student. The objectives of science teaching have gone under a tremendous change during the course of last few decades.

Self-Check Exercise-2

Ans-1: Bloom's Taxonomy is mainly designed to be a classification of the student behaviors which represent the intended outcomes of the educational process. It is assumed that essentially the same classes of behavior may be observed in the usual range of subject-matter content of different levels of education (elementary, high school, college), and in different schools.

Self-Check Exercise-3

Ans-1 It was published in 1966 AD.

Ans-2 Analyzing

Ans-3 True

Ans-4 Six

3.9 References and suggested readings:

Mangal S. K. , Teaching of Physical Sciences

Bhatnagar AB, Teaching of Science

Kulshrestha S.P. Gaya Singh, Teaching of Science Ahmann, J.S and Glock. M.D.

3.10 Terminal Questions:

1. What are the objectives of science teaching at secondary level?
2. Describe the objectives of science teaching on the basis of Bloom's taxonomy.
3. What are the objectives of science teaching? What do you understand by specific behavioral objectives? Write them separately.
4. Analyze the objectives of science teaching at high school level. How far can they be realized?
5. What is the between aims and objectives?

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Unit-4

FORMULATION OF THE EDUCATIONAL OBJECTIVES

Structure:

4.1 Introduction

4.2 Learning Objectives

4.3 Formulation of the educational objectives

Self-Check-Exercise-1

4.4 Summary

4.5 Glossary

4.6 Answers to Self-Check Exercise

4.7 References and suggested readings

4.8 Terminal Questions

4.1 Introduction

The objectives of science teaching are to affect all-round development of a student in order to make him an efficient and able citizen. This wide objective of science teaching directs class teaching. A student's behavior is changed suitably by class teaching. Therefore, an objective of science teaching is to effect behavioral change in a student. The objectives of science teaching have gone under a tremendous change during the course of last few decades. The subject of science has acquired its place as an independent subject a few years ago only. According to the NCERT in its Evaluation and Examination Score towards which action is taken, it is that systematic change which is realized by activity for which we all work. Objective is that final point of educational process whose realization is achieved by planned activities of teaching. Objectives are determined by from psychological and philosophical point of view. These Objectives are realized by the teaching of different subjects in school. Teaching objectives curriculum and methods are selected on the basis of subject Objectives are of great importance in class teaching. Educational objectives are achieved by teaching of a subject. Educational objectives keep changing as per the needs of life philosophy, country and community. Learning objectives of physical science should be consistent with the aims of physical as well as cognitive abilities of the learners. Obvious all the scientific facts principles and theories of science cannot be learnt by all learners and there may be a qualitative hierarchy in different aspects of learning of a particular learner. For example, a learner may be very good in experimental skills, but not so in solving numerical problems.

4.2 Learning Objectives:

After studying this chapter, the students will be able to Know about:

- Formulation of instructional objectives

4.3 FORMULATION OF INSTRUCTIONAL OBJECTIVES

Benjamin S. Bloom has divided the cognitive objectives into six categories. But instructional objectives are related to classroom objectives. We will see them one by one.

(A) Classroom Instructional Objectives: -

1. The pupil acquires knowledge of scientific facts, terms, concepts, principles, theories. Specifications: -

i) The pupil recalls.....

a) The facts, terminology.

b) The definition of various laws, principles.

c) The names of different parts of flower, leaf, plants.

d) The concept of classification of substances.

e) The names of types of diseases.

ii) The pupil lists all the elements on the periodic table.

iii) The pupil recognizes.....

a) Different apparatus used in various experiments.

2. The pupil develops an understanding of various scientific terms, facts, definitions, concepts, laws, theories, procedures, etc.

Specifications: -

i) The pupil sees a relationship between different facts, concepts i.e., mass and volume.

ii) The pupil cites examples of metals and metalloids.

iii) The pupil classifies plant kingdom and animal kingdom.

iv) The pupil selects appropriate for performing experiment.

v) The pupil compares the characteristic of metals, non-metals etc.

vi) The pupil defects errors in a given example.

vii) The pupil rectifies errors in a given statement, diagram, formula, example etc.

viii) The pupil verifies the answer by substituting the values in a given problem or equation.

ix) The pupil uses an appropriate method to solve a problem, to do titration.

x) Pupil cites illustrations of different types of chemical equations.

3. The pupil applies his knowledge and understanding in new and unfamiliar situation. Specifications: -

i) The pupil analyses the given example into what in given and what to be found out.

ii) The pupil formulates hypothesis to organize the elements.

iii) The pupil collects relevant data related to a hypothesis.

iv) The pupil selects relevant data, i.e., facts and principles for a particular situation e.g., Relationship among different group elements.

v) The pupil judges the adequacy of data or procedure or apparatus e.g., to check laws of reflection, refraction, etc.

vi) The pupil suggests new illustrations for different of lenses, propagation of lights etc.

vii) The pupil predicts various applicability of laws.

viii) The pupil solves the problems on velocity, momentum, etc.

ix) The pupil interprets various graphs, charts etc.

x) The pupil translates statements into symbols.

4. The pupil develops the skills required for science learning.

Specifications: -

i) The pupil checks the feasibility on instruments before using them.

ii) The pupil rectifies the defects in the instruments e.g. the presence of air bubble in the burette during titration.

iii) The pupil sets up appropriate apparatus for perform different experiment.

iv) The pupil measures with reasonable accuracy the length of pendulum and period of oscillations.

v) The pupil reads the log table, mathematical symbol, and different tables.

vi) The pupil records the observation accurately and neatly.

vii) The pupil makes accurate observations while reading graphs, tables etc.

viii) The pupil uses the relevant data to reach at a solution.

ix) The pupil draws conclusions.

x) The pupil summarizes observations after the experiment.

B) Personality Objectives

5. The pupil develops interest in science.

Specifications: -

i) The pupil reads, on his own, a number of books, magazines, newspapers related to scientific information.

ii) The pupil visits places of scientific importance and interest e.g., planetarium, laboratories, science center's etc.

iii) The pupil participates in activities like debates, projects, talks, elocution, in or out side school.

iv) The pupil collects, picture, specimens, data, of scientific importance from books, journals, gardens etc.

v) The pupil prepares models, charts, pictures etc.

vi) Contributes exhibits censuring scientific facts for display in or outside schools.

vii) The pupil writes articles, news items related to scientific concepts.

viii) The pupil prefers to attend to programme related to science on TV, Radio, etc.

ix) The pupil meets scientist astronauts etc.

x) The pupil helps in maintenance of a science laboratory, science club, museum, herbarium etc.

6. The pupil develops positive scientific attitude.

Specifications:

i) Pupil respects research finding or new approaches contrary to existing theory.

ii) The pupil accepts those conclusions based on logical reasoning.

iii) The pupil expresses his ideas in a logical sequence.

iv) The pupil arrives at a judgment after weighing all possible evidence carefully.

v) The pupil considers new ideas, discoveries, and inventions free from prejudice.

vi) The pupil reconsiders his own judgments and beliefs in the light of new knowledge and theories.

vii) The pupil cooperates with others in arranging scientific, models, charts, materials, etc in proper places.

viii) The pupil faces problems with full confidence.

7. The pupil appreciates the contribution of science in every walk of life and knowledge.

Specifications: -

i) The pupil expresses his appreciation of man's effort to conquer nature and natural forces.

ii) The pupil recognizes the contribution of scientists to the modern world.

iii) The pupil derives a sense of pleasure in understanding the achievement of science e.g., God particle, travel to space, satellites etc.

Self-Check-Exercise-1

Q-1 According to blooms taxonomy of educational objectives, the lowest level of cognitive domain is:

a) Analysis

b) Evaluation

c Comprehension

d Knowledge

Q-2 The question, how would you prove that the earth is round and not round? is based on ……. objective**.**

a) Comprehension

b) Evaluation

c) Application

d) Synthesis

Q-3 Instructional objectives are related to classroom objectives.

Q-4 An objective of science teaching is to effect behavioral change in a student.

True/False

4.4 Summary:

We initially limited ourselves to those objectives referred to as knowledge, intellectual abilities, and intellectual skills. (This area, which we named the cognitive domain, may also be described as including the behavior, remembering, reasoning, problem solving. concept formation, and to a limited extent creative thinking)". Furthermore, classifying the objectives will help you to focus on various aspects of student's learning in their knowledge and cognitive process dimension about which we shall discuss in the next section. Learning objectives should be aligned with three major components of teaching-learning process the objective, assessment and teaching learning activities. Whether the objectives are realized or not is known by assessment of learners. Accordingly teaching-learning activities are modified to realize the objectives. Whatever may be the aims of teaching science (as they change with requirements of

time) the basis of their formation should be child, society and subject matter Apart from these aims discussed, the most important function of science education should be development of all dimensions of child's and this can only be possible if we shift our focus from acquisition of knowledge to development of scientific attitude, reflective thinking, skills, desirable habits, interest in scientific literature and impact of subject on their daily life, provide work for leisure, training for better living, providing opportunities and facilities for specialization for vocation etc.

4.5 Glossary:

Logical: Seeming natural, reasonable or sensible

Hypothesis: Tentative solution of the problem

Creative thinking: It is the characteristics of someone or some process that forms something new and valuable

4.6 Answers to Self-Check Exerciser:

Ans-1 Knowledge

Ans-2 Evaluation

Ans-3 True

Ans-4 True

4.7 References and suggested readings:

Mangal S. K. , Teaching of Physical Sciences

Bhatnagar AB, Teaching of Science

Kulshrestha S.P. Gaya Singh, Teaching of Science Ahmann, J.S and Glock. M.D.

4.8 Terminal Questions:

1. What are the objectives of science teaching? What do you understand by specific behavioural objectives? Write them separately.
2. Analyze the objectives of science teaching at high school level. How far can they be realized?

Unit -5

Curriculum

Meaning of science curriculum, Principle of Curriculum Construction

Structure:

5.1 Introduction

5.2 Learning Objectives

5.3 Meaning of science curriculum

Self Check Exercise-1

5.4 Principle of Curriculum Construction

1.4.1 Aims of education and objectivity

1.4.2 Child-centric principle

1.4.3 Principles of civic and social needs

1.4.4 Principle of conservation and providing proper inspiration

1.4.5 Principles of creativeness and activity centeredness

1.4.6 Principle of forward-looking

1.4.7 Principle of preparation for living

1.4.8 Principle of integration and correlation

1.4.9 Principle of developing scientific attitude

1.4.10 Principle of individual difference

1.4.11 Principle of social relevancy and utility

1.4.12 Principle for utilization of leisure

1.4.13 Principle of variety and flexibility

Self-Check Exercise-2

5.5 Summary

5.6 Glossary

5.7 Answers to Self-Check Exercise

5.8 References and Suggested Reading

5.9 Terminal Questions

5.1 Introduction:

Before starting to think about the science curriculum it becomes necessary to know about the meaning of the term curriculum. Curriculum includes the totality of experiences that a child receives through the numerous activities that go on in the classroom, library, laboratory, workshop, assembly hall, science club, play field and in the manifold informal contacts between the teacher and students. In a way the whole life of the school becomes curriculum which can touch the life of students at all points and help in the development of balanced personality, Science curriculum is sum total of activities performed in the school to develop balanced personality. It becomes important to think how to develop a balanced personality of the students. Science is one of the school subjects which can develop the scientific temper and develops balanced personality of the students because of the following essential values. Curriculum has been regarded as a means to achieve the set goals. In context to physical sciences it may be regarded all what is to be given or acquired by the child in the form of specific learning experiences for achieving the aims and objectives of physical science teaching. The learning experiences imparted or gained by the child in the subject physical sciences need to be quite diversified and varied and talking and listening in the classroom. As a result by the term physical sciences curriculum, we mean all those learning experience that are received by a child through a number of activities going on inside the school or outside the school in the form of formal or informal education for the realization of the set goals and objectives of leaching physical sciences.

5.2 Learning Objectives:

After studying this chapter, the students will be able to know about:

- Meaning of science curriculum
- Principles of curriculum construction

5.3 Meaning of Science Curriculum:

Curriculum etymologically the term has been derived from a Latin word which stands for a 'course to' run. A renowned educationist Cunningham has defined it in the following words, "The curriculum is the tool in the hands of the artist to mould his material (the pupils) according to his ideals (objectives) in his studio (the school). In every sense, therefore, curriculum should stand for all those experiences that can be included in the study of a particular subject which are thought to be essential for the realization of the set goals or objectives of that study. Secondary Education Commission stated that curriculum does not mean only academic subjects traditionally taught in school, but it includes totality of experiences that a pupil receives through the numerous activities that go on in the school, classroom, library, laboratory, workshop and playground and in the manifold informal contacts between the teachers and the pupils Curriculum is an important element of education, aims of education are reflected in the curriculum. In other words, the curriculum is determined by the aims of life and society. Aims of life and society are subject to constant change.

Hence, the aims of education are also subject to change and dynamic The aims of education are attained by the school programmes, concerning knowledge,

experiences, activities, skills and values. The different school programmes are jointly known as curriculum Traditional concept-The traditional curriculum was subject-centred while the modern curriculum is child and life-centred From now on, the physical science teacher is expected to play a more important role. He is emphasized to use educational technology for more effective learning. He is also to include values while teaching physical science values like truth, cleanliness, trust, respect, love, nonviolence, right conduct and peace. If these values inculcated among students along with scientific temper, will make them better human beings and citizens. The teacher is now guided for more objective evaluation. He is supposed to be more accountable to prepare students for twenty-first century. Some of the definitions of curriculum are given as below.

Froebel - "Curriculum should be conceived as an epitome of the rounded whole of the knowledge and experience of the human race."

Crow and Crow - The curriculum includes all the learners' experience in or outside school that are included in a programme which has been devised to help him developmentally, emotionally, socially, spiritually and morally".

T.P. Nunn-The curriculum should be viewed as various forms of activities that are grand expressions of human spirit and that are of the greatest and most permanent significance to the wide world".

Self Check Exercise-1

Q-1: Discuss the term curriculum.

5.4 Principle of Curriculum Construction:

In case when we talk about the construction and organization of the curriculum in the subject physical sciences we usually mean to think about the type of learning experiences to be given to the child at the various age and grade levels for the realization of the set goals at that particular age and grade level Naturally, it will need a systematic and sequential planning as to widen the sphere of learning experiences at each level by keeping in view the principle of integration and correlation. How it can be done and what principles are to be followed for this purpose can be understood through the following discussion. The content of curriculum is determined on the basis of some academic principles which are stated below:

5.4.1 Aims of education and objectivity

Life is complex A curriculum should reflect the complexities of life in other words, in farming the curriculum one should take into consideration the aims and objectives of education.

5.4.2 Child-centric principle

What is to be given to the children in the form of learning experiences at a particular age and grade level should suit properly their age and mental level development. The intelligence and the mental functioning of the children grow with their age and so their capacity of understanding and grasp. Therefore, it will be in the fitness of things if their courses or content of study in any subject should be framed to suit their ability. Nothing should be taught to them which may float above their heads. The curriculum should be framed according to the actual needs, interests and capacities of

the child. That means a curriculum must be child-centric as modern education is child-centred.

5.4.3 Principles of civic and social needs:

Man is a social being. He lives in the society. The child develops in the society. Modern education aims at both developments of the individuality of the child as well as the development of the society.

5.4.4 Principle of conservation and providing proper inspiration:

Man has conserved experiences very carefully for better adaptability. Education is regarded as a means of deserving the cultural heritage of humanity. The school serves two-fold functions in this regard preservation of the past experiences and transmission of experiences. Physical science education must place to such learning experiences which may prove helpful in providing due inspiration to the children. For this purpose, it may have biographies and life history of great scientists and developmental history or the scientific inventions and discoveries. With the provision of science clubs and other co-curricular activities a physical science may also provide proper opportunity to the students of getting inspiration and stepping in to the foot prints of the great inventors and discoveries.

5.4.5 Principles of creativeness and activity centeredness:

Children are very active in nature. They take interest in the things and events related with the playful activities. They enjoy the participation in the activities and experiences where they find opportunity for self-doing like manipulation of the objects with their own hands and exploring or discovering the things with their own sense organs. Therefore, attempts should be made to include such learning experiences in the science curriculum which may provide children sufficient opportunity for self-doing in the form of independent observation, experimentation and improvisation etc. However, the level of such experiences should always vary according to the needs of the age group and environmental circumstances of the children.

Education not only conserves that past experiences of humanity but also helps an individual to develop his innate potentialities.

5.4.6 Principle of forward-looking

The aim of life-centred education is not limited to the present life-situations in the family and society. Hence, education must prepare the child of shouldering future responsibilities. So in farming the curriculum we must take into consideration the future needs of the child as well as the needs of the society.

5.4.7 Principle of preparation for living:

The children should know the various activities of the environment around them and how these activities are people to meet their basic needs of food, shelter, clothing, recreation, health and education. The content of learning experience for children should be linked with the needs of environment in which they live. The children for rural areas can understand and grasp easily the information which is directly connected with their experience in their own rural environment. In the same way the children of urban areas can understand things in a better and easy way which are connected with modern

inventions and development. Similarly, the contents of the learning experiences for children belonging to hilly areas, deserted places, and sea beaches should be located with the things and events related to these places.

5.4.8 Principle of integration and correlation:

Subjects should be arranged logically and psychologically in accordance with the child's developing interests. It is a natural law that children will be able to learn better in which they have special taste and inclination of mind. Such things they can retain in their memory for a long time as well. It is also found that at different stage of age group, children have different interest patterns. Besides that there comes a change in their interests according to change in the circumstances and situations. Therefore the learning experiences should be designed as to suit the interest and tastes of the age group of the children. It should be carefully observed that the learning experience in science at different levels should be essentially correlated with the learning experiences of other subjects of the school curriculum. All the subjects of the school curriculum through their respective learning experiences are to attain the same goal i.e. the realization of the aims of education. Therefore what is included in the learning experiences of the physical science curriculum should have a direct or indirect relationship with the curricular contents of the other subjects taught at a particular grade or level.

5.4.9 Principle of developing scientific attitude:

Development of scientific attitude is one of the major objectives of physical science education. Therefore the learning experiences included in the science curriculum should essentially serve this purpose as effectively as possible. We must include in it such topic curricular or extracurricular experiences which may help the children to give up the false beliefs and superstitions, and picking up the habits of open mindedness, critical observation, independent thinking, scientific method of attacking the problem etc, essential for the development of a proper scientific attitude among them.

5.4.10 Principle of individual difference:

The curriculum should be framed in such a way that every individual can have opportunity for self-expression and development. The curriculum should be based on the psychology of individual difference, which can meet the complexities of modern democratic society.

5.4.11 Principle of social relevancy and utility:

Subjects should not be determined on the basis of their disciplinary value but on the basis of their intrinsic value, social relevancy and utility.

5.4.12 Principle for utilization of leisure:

Variety of subjects such as games and sports, fine arts, subjects of aesthetic value are to be introduced in the school programme to utilize leisure. Relative significance and importance of each subject in the curriculum has to be judged and determined in the light of the time available in the timetable, which is regarded as the mirror of the school programme.

5.4.13 Principle of variety and flexibility:

The curriculum should include such activities and experiences, which may facilitate his normal development. The curriculum for girls should naturally be different from that of boys and girls have different needs and attitudes. Instead of being rigid the physical science curriculum should show signs of flexibility and dynamicity. With the lapse of time and other factors, the changes in the social set up and environmental surroundings are bound to appear and in case science education has to cater to the needs of the society. and day to day requirements it has to be re-designed and remodeled as to suit these. changes Similarly, the content and learning experiences related with physical science education need to be varied according to the variation in the physical science and social environment, prevailing situations and circumstances and even the physical and mental level of the children belonging to a particular community, society or region. Moreover, the contents or learning experiences are to be enriched and modified in the light of the development and advancement introduced in the field of science and technology. Consequently the physical science curriculum must adopt adequate flexibility in terms of the selection as well as organization of the learning experiences.

In this way the physical science curriculum should be planned and formed in the light of the well thought principles mentioned as above. The other most important thing which should also be kept in view is the active involvement of the teacher who actually has to implement and carry out the spirit of curriculum. Therefore, it is essential to take advice and help of some of the experience holder physical science teacher for the construction and planning of physical sciences curriculum at different grade level and stages. Their practical experiences regarding the difficulties faced in physical sciences teaching and the type of learning experiences required for achieving the set objectives may certainly help in arriving at many good things regarding the framing of an appropriate curriculum.

Self-Check Exercise-2

Q-1 Curriculum in school means:

a) All the educational experiences under the school's jurisdiction
b) All the subjects offered by the school
c) All the learning experiences provided in the class
d) All the academic works undertaken in school and communities

Q-2 Area of curriculum includes:

a) Internal activities in the school
b) Both of them
e) External activities in the school

Q-3 Development of scientific attitude is one of the major objectives of physical science education. **True/False**

Q-4 "The curriculum is the tool in the hands of the artist to…… his material (the pupils) according to his ideals (objectives) in his studio (the school).

5.5 Summary:

The manner in which curriculum is delivered will be determined by the society in which is living. All of the definitions of curriculum have some commonality that will link to part of another definition. Curriculum is the information that is or will be taught. What determines or what is important to teach will be defined by status, position and politics that are evolving at the time the curriculum is planned. There has been change in the definition of curriculum since its original, but that change in definition has accommodated the change society. Overall curriculum as a definition has adapted with time but the method in which curriculum is delivered has changed. Curriculum is meant the of experiences which a student performs in and outside the classroom. To the modern concept, the curriculum is the collection of experiences, activities and real life situations. The curriculum is subject centered, examination centered but not as per objectives of science teaching. It is incapable of meeting needs of students and community, and is not related to life. It should be reconstructed on the basis of principles of curriculum construction. Now the physical science teacher is expected to play a more important role. He is emphasized to use educational technology for more effective learning. He is also expected to inculcate values while teaching science values like truth, cleanliness, trust, respect, love, non-violence, right conduct and peace. If these values inculcated among students along with scientific temper, will make them better human beings and citizens. There is a need to have objective evaluation in physical science. Some of the important things should be kept in mind at the time of the development of curriculum.

5.6 Glossary:

Intrinsic value: The anticipated or calculated value of a company, stock, currency or product determined through fundamental analysis

Etymologically: It is the scientific study of the origin and evolution of a word's semantic meaning across time, including its constituent morphemes and phone memes.

5.7 Answers to Self-Check Exercise:

Self-Check Exercis-1

Ans-1: Bloom's Taxonomy is designed to be a classification of the student behaviors which represent the intended outcomes of the educational process. It is assumed that essentially the same classes of behavior may be observed in the usual range of subject-matter content of different levels of education (elementary, high school, college), and in different schools.

Self-Check Exercis-2

Ans-1 All the educational experiences under the school's jurisdiction

Ans-2 Both of them

Ans-3 True

Ans-4 Mould

5.8 References and Suggested Reading:

- Bobbitt, J. F (1918). The curriculum. Boston: Houghton Mifflin
- Tyler, R. W (1949). Basic Principles of Curriculum and Instruction. Chicago: University of Chicago Press.
- American Psychological Association, January 18, 2006. Retrieved April 15, 2009, from http://www.psychologymatters.org/thinkagain.html
- Bloom, J. W. (2006). Background to curriculum: historical definitions. The exploring science site. Retrieved April 15, 2009, from http://elsci.coe.nau.edu/readarticle.php? article id=19
- Lekan, T. (2009) Retrieved April, 15, 2009, from http://irs.ed.uiuc.edu/students/anicke/Dewey.html
- Ornstein, A., Hunkins, F. (2004). Curriculum: foundation, principles, and issues (p2) Boston: Pearson

5.9 Terminal questions:

1. What is your definition for curriculum? How does it compare to historical definitions? Compare it to three different historical definitions.

2. What are major social influences on curriculum today? Political influences?

3. How has technology changed the way that we look at curriculum?

Unit-6

Curriculum

Meaning of Science Curriculum, Organizational Structure of Curriculum

Structure:

6.1 Introduction

6.2 Learning Objectives

6.3 Meaning of science curriculum

Self Check Exercise-1

6.4 Organizational structure of curriculum

Self Check Exercise-2

Self Check Exercise-3

6.5 Selection of content

6.6 Organization of Facts

Self Check Exercise-4

6.7 Factors affecting curriculum organization

Self-Check Exercise-5

6.8 Summary

6.9 Glossary

6.10 Answers to Self-Check Exercise

6.11 References and Suggested Reading

6.12 Terminal Questions

6.1 Introduction:

Before starting to think about the science curriculum it becomes necessary to know about the meaning of the term curriculum. Curriculum includes the totality of experiences that a child receives through the numerous activities that go on in the classroom, library, laboratory, workshop, assembly hall, science club, play field and in the manifold informal contacts between the teacher and students. In a way the whole life of the school becomes curriculum which can touch the life of students at all points and help in the development of balanced personality, Science curriculum is sum total of activities performed in the school to develop balanced personality. It becomes important to think how to develop a balanced personality of the students. Science is one of the school subjects which can develop the scientific temper and develops balanced personality of the students because of the following essential values. Curriculum has

been regarded as a means to achieve the set goals. In context to physical sciences, it may be regarded all what is to be given or acquired by the child in the form of specific learning experiences for achieving the aims and objectives of physical science teaching. The learning experiences imparted or gained by the child in the subject physical sciences need to be quite diversified and varied and talking and listening in the classroom. As a result, by the term physical sciences curriculum, we mean all those learning experience that are received by a child through a number of activities going on inside the school or outside the school in the form of formal or informal education for the realization of the set goals and objectives of leaching physical sciences.

6.2 Learning Objectives:

After studying this chapter, the students will be able to know about:

- Meaning of science curriculum
- Organizational structure of curriculum

  Selection of content & Organization of Facts
- Factors affecting change in science curriculum

6.3 Meaning of science curriculum:

Curriculum etymologically the term has been derived from a Latin word which stands for a 'course to' run. A renowned educationist Cunningham has defined it in the following words, "The curriculum is the tool in the hands of the artist to mould his material (the pupils) according to his ideals (objectives) in his studio (the school). In every sense, therefore, curriculum should stand for all those experiences that can be included in the study of a particular subject which are thought to be essential for the realization of the set goals or objectives of that study. Secondary Education Commission stated that curriculum does not mean only academic subjects traditionally taught in school, but it includes totality of experiences that a pupil receives through the numerous activities that go on in the school, classroom, library, laboratory, workshop and playground and in the manifold informal contacts between the teachers and the pupils Curriculum is an important element of education, aims of education are reflected in the curriculum. In other words, the curriculum is determined by the aims of life and society. Aims of life and society are subject to constant change.

Hence, the aims of education are also subject to change and dynamic. The aims of education are attained by the school programmes, concerning knowledge, experiences, activities, skills and values. The different school programmes are jointly known as curriculum Traditional concept-The traditional curriculum was subject-centred while the modern curriculum is child and life-centred from now , the physical science teacher is expected to play a more important role. He is emphasized to use educational technology for more effective learning. He is also to include values while teaching physical science values like truth, cleanliness, trust, respect, love, nonviolence, right conduct and peace. If these values inculcated among students along with scientific temper, will make them better human beings and citizens. The teacher is now guided for more objective evaluation. He is supposed to be more accountable to prepare students for twenty-first century. Some of the definitions of curriculum are given as below.

Froebel - "Curriculum should be conceived as an epitome of the rounded whole of the knowledge and experience of the human race."

Crow and Crow - The curriculum includes all the learners' experience in or outside school that are included in a programme which has been devised to help him developmentally, emotionally, socially, spiritually and morally".

T.P. Nunn-The curriculum should be viewed as various forms of activities that are grand expressions of human spirit and that are of the greatest and most permanent significance to the wide world".

Self Check Exercise-1

Q-1: What do you mean by curriculum?

6.4 ORGANIZTIONAL STRUCTURE OF CURRICULUM:

In some school's curriculum is organized on a correlated or fused subject-centered basis. The fused types include core integrated, unified, broad field and subject-centered activity curriculum. Each of these are considered to be an effective means for communicating information and skills to the children and youths.

TYPES OF CURRICULUM ORGANIZATION:

1. **Correlated-subject-centered: -** It refers to the teaching of two subjects in close relationship.
2. **Fused subject-centered: -** It brings together two or more subjects and teaching is done in combination.
    1. Core: - two or more class periods are scheduled and are assigned to the same teacher.
    2. Integrated: it means teaching content is in such a way as to erase subject- matter lines completely. Thus, using subject matter as a resource in the developing unit or project children rather than the subject is integrated.
    3. Unified curriculum is as similar to fused curriculum as to be considered synonymous.
    4. Broad fields are a variation of fusion. Combining history, civics and geography in the social studies creates a broad field.
    5. Subject-centered activity curriculum: this makes use of activity in projects to make learning meaningful. It involves art and craft work.
    6. Experience curriculum is a general term for a curriculum organization which is flexibly planned so that the experiences of the children serve their needs and purposes in the ways consistent with principle of human development.

       It relates to the whole life of the children, not merely to the happiness at the school activity in the subject-centered curriculum. Class-room furniture is moveable, curriculum flexible, learners vocal. The child centered curriculum is learner oriented. Scope and

sequence of each learner's activities and experiences in the school are adjusted to his biological, intellectual and social growth.

Self Check Exercise-2

Q-1: Discuss two types of curriculum organization.

CORE CURRICULUM

Little agreement is found among people as to what constitutes a core. A somewhat possible definition of core is given under.

The core is curriculum includes learning experiences that are fundamental for all learners because they drive from our common individual drives or needs and from our civic and social needs as participating members of a democratic society.

Core is the minimum that an individual needs for learning a satisfactory life in the modem society. It prepares him for living and not for making a living. It teaches subject matter which may help him in the solution of problems that may have to be faced by him as an adult in the initial stages the core in the curriculum is emphasized and as the child reaches higher stages, the importance of the core decreases in the beginning the curriculum is same for all the pupils and at a later stage takes place and students are allowed to opt for subject they like the best. The problem of the specialization is postponed to the university stage. In the early stage the learner is required to become a human being first and at the last stage he is required to be a technician, a scientist, an engineer, a doctor, an artist etc.

The core curriculum tries to meet needs of every school child up to 14+ and introduces him to move towards advanced studies if he wants to continue his e3ducation beyond this age Up to 8 we have core subjects (social studies, general science, crafts, and languages) after that we have periphery.

The national policy on education-1986 has laid greater emphases on the teaching of the science and has made several recommendations.

NCERT has been engaged in revising the old science texts under the guidelines and recommendations of new policy of education. Class 3rd to 12th science texts is now available in the market.

In primary classes (3rd 4th, 5th) more emphases is laid on use of environment and local resources. At the middle level (6, 7th, and 8th) integration of all the sciences is tried out. At secondary level (9th, 10th) there are no separate texts of physics, chemistry and biology. There are two texts one for class 9th and other for class 10th. Here also like the middle science texts integration of all the sciences is being tried out. Let us hope for the best. At senior secondary level (XI, XII) physics, chemistry and biology text-books are continued to prepare students for admission to B.Sc., medical and engineering etc., hopefully in the more effective way.

From now on, the science teacher is expected to play a more important role. He is emphasized to use educational technology for more effective learning. He is also expected to inculcate values while teaching science value like truth, cleanliness, trust, respect, love, non-violence, right conduct and peace. If these values are inculcated among the students along with scientific temper, will make them better human beings

and citizens. The teacher is now guided for more objective evaluation. He is supposed to be more accountable to prepare students for twenty-first century.

Self Check Exercise-3

Q-1: What do you mean by the term core?

6.5 Selection of content

For selection of content in the curriculum, it is tried to make utility and meaningfulness as the bases. The content should be specified as per the educational objectives since the ancient times. However, awareness has increased in the present times in this context According to Wheeler's Criteria, the selection of content should be done as follows:

1. After objectives have been determined, suitable context should be selected for their realization.
2. The content should be authentic.
3. The significance of content should be specified on the basis of its basic concepts and assumptions.
4. The selection of content should be on the basis of student's needs and aptitudes.
5. Only that content should be selected which is helpful to solve present and future problems of students.
6. While selecting the content, student's ability to learn and difficulty level should be kept in view.

6.6 Organization of Facts:

After the content has been selected, it should be so arranged that students do not face any difficulties in assimilating it. According to the principles of correlation, the selected content should be so organized that a particular material can relate with other branches of science. This correlation should be two- way. The content studies in one class should assist in the study of content in the next class. This type of relationship is called vertical correlation. When the content of one subject has mutual relationship with content of another subject, it is called horizontal relationship. The science content should be so organized that students can take advantage of both these relationships and can assimilate the content easily and conveniently.

Besides, those situations should be made the basis in the organization of facts which remain in a student's contact. The organization of content should be such that it fulfills individual differences, interests, attitudes, abilities and skills and provide opportunities for progress. The laws of transfer of learning should also be kept in view while organizing content, so that a student is able to learn one subject with the help of another subject.

Self Check Exercise-4

Q-1: Discuss the primary factors that affect the curriculum organization**.**

6.7 FACTOR AFFECETING CURRICULM ORGANIZATION:

Factors which affect the curriculum organization should be considered along with the principles. Though curriculum is the core of the whole educational enterprise, it is likely to be affected by:

1) Teacher (2) text-books (3) tools, aids and equipment's (4) guidance and counseling (5) supervision and administration (6) examination and evaluation.

The primary factors which determine the content and method of teaching are (1) the need of society (2) the position of scientific knowledge (3) the particulars of the development of the children who study science.

Keeping the above factors in view, the framers of curriculum should try to co-ordinate them in such a way that all the three are equally realized. Stress on one factor should not hamper the fulfillment of the other but should rather be equally emphasized Out of these three factors, the most flexible and changeable n factor is the rapid and unprecedented achievements in the field of science and technology. These changes affect the society as well as the individual. These are so rapid that the new invention of today becomes old and out dated tomorrow. This requires the revision of the curricula every now and then so that the children's knowledge is up-to-date.

Science occupies different places in the curricula in different states in the country. In some it is compulsorily studied up to 8th class and in other up to 10th class Similarly the number of periods for teaching science also varies from two to five periods per week Keeping in view the need, economy and culture of the country the curricula in all the states should be similar. A well-integrated curriculum should be framed including the study of science as well as language and humanities.

Self-Check Exercise-5

Q-1 The concept of curriculum development excludes:

a) International Considerations

b) Family Aspirations

c) Societal Goals

d) National Goals

Q-2 According to the principles of correlation, the selected content should be so organized that a particular material can relate with other branches of science.

True/False

Q-3 The national policy on education-1986 has laid greater emphases on the teaching of the science and has made several recommendations. **True/False**

Q-4- "Curriculum should be ……. as an epitome of the rounded whole of the knowledge and experience of the human race."

6.8 Summary:

The manner in which curriculum is delivered will be determined by the society in which is living. All of the definitions of curriculum have some commonality that will link to

part of another definition. Curriculum is the information that is or will be taught. What determines or what is important to teach will be defined by status, position and politics that are evolving at the time the curriculum is planned. There has been change in the definition of curriculum since its original, but that change in definition has accommodated the change society. Overall curriculum as a definition has adapted with time but the method in which curriculum is delivered has changed. Curriculum is meant the of experiences which a student performs in and outside the classroom. To the modern concept, the curriculum is the collection of experiences, activities and real-life situations. The curriculum is subject centered, examination centered but not as per objectives of science teaching. It is incapable of meeting needs of students and community, and is not related to life. It should be reconstructed on the basis of principles of curriculum construction. Now the physical science teacher is expected to play a more important role. He is emphasized to use educational technology for more effective learning. He is also expected to inculcate values while teaching science values like truth, cleanliness, trust, respect, love, non-violence, right conduct and peace. If these values inculcated among students along with scientific temper, will make them better human beings and citizens. There is a need to have objective evaluation in physical science. Some of the important things should be kept in mind at the time of the development of curriculum.

6.9 Glossary:

Commonality: A sharing of characteristics in common possession

Assimilate: To learn and understand something

Evaluation: The process of judging and calculating the quality, importance, amount or value of something.

6.10 Answers to Self-Check Exercise:

Self-Check Exercise-1

Ans-1: The curriculum includes all the learners' experience in or outside school that are included in a programme which has been devised to help him developmentally, emotionally, socially, spiritually and morally".

Self-Check Exercise-2

Ans-1: Correlated-subject-centered**: -** It refers to the teaching of two subjects in close relationship.

Self-Check Exercise-3

Ans-1: Core is the minimum that an individual needs for learning a satisfactory life in the modem society. It prepares him for living and not for making a living.

Self-Check Exercise-4

Ans-1: The primary factors which determine the content and method of teaching are (1) the need of society (2) the position of scientific knowledge (3) the particulars of the development of the children who study science.

Self-Check Exercise-5

Ans1- International Considerations

Ans-2 True

Ans-3 True

Ans-4 Conceived

6.11 References and Suggested Reading:

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- Tyler, R. W (1949). Basic Principles of Curriculum and Instruction. Chicago: University of Chicago Press.
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- Lekan, T. (2009) Retrieved April, 15, 2009, from http://irs.ed.uiuc.edu/students/anicke/Dewey.html
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6.12 Terminal questions:

1. What is your definition for curriculum? Discuss the concept of curriculum.
2. Males and females are shown to be psychologically different when it comes to learning. How could you regulate your classroom to be able to accommodate each?
3. How could the way that different people learn change the way that we look at curriculum?

Unit-7

Science Club, Science Fair

Structure:

7.0 Introduction

7.1 Learning Objectives

7.2 Science Club

Self Check exercise-1

Self Check exercise-2

Self Check exercise-3

7.3 Science Fair

Self Check exercise-4

Self Check exercise-5

7.4 Summary

7.5 Glossary

7.6 Answers to Self-Check Exercise

7.7 References and suggested readings

7.8 Terminal Questions

7.0 Introduction:

The non-formal mode of education is an organized activity with educational purposes carried on outside the highly structured frame work of formal educational systems and consists of an assortment of separate educational activities, not bound by age restrictions, time schedules and sequences to keep in line with the levels of academic standards. It can assume a variety of forms; it can use any pedagogical method or methods to suit the specific requirements of the learners. It should, however, be distinguished from the informal mode of education. The informal mode of education is incidental without being organized and pre-planned learning experiences, whether in school or outside school. Recognizing the importance of non-formal mode of education, the Government of India has already initiated pilot projects with the help of UNICEF and UNESCO in many parts of the country to provide education to children in the age group of 6 to 15 through non-formal methodology. Co-curricular activities ensure balanced development of the child and good citizenship of the country. The commission also stressed "We conceive of the school curriculum as the totality of learning experiences that the school provides for the pupils through all the manifold activities in the school or outside that are carried on under its supervision. Learning by doing and learning by living are the two cardinal principles of teaching and the same is true in the case of teaching science.

7.1 Learning Objectives:

After studying this chapter, the students will be able to know about the meaning, organization, and utility of Science Club, Science Fair, in the field of education.

7.2 Science Club:

The present age is the age of science and technology. The progress and development of the society is now closely linked with the progress and development in the field of sciences which in turn depends upon the quality of science education imparted to the youngsters in schools Consequently it needs the inclusion of genuine interest towards the of sciences, development of scientific attitude and nurturing of the creative and inventive faculties of the science of the students. Science club is an organization which caters for the inculcation of scientific attitude, a genuine interest in science and scientific activities, supplements the work of the classroom and the laboratory and puts the syllabus on practical bias. Through the science club the learning of science becomes joyful. The students learn the things without the conscious effort on their part and pursue science as a pleasant hobby and not a burden on them. They get a better comprehension of the things and thereby develop a zealous enthusiasm in them to strive tirelessly for the cause of science. So, there should be science clubs up to higher secondary stage which can provide a large number of activities and thereby, widen and deepen the interests of pupils and provide means of developing desirable ways of utilizing leisure time. Curiosity for the unknown and self-realization are two such instincts which determine the child's behaviour to a great extent. The child motivated by these instincts to observe the things about him by opening things, implements and tools to know as much as he can. It is sorrowful that in this effort he often destroys things. So, this instinct of his should be moulded in to creativity. The formal form of education in the classroom does not provide an opportunity to him to express the above instincts. It is necessary to make available suitable opportunities to him in order to make science education more interesting and to allow the students to use their scientific talents. In place of this formal and bounded education, a vista should be provided which may have the following facilities.

The convenience of allowing the students to work according to their desire and on their own.

The convenience of using their scientific knowledge

The opportunities to use their creative facilities for inventions.

The students can be provided such a stage in the form of a science club or discussion. The science club is such as an organization in which such opportunities can be provided to the students.

Self Check exercise-1

Q-1: What do you mean by science club?

Significance of science club:

1. **Spinal cord:** The science club is the spinal cord of the biology curriculum. It can be proved that the scientific activities conducted outside the classroom are able to face the activities conducted in the regular classroom teaching.
2. **According to interest:** The education in the science club is based on the maxim 'learning by doing. So, it is more interesting. As compared to classroom formal teaching, it is according to the ability and interest of the students, because much emphasis is not lead on the regular and definite teaching-learning.
3. **Co-operation:** The students have more opportunities to work in co-operation with one another in a science club. Thus, it has the following advantages:
   (a) It provides effective opportunities for self-expressions.
   (b) It encourages research proclivity of the students.
   (c) It develops hand skills.
4. **Informal teaching**: The club provides opportunities to acquire such qualities which they cannot beget in the classroom for example:
   (a) The classroom work is formal. They are told in the class but is to be done, while they busy themselves of their own free volition.
   (b) They have to follow the instructions of the teachers in the classroom while working on a topic or a project, while they determine the working of the club programs by themselves.
   (c) The students in a classroom work to appease the teachers, while in a club they work of their own free will.
   (d) In the classroom, the students work by a definite method, while in a club they work as may be convenient to them.

McKnow has compared the educational significance of science club and classroom teaching as follows:

"The science club provides nutrition to the individual interest of the students. It is a good medium of expression also. There is no harassment of boundation, but has an experience of freedom. The student is not bounded within the four walls of the classroom in a science club. By the formal classroom teaching acquaints himself mere theories of science in a less or greater extent, but by the science club, he experiences fully how to use them in the practical life. Whereas in the classroom he passes his time in treading the of trodden path and to conduct the experiments as told by the teacher, while in the science club he moves according to his interest and invests his talents and faculties in knowing newer things, invention and using his creative powers".

The above discussion makes it clear that the science club has great educational and experimental significance even though it is non-formal by nature.

In India, a science club movement was started some years back. In science clubs such activities are organized which are desired to develop scientific knowledge of children.

Self Check Exercise-2

Q-1: Write two significance of science club.

Objectives of Science Club:

- To inculcate scientific attitude.
- To develop habits of exploration.
- To develop interest in the scientific hobbies.
- To widen the outlook of the students and to enable them to apply their knowledge of science in certain life situations.
- To develop in children a sense of healthy competition.
- To keep the students in touch with the recent advances of science.
- To contact other science clubs to exchange views and information.

Self Check Exercise-3

Q-1: Write two objectives of science club.

Organization of Science Club:

Every science club should have a constitution and every member should strictly abide by There should be a head an executive body elected from amongst the students consisting of a chairman, secretary, a treasurer, librarian, a store keeper, a publicity officer, class representative, and teacher in charge and sponsor.

This committee should formulate the constitution of the club before the election of office bearers is held and the membership is thrown open. The constitution of the club should include decisions and directions about the following aspects:

- The name of the club and its aims
- Conditions and the procedure of becoming the member
- Types of activities to be undertaken
- Expelling of members

Activities of the Club:

- Holding discussion, meeting, declamations, debates, etc.

- Arranging excursions and visits to places of scientific interest.
- Holding science exhibitions and fairs annually.
- Improvising and preparing hand-made apparatus.
- Celebrating science days.

7.3 Science Fairs:

Science fairs provide an excellent opportunity for discovering and encouraging science talent. The science fairs have Science fairs and exhibitions are organized by government agencies and non-government agencies too. The government agency which organizes science fairs for children is NCERT. The main objectives of national level science fairs are:

- To give encouragement to students to try out their ideas.
- To provide opportunity to students to witness the achievements of their colleagues and thereby stimulate them to plan their own projects.
- To popularize activities among greater number of students.

Self Check Exercise-4

Q-1: Discuss the term science fairs.

Organization of Science Fair:

The organization of science fair should be a teacher-pupil activity and everything should be thought of well in advance The following procedure is suggested for organization and administration of the science fair:

7.3.1- Planning: During planning the following aspects should be considered:

Objectives and aims of the fair.

- Scope of the fair
- Procedure.
- Financing.
- Place, time and duration.
- Other factors and facilities.

7.3.2 Distribution of work: After planning, the work should be assigned to different individuals or groups.

7.3.3 Execution: The different committees now execute the playing of the fair. The programmes like demonstration, films, charts, models, collections etc are organized. It is well leveled, preferably with an explanatory called with title and explanation. Selected students should make in charge in various activities. They should be given full explanation of each experiment a day before the exhibition is opened. The fair can be

inaugurated by some important man of science. People from other schools and from the community may be invited.

7.3.4 Judging: The fair should be judged by different committees of judges for different items of the fair. The judging criteria should be made well known to the participants in the fair. Judges may be chosen from amongst the individuals in the community having some background of science, scientists, college professors, science teachers etc. It is always better not to allow the public or students to see the exhibition before the judging has been completed. The judging criteria should be well known to the participants in the fair. These criteria may even be displayed at a prominent place for public view. The judging system should be as objectives as possible. Separate criteria and proformae be developed for each item. These proformae may be developed on the lines suggested below:

- Scientific approach (30%)
- Originality- in planning and execution (20%)
- Technical skill and workmanship (20%)
- Thoroughness (10%) - gives clear, full and concise story of the project Completeness and accuracy of presentation of exhibit.
- Dramatic value (10%) - exhibit attractive. Labels large and descriptions neatly presented.
- Personal interview
- (10%) with the respective students who exhibit

After the fair is over the teacher and the students should evaluate it and find out whether the objectives of the fair have been achieved or not. If not, where does the fault lie and, then to improve it next time.

Self-Check Exercise-5

Q-1 Science parks are places meant for:

a) Scientific research

b) Leisure activities

c) Interactive exhibits

d) Both 2 and 3

Q-2 Science fairs provide an excellent opportunity for ……science talent.

7.4 Summary:

In order to make science clubs more effective, the NCERT organized some science club sponsor's workshops during the last few years. In these workshops, some such activities were organized which were desired to be started in the science clubs. These workshops could make a little impact on the science clubs. The problem of finance and guidance still remains unsolved. The role science teacher is very important here. The success of failure of the programme depends upon his enthusiasm,

resourcefulness and ingenuity. He is the pivot of all activities. It is also the responsibility of the physical science teacher to encourage the students to take part in science fairs at district, state or national level. It very important to include field trips in the curriculum of physical sciences.

7.5 Glossary:

Falsification: The action of changing something, such as a document, in order to deceive people

Plagiarism: Presenting ideas from another source as your own, with or without consent of the original author, by incorporating it in to your work without full acknowledgement

Anatomy: A field in the biological sciences concerned with the identification and description of the body structures of living things.

7.6 Answers to Self-Check Exercise:

Self Check Exercise-1

Ans-1: Science club is an organization which caters for the inculcation of scientific attitude, a genuine interest in science and scientific activities, supplements the work of the classroom and the laboratory and puts the syllabus on practical bias.

Self Check Exercise-2

Ans-1: The science club is the spinal cord of the biology curriculum. It can be proved that the scientific activities conducted outside the classroom are able to face the activities conducted in the regular classroom teaching.

The education in the science club is based on the maxim 'learning by doing. So, it is more interesting. As compared to classroom formal teaching, it is according to the ability and interest of the students, because much emphasis is not lead on the regular and definite teaching-learning.

Self Check Exercise-3

Ans-1: To develop habits of exploration.

To develop interest in the scientific hobbies.

Self Check Exercise-4

Ans-1: Science fairs provide an excellent opportunity for discovering and encouraging science talent. The science fairs have Science fairs and exhibitions are organized by government agencies and non-government agencies too.

Self Check Exercise-5

Ans-1 Both 2 and 3

Ans-2 Discovering and encouraging

7.7 References and suggested readings:

- School Science (Quarterly), NCERT, New Delhi.

- Baez, Albert B. Innovations in Science Education - World Wide. Paris: The Unesco Press, 1976.
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- Misra, K.S. Perspectives of Science Education. Agra: Arya Book Depot, 1997.

7.8 Terminal Questions:

1. What are the objectives of science club? Discuss the role of science teacher in organizing science club.
2. What are science fairs? Describe their educational utility.

Unit-8

SCIENCE LABORATORY: NEED AND IMPORTANCE SCIENCE EXHIBITIONS

Structure:

8.0 Introduction

8.1 Learning Objectives

8.2 Science Laboratory: Need and importance

Self Check exercise-1

8.3 Science Exhibitions

Self Check Exercise-2

Self-Check Exercise-3

8.4 Summary

8. 5 Glossary

8.6 Answers to Self-Check Exercise

8.7 References and suggested readings

8.8 Terminal Questions

8.0 Introduction:

It is the natural urge in children to make things, to break things and to handle things but the present curriculum doesn't provide ample opportunities for the students for self-expression, independent research, constructive activities and other projects. It becomes absolutely clear from the subject matter of the physical science that it is not possible to conduct its teaching-learning only by speech or hearing. That is, it can neither be taught like other social sciences, nor can it be studied. On the contrary, the following process is followed in the teaching- learning of sciences:

They are demonstrated

They are inspected

They are experienced

Different functional and practical activities and tasks are used in its teaching-learning. The use of science laboratories and practical tasks and certainly useful in the of physical sciences, but the extensive objectives of teaching of life sciences cannot be obtained only by them It is necessary to assimilate the knowledge and skill of life sciences in the practical 19fe and to create interest and favorable attitude towards its studies. It is necessary that the following qualities are created in the students:

Curiosity towards scientific discoveries, experiments and uses

Desire for invention

Development of creativity

In the direction of creating the above qualities, only classroom teaching and laboratories work are not sufficient. The students need something more for it. The question is: What should be done for success in this direction? We can answer this question like this: We should go out of the field of curriculum and formal teaching, to opt for co-curricular activities and non-formal approaches. Different types of co-curricular activities can be organized for supplementing classroom teaching. Some of these activities are as follows:

Science Clubs.

Science Fairs.

8.1 Learning Objectives:

After studying this chapter, the students will be able to know about the meaning, organization, and utility of Science laboratory, Science exhibition, in the field of education.

8.2 Science Laboratory: Need and importance: A laboratory is a facility that provides controlled conditions in which scientific or technological research, experiments, and measurement may be performed.

Laboratories used for scientific research take many forms because of the differing requirements of specialists in the various fields of science and engineering. A physics laboratory might contain a particle accelerator or vacuum chamber, while a metallurgy laboratory could have apparatus for casting or refining metals or for testing their strength. A chemist or biologist might use a wet laboratory, while a psychologist's laboratory might be a room with one-way mirrors and hidden cameras in which to observe behavior. In some laboratories, such as those used by scientists, computers (sometimes supercomputers) are used for either simulations or the analysis of data collected elsewhere. Scientists in other fields will use still other types of laboratories. Engineers use laboratories as well to design, build, and test technological devices.

The need and importances of the science laboratory are discussed as below:

Scientific laboratories can be found as research and learning spaces in schools and universities, industry, government, or military facilities, and even aboard ships and spacecraft.

Science is different from any other subject. In order to understand its concepts, one has to look beyond the books and conventional classroom teaching. Effective teaching and learning of science involve seeing, handling, and manipulating real objects and materials. The knowledge that kids attain in classrooms would be ineffectual unless they actually observe the process and understand the relationship between action and reaction.

Effective teaching and learning of science involve a perpetual state of show and tell good schools combine classroom teaching with laboratory experiments to ensure that their students grasp each and every concept thoroughly. It is also believed that laboratory teaching and experiments that are being conducted their help encourage

deep understanding in children. Children are able to retain the knowledge for longer when they see the experiments being performed in front of their eyes.

Science lab equipment allows students to interact directly with the data gathered. They get a first-hand learning experience by performing various experiments on their own. Students are made to use the models and understand different scientific theories and concepts. It is also found that school science lab equipment and supplies make teaching and learning easy both for the teachers, as well as for the students. There are several scientific theories and concepts that are difficult to explain directly from the books Anatomy models, physics science kits, and chemistry science kits for instance make it easy to understand the otherwise complex theories of science.

Science is a practical subject, teaching of which cannot be done properly only in theory form. For proper education of science, it is necessary to conduct various kinds of experimental works, which are practical in nature.

These practical functions cannot be carried out in absence of scientific apparatus and equipments. The place where various kinds of scientific apparatus and equipments are arranged in systematic manner is called science laboratory.

Science laboratory is central to scientific instructions and it forms essential component of science education.

It is in this place that various kinds of practical works are carry out by the students. Without proper and well-equipped science laboratory, it is not possible to carry out the science teaching process effectively in any school or educational institution.

Students learn to handle various apparatus and to think independently in the laboratory, because of which it is considered to be one of an important place. When students carry out various kinds of experiments, then they draw conclusions from their studies, which raise their level of self-confidence and develop scientific attitude among them.

These are considered to be main objectives of science teaching, for which it is considered by experts that without a well-equipped and organized scientific laboratory, there cannot be any proper teaching of science. Students should be encouraged by the science teacher to make active parts in various experimental processes, as most of the achievements of modern science are due to the application of experimental methods

If students get information or knowledge by playing active role in learning process then they get permanent kind of information, because of which at school stage, practical work is considered to be more important for the students.

Although it has proven by the above discussion that science laboratories play very important functions, for which they are considered to be much important, but still need and importance of science laboratories can be explained in the following points:

i. In laboratory, it is possible to keep various scientific instruments and chemicals in safe and secure conditions, as without them, it is not possible to carry out any kind of experiment in any way.

ii. If there is proper of well-equipped and properly arranged laboratory in the school, then students will get encouraged by it to take active part in the experimental processes as in such kind of laboratory, a congenial kind of atmosphere exist, which promote the interest of students in practical works.

iii. With the help of well-equipped and organized laboratory, science teacher will get help in developing the scientific attitudes among the students to considerable extent.

iv. All the students have to carry out experiments collectively in the laboratory as often there is shortage of such facilities in schools. With such functions, spirit of co-operation and team work gets developed among the students and they begin to appreciate the work done by others. Not only this, through this, they also begin to appreciate the views and ideas of others, which help them in becoming successful in future life.

v. When students themselves get the opportunity to take part in experimental processes, then their area of experiences get widen and their level of intuitiveness also get developed, as a result of which, they become people with wide mentality and open-mindedness.

Self Check exercise-1

Q-1: What do you mean by the term laboratory?

8.3 Science Exhibitions:

Everybody knows about the term 'Exhibition', which mostly related to student and school. Maximum schools are conducting different types of exhibitions related to subject and non-subjects. In our school life, we too participated many kinds of exhibitions, to exhibit our latent in any specific field. I am sharing some of the benefits from 'Exhibitions in schools", please participate and share your valuable points on this topic. An exhibition, in the most general sense, is an organized presentation and display of a selection of items. In practice, exhibitions usually occur within museums, galleries and exhibition halls, and World's fairs. Exhibitions can include many things such as art in major museums and smaller galleries, interpretive exhibitions, natural history museums and history museums, and also varieties such as more commercially focused exhibitions and trade fairs.

The word "exhibition" is usually, but not always, the word used for a collection of items. Sometimes "exhibit" is synonymous with "exhibition", but "exhibit" generally refers to a single item being exhibited within an exhibition.

Exhibitions may be permanent displays or temporary, but in common usage, "exhibitions" are considered temporary and usually scheduled to open and close on specific dates. While many exhibitions are shown in just one venue, some exhibitions are shown in multiple locations and are called travelling exhibitions, and some are online exhibitions.

Though exhibitions are common events, the concept of an exhibition is quite wide and encompasses many variables. Exhibitions range from an extraordinarily large event such as a World's fair exposition to small one-artist solo shows or a display of just one item. Curators are sometimes involved as the people who select the items in an exhibition Writers and editors are sometimes needed to write text, labels and accompanying printed material such as catalogs and books. Architects, exhibition designers, graphic designers and other designers may be needed to shape the exhibition space and give form to the editorial content Organizing and holding exhibitions also requires effective event planning management, and logistics.[1]

Art exhibitions include an array of artifacts from countless forms of human making paintings, drawings, crafts, sculpture, video installations, and sound installations. Performances, interactive art, etc. Art exhibitions may focus on one artist, one group, one genre, one theme or one collection; or may be organized by curators, selected by juries, or show any artwork submitted.

Fine arts exhibitions typically highlight works of art with generous space and lighting, supplying information through labels or audio guides designed to be unobtrusive to the art itself.

Exhibitions may occur in series or periodically, as in the case with Biennales, triennials and quadrennials.

Interpretive exhibition:

Interpretive exhibitions are exhibitions that require more contexts to explain the items being displayed. This is generally true of exhibitions devoted to scientific and historical themes, where text, dioramas, charts, maps and interactive displays may provide necessary explanation of background and concepts. Interpretive exhibitions generally require more text and more graphics than fine art exhibitions do.

The topics of interpretive graphics cover a wide range including archaeology anthropology, ethnology, history, science, technology and natural history.

Commercial exhibitions:

Commercial exhibitions, generally called trade fairs, trade shows or expos, are usually organized so that organizations in a specific interest or industry can showcase and demonstrate their latest products, service, study activities of rivals and examine recent trends and opportunities. Some trade fairs are open to the public, while others can only be attended by company representatives (members of the trade) and members of the press.

Science exhibitions: learning outside the school:

Many schools organize school level science exhibition every year. It is a great idea to arrange an outside visit for those schools to visit the science exhibition. By visiting those exhibitions students can learn about different scientific lessons and they will be able to know many scientific facts by visiting method. By visiting a science exhibition, they can learn the importance of science exhibition. By this activity teacher may be able to create scientific attitude among the students. He can teach students

about the objectives and meaning of science exhibition. Visiting other school's science exhibition is a nice activity of learning outside the school". By visiting a science exhibit student can learn how to make a science exhibit. There are many Regional Science centers in India in many cities where students may visit science exhibitions and much more. They can also participate in different scientific activities like science quiz, science related competitions, science workshops etc.

Science exhibition: learning inside the school

There are many activities that can be done inside the school, just like science exhibition and making science models. Making science models is a very interesting activity. This activity depends upon the different factors and available resources school manager has the required resources he may organize science exhibition in his schools, but if he do not has enough resources he can do another activities like inspiring students to prepare the scientific models. Students can learn by preparing the scientific models. There is teacher's different role. He can be as a motivator (Teacher as a motivator). Teacher has a great opportunity to develop student's creativity by preparing science kits or models involving students directly (teacher as a facilitator). The great way is teacher play a role as a facilitator in learning.

Self Check Exercise-2

Q-1: Discuss interpretive exhibition.

Benefits of Exhibitions in school are:

1. Before exhibition, subject teachers find out or choose their best students to exhibits something different to others. In addition, teachers give their selected students a short list of contents, which they can study, create a subject, & design the exhibit. At this time, the teacher-student interaction increases; where teacher understand the knowledge of student and students to understand their teacher's quality and interest, vise verse.
2. While preparing for exhibition, students are in happy mood in thought of participating and showing their friends a new thing different from others. Their inner core develops while doing some creativity act in this stage.
3. At the time of exhibition, every student feels happy and enthusiastic, which we never find in other competitions. This is because, art, games, athletic or music are not fond for every student everyone do not like everything. However, in exhibition, participants were keen to show their content and non-participants were willing to know about various subjects, and gain some knowledge on different subjects.
4. It provides a platform to the students to exhibit their inner talents. As it is completely practical based, so students also find interest in participating in such events.
5. It strengthens the student's knowledge of the subject matter. In these events the groups of students are divided according to their age and class

standards. Thus, they are given projects based on their class standards only

6. Students can develop the skills of leadership, and relate how to work in groups through such events. As they have to work in a group, it is very important for them to work co- operatively.
7. A science fair project even provides an opportunity for the discussion of ethical issues, such as plagiarism and falsification of data. Indeed, such a discussion is highly recommended. The ease of copying information from the Internet is hard to resist, and many students are far ahead of their teachers in understanding what is possible.
8. It plays a vital role in spreading awareness about a particular issue.

Self-Check Exercise-3

Q-1 Which one of the following is co-curricular activity in science teaching?

a) Science Club

b) Audio-visual Aids

c) Text-Book

d) Black-Board

Self-Check Exercise:

Q-2 Interpretive exhibitions are exhibitions that require more contexts to explain the items being displayed. **True/False**

8.4 Summary:

It very important to include field trips in the curriculum of physical sciences. It is well known fact that while things which can be learnt best in school should be learnt there, things which can be learnt best outdoors should be learnt out-doors. Text books are important tool in the hand of a teacher. It helps student to how and what they learn to achieve some definite goals. When we make a text we should give importance to its content organization literary style, vocabulary, mechanical makeup and authorship.

8.5 Glossary:

Independent research: is an educational activity that allows students to investigate a topic of interest.

Constructive activities: A type of play, a learning theory, or a teaching method.

Curator: A person whose job is to look after the things that are kept in a museum.

8.6 Answers to Self-Check Exercise:

Self-Check Exercise-1

Ans-1: A laboratory is a facility that provides controlled conditions in which scientific or technological research, experiments, and measurement may be performed.

Self-Check Exercise-2

Ans-1: Interpretive exhibitions are exhibitions that require more contexts to explain the items being displayed. This is generally true of exhibitions devoted to scientific and historical themes, where text, dioramas, charts, maps and interactive displays may provide necessary explanation of background and concepts. Interpretive exhibitions generally require more text and more graphics than fine art exhibitions do.

Self-Check Exercise-3

Ans-1 Science Club

Ans-2 True

8.7 References and suggested readings:

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8.8 Terminal Questions:

1. What are the objectives of science exhibition? Discuss the role of science teacher in organizing science exhibition.

2. Discuss the need and importance of science laboratory.

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Unit-9

SCIENCE TEXT BOOKS

Structure:

9.0 Introduction

9.1 Learning Objectives

9.2 Science text-books

Self Check Exercise-1

Self Check Exercise-2

Self Check Exercise-3

9.3 Summary

9.4 Glossary

9.5 Answers to Self-Check Exercise

9.6 References and suggested readings

9.7 Terminal Questions

9.0 Introduction:

Learning by doing and learning by living are the two cardinal principles of teaching and the same is true in the case of teaching science. It is the natural urge in children to make things, to break things and to handle things but the present curriculum doesn't provide ample opportunities for the students for self-expression, independent research, constructive activities and other projects. It becomes absolutely clear from the subject matter of the physical science that it is not possible to conduct its teaching-learning only by speech or hearing. That is, it can neither be taught like other social sciences, nor can it be studied. In addition to academic improvement, there is the opportunity to engage the student more fully, expose them to technology used in the workplace and get immediate feedback of classroom knowledge. Smart classes use all interactive modules like and presentations and these visually attractive methods of teaching becomes appealing to students who are already struggling with the traditional method of teaching in a classroom’s text book should really design for the pupils rather than the teacher. Text book should stimulate reflective thinking and cultivate in students the scientific attitude.

In the teaching-learning process, the text-book occupies an important place. There is a saying "As is the text-book, so is the teaching and learning".

9.1 Learning Objectives:

After studying this chapter, the students will be able to know about the meaning and importance text books in the field of education.

9.2 SCIENCE TEXT BOOKS

"As the text book, so is the teaching and learning"

Text books are the most widely used of all instructional materials. Now a day's text book has become a course of study. A set of unit plans and a learning guide as well. A text book should really design for the pupils rather than the teacher. Text book should stimulate reflective thinking and cultivate in students the scientific attitude.

In the teaching-learning process, the text-book occupies an important place. There is a saying "As is the text-book, so is the teaching and learning". A good text-book can even replace class-room teaching. The science text-book should aim at aiding the pupils in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely stuffing their minds with facts.

Self Check Exercise-1

Q-1: Discuss the role of text books in teaching learning process**.**

Importance:

Sometime back, Gaodhi Ji, as an educationist was of the opinion that there should be no text-books and the students with the help of the subject teacher, should evolve their own text book. It was expecting too much from the children, to be idealistic.

But for the subject of science good text book are a necessary, rather than the same may be considered as indispensable.

Sometime back the position of textbooks in the schools has been disheartening. A number of committees were set up in different states to improve their quality.

By establishment of the National Council of Educational Research and Training (NCERT. good books in the direction is being done.

The central committee of NCERT has set up a number of expert panels and Editorial Boards for all school subjects. These books are being brought out in English and Hindi and then the same are translated into Regional Language by the State Governments.

Functions of Science Text-Books:

Good science Text-Books are necessary for the following purposes-

1. To supplement the class work.
2. For home study after demonstration lesson in the class.
3. For doing homework and the preparatory part of the assignment.
4. For a scientific and speedy revision after the course has been finished.
5. To develop an open mindedness, training in scientific method and to inculcate other scientific discipline.

6. To develop particular skills, which may later on, be of utility in life.

Self Check Exercise-2

Q-1: Write two functions of science text books.

Qualities of a good science Text book

Thurber Collette suggested six criteria for choosing a good textbook. They are:

1. Content
2. Organization
3. Literary style vocabulary
4. Illustrations
5. Teaching aids
6. Mechanical make up and appearance
7. Authorship

Content

The content of text books for any one subject matter field is remarkable uniform about 85 percent of the content being common to all of them

1. The content should be appropriate for the age level and experience backgrounds of the pupils
2. The concept should not be too complex for the maturity of the pupils
3. The content should be consistent with the pupil's needs and interests
4. The statements must be accurate

Il Organization

1. The subject matter should cover the whole syllabus
2. Subject matter should be developed in psychological sequence
3. The text book has to be organized into units which are based on student interests and probability of use
4. Inductive approach is to be used whenever possible in introducing new topic
5. At the end of each unit there should be assignments informing to the following
6. Application to life situations
7. Self-assessment test
8. Suggestions for further reading
9. Numerical questions if necessary

10. Assessment for practicing skills
11. The text book should be written in simple unambiguous scientific language. Prefer simple and compound sentence to complex sentences
12. It should contain a glossary of technical terms used in the books
13. It should suggest some good methods of learning's
14. Historical development of science should be attempted
15. Adequate provision should be made to correlate science with other subject and crafts.
16. It is better if the text book contains examples from the local environment
17. There should be a detailed table of contents and index text books
18. Controversial topics should be treated impartially
19. The social significance of science should be stressed
20. Headings and sub-headings should be in bold type
21. Important principles should be set in italics
22. Each text books should be accompanied by a laboratory manual and pupil's work book
23. It must be supplemented by a teacher's hand book

III. Literary style and Vocabulary of text book

Literary style has much to do with the readability of the book. Although style is difficult to judge.

1. Length of sentences
2. Directness of sentences
3. Number of ideas per seconds
4. Use of lead sentence or paragraphs
5. Presence or absence of irrelevant thoughts continuity of thought

While evaluating a text book the teacher must whether or not the vocabulary is excessive or in appropriate text book should be easy to read

IV Illustrations

The quality and the quantity of the illustrations should be considered.

1. Photographs should be clearly reproduced
2. Diagrams should be carefully made attractive
3. Color in the illustrations add to eye appeal and when properly used has considerable teaching value

4. The recently introduced transparencies made on plastic sheets are excellent teaching aids but because of cost it can only be used in small quantities in any one book

5. Photograph should have relation with content in the text

V Teaching aids

1. The table of content and Index should be comprehensive
2. Glossary should be included
3. Activities should be given the end of a chapter
4. Activities should be closely related to content

VI Mechanical make-up and appearance

1. Artistic cover
2. Durability for binding
3. Size of the book
4. Good quality of paper
5. Length of line and size- legible
6. Attractive over all experience
7. Cover design and colour should be appealing
8. Ample space to be left between lines to provide for ease in reading

VII Authorship

Only such persons who have experience of teaching the subject should be allowed to become authors of school science text books. Such authors can understand the actual learning's situations. Certain qualifications may also be prescribed for the authors. It will be better if some training is given to them

VIII Characteristic

Besides these characteristics, the UNESCO Planning Mission has given some principles of writing text-books in U.S.S.R. and other countries. They are as follows:

(i) It should be first of all according to the requirements of the syllabus. It should also help in the improvement of the syllabus.

(ii) The facts, concepts etc., should be modern and within the comprehension of the pupils.

(iii) The contents should contain not only the established facts but also the problems which are being researched and thereby, arousing the interest in the pupils in these problems.

(iv) It should help in linking up science with life and practice. The pupils should be equipped with "know-how' utilizing the knowledge in everyday life.

(v) The whole content of the text-book should be aimed at shaping the integrated modern scientific outlook which ensures success in mastering scientific knowledge and solution of the problems of vital issues. The content should be simple, brief, exact, definite and accessible.

Self Check Exercise-3

Q-1 Identify media resources that may be helpful in the teaching-learning process.

a) Newspaper

b) Picture

c) Exhibitions

d) All of the above

Q-2 In the teaching-learning process, the text-book occupies an important place. **True/False**

Self-Check Exercise:

Q-3 "As is the text-book, so is the …….and learning".

9.3 Summary:

It is well known fact that while things which can be learnt best in school should be learnt there, things which can be learnt best outdoors should be learnt out-doors. Text books are important tool in the hand of a teacher. It helps student to how and what they learn to achieve some definite goals. When we make a text we should give importance to its content organization literary style, vocabulary, mechanical makeup and authorship. In the teaching-learning process, the text-book occupies an important place. There is a saying "As is the text-book, so is the teaching and learning". A good text-book can even replace class-room teaching. The science text-book should aim at aiding the pupils in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely stuffing their minds with facts.

9.4 Glossary:

Demonstration lesson: A planned for a group of students that can serve as a test of teachers skills.

Accessible: Possible to be reached

Unambiguous: Expressed in a way that makes it completely clear what is meant.

9.5 Answers to Self-Check Exercise:

Self-Check Exercise-1

Ans-1: In the teaching-learning process, the text-book occupies an important place. There is a saying "As is the text-book, so is the teaching and learning". A good text-

book can even replace class-room teaching. The science text-book should aim at aiding the pupils in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely stuffing their minds with facts.

Self-Check Exercise-2

Ans-1: To supplement the class work.

For home study after demonstration lesson in the class.

Self-Check Exercise-3

Ans-1: All of the above

Ans-2: True

Ans-3 Teaching

9.6 References and suggested readings:

- Chauhan. S.S (1985), Innovation in teaching-Learning Process, Delhi, Vikas Publishing House.
- Das RC (1985), Science Teaching in school, Sterling Publishers Pvt. Ltd., New Delhi.
- Retrieved from Preserve Articles www.preservearticles.com
- E How-Qualities of Good Textbooks www.ehow.com

9.7 Terminal Questions:

1. What do you mean by text-book? Discuss the advantages of a goodtext-book.

Unit-10

SMART CLASSROOM IN SCIENCE, NEEDAND IMPORTANCE OF THE TEACHING AIDS

Structure:

10.0 Introduction

10.1 Learning Objectives

10.2 Need and Importance of the teaching Aids

Self Check Exercise-1

10.3 Smart classroom in science

Self Check exercise-2

10.4 Summary

10.5 Answers to Self-Check Exercise

10.6 Glossary

10.7 References and suggested readings

10.8 Terminal Questions

10.0 Introduction:

Teaching aids should be used to supplement the process of teaching Most of teaching aids are sensory aids and their function is to make teaching correct, effective and interesting. It can assume a variety of forms; it can use any pedagogical method or methods to suit the specific requirements of the learners. It should, however, be distinguished from the informal mode of education. The informal mode of education is incidental without being organized and pre-planned learning experiences, whether in school or outside school. Recognizing the importance of non-formal mode of education, the Government of India has already initiated pilot projects with the help of UNICEF and UNESCO in many parts of the country to provide education to children in the age group of 6 to 15 through non-formal methodology. Co-curricular activities ensure balanced development of the child and good citizenship of the country. The commission also stressed "We conceive of the school curriculum as the totality of learning experiences that the school provides for the pupils through all the manifold activities in the school or outside that are carried on under its supervision.

10.1 Learning Objectives:

After studying this chapter, the students will be able to know about the meaning, teaching aids, smart classroom and text books in the field of education.

10.2 Need and Importance of the teaching Aids:

Teaching 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. Teaching aids should be used to supplement the process of teaching Most of teaching aids are sensory aids and their function is to make teaching correct, effective and interesting. The importance of the teaching aids is given as below:

1. **Help to draw interest: -** The audio-visual aids help the teacher to win the interest and attention of the pupils. They motivate the students to physical and mental activity.

2. **Learning become effective: -** They save time and make teaching learning process effective and durable. Studies have shown that pupils retain the knowledge gain through these aids for a much longer duration of time as compared to the subject matter learnt in the absence of these aids.

3. **Firsthand experience: -** They help the pupils to get firsthand experience by looking at concrete things, living specimens and actual demonstrations, handling the apparatus and performing the practical themselves.

4. **Help for clear conception:** They help the pupils to have clear conception of information, facts and principles. Students can have better understanding of the various complicated and difficult topics.

5. **Change for atmosphere: -** They help to bring a change in the atmosphere of class. The traditional monotony goes away. For example, when a film strip or slide is shown, the students laugh, talk and pass their comments as they go outside the class.

6. **Teacher becomes friendly:** Through this process the attitude of the teacher is very friendly. For the purpose of explaining models, showing exhibitions or taking the pupils to outdoor places, the teacher has to be a true friend and guide. The pleasant and natural atmosphere thus created, greatly helps proper learning.

7. **To inspire proper thinking: -** They help the students to inspire correct thinking for they give actual meaningful association. In the words of Edger Dale -"because audio-visual aids supply of concrete basis for the conceptual thinking, they give rise to meaningful association. Hence, they offer the best antidote available for the disease of verbalism."

8. **To develop scientific attitude: -** They help the pupils to develop scientific attitude and get training in the scientific method.

9. **To teach large numbers: -** A large number of students can be taught at a time by their use. For example, the use of magic lantern or epidiascope can be conveniently made for big audience.

10. **Based on principle of psychology: -** It is most convenient, easy and natural way of learning, for the use of audio-visual aids is based on the principle of psychology.

Self Check Exercise-1

Q-1: What are the teaching aids?

10.3 Smart classroom in science:

Smart classrooms are the amalgamation of technology used at the teacher's desk and in front of the classroom, technology in the hands of the student and a physical environment that allows the successful use of that technology.

There is solid research supporting modest academic gains from the use of technology in the classrooms. In addition to academic improvement, there is the opportunity to engage the student more fully, expose them to technology used in the workplace and get immediate feedback of classroom knowledge. Smart classes use all interactive modules like and presentations and these visually attractive methods of teaching become appealing to students who are already struggling with the traditional method of teaching in a classroom. In fact, smart classes are almost like watching movies as sometimes, animated visuals are used to teach a point. This kind of visual is both eye-catching and young students can easily relate with them. This is because the audio-visual senses of students are targeted and it helps the students store the information fast and more effectively. And then, there is the advantage of utilizing much of the time wasted earlier in drawing or preparing diagrams on board. Smart boards have all these information in memory and can be presented during the time of class lectures and thus, the time saved can be used in more important things.

Some students and teachers have problems with chalk dust and they tend to suffer from allergic reactions. The smart boards save you from such distress and won't let you develop any health issues later Smart boards are a lot smarter when it comes to field trips which are impossible with textbooks. A field trip to the deserts of Sahara or the rainforests of the Amazon basin becomes easy with visuals in the smart boards of smart classroom. These visuals are definitely more attractive than those descriptions in a few lines of a textbook.

One of the main reasons behind the constant increase in popularity of smart classes is the fact that this kind of education is perfect for all kinds of students. A classroom has students with varied power of understanding and learning, and studying from notes and other materials becomes difficult for some students. But the use of smart classes and modern technology eases the learning process for all students. Moreover, this kind of education in class promotes more interaction between teacher and student with more participation from both sides.

1. Improving classroom management

SMART Board uses in the classroom at the elementary level increasingly are including management start-of-day routines such as taking attendance and lunch count.

For example, before class every day, a first-grade teacher may post large, colorful icons marked with individual student names. The board may also saw pictures of the day's choices. Then, instead of waiting for roll call and lunch count or checking in on a magnet board or pocket chart, the students use their fingers to guide their icons to their lunch choices. The teacher views the class and the board to see if the record keeping is complete. Then she can report the attendance and lunch counts.

This process also helps young students become comfortable with the touch process that is becoming so important in using Wi-Fi digital tools, such as the computer notepads and e-readers that some schools are adopting for instructional use.

2. Minimizing the need for eyes at the back of the head

Teachers often jokingly say that it takes a few years to develop "eyes" at the back of their heads so they can detect misbehavior when facing away from students. SMART Boards change classroom management by minimizing the amount of time teachers need to turn their back to the class to write on dry-erase whiteboards or chalkboards.

By connecting a computer to a SMART Board, a teacher can stand face forward and attract student attention to a particular topic by sharing PowerPoint presentations, software lessons or interactive websites with the entire class at one sitting. This occurs before students begin small group or independent work on the same topic.

3. Providing academic & digital learning

During SMART Board lessons, teachers may also help students gain digital and presentation skills by taking turns manipulating the equipment. Think of this practice as the Digital Age equivalent of going up to the blackboard to solve a problem.

SMART Board uses in the classroom may include teaching various lessons. Examples include:

- Fourth grade fractions made more comprehensible by viewing the movement of virtual tools, such as pictures of cubes, pie graphs and other objects.
- Civil War history for middle school students, who enrich textbook learning by taking a fictional tour of the Underground Railroad in which the class makes choices and sees where those decisions lead.
- Virtual dissection of a frog in high school biology.

4. Building motion into kindergarten lessons

Young children have short attention spans and respond better to instruction if it includes movement and hands-on action, such as getting up to answer a question or demonstrating how to use a tool. As one kid-favorite song says, they "like to move it, move it."

The Australian journal Teaching Science notes that kindergarten students enjoy touching SMART Boards to answer questions and participate in lessons. They also respond well to the colorful graphics that are much easier for a large group to view on a large screen.

Using electronic pens to circle items or moving virtual objects with their fingers, kindergarten students can sort items on a SMART Board to show what they know about a particular subject. For example, they might be asked to separate objects that need electricity from those that don't.

5. Smart class room learning help to increase the learning abilities.
6. Smart class may use as a experimental learning tool to teaching students.
7. The curriculum should be framed keeping in view the application of smart classes of teaching.
8. This strategy helps the learner to move at his own pace as it helps the learners to provide individual instruction.
9. Although students generally work together in small groups in hands on science classes, there are times when all class discussions are valuable. Experimentation, summarizing comparing, observation and interpreting often involve the whole class. Teachers can use both small group and whole class approaches to teaching science, and discuss when each may be appropriate.

Self Check exercise-2

Q-1: Discuss the term Smart classroom in science.

Q-2 Which of the following is an example of assistive technology to aid hearing?

a) Braille system
b) Walking stick
c) Sound amplifier
d) Eyeglasses

10.4 Summary:

Different functional and practical activities and tasks are used in its teaching learning. The use of science laboratories and practical tasks and certainly useful in the of physical sciences, but the extensive objectives of teaching of life sciences cannot be obtained only by them It is necessary to assimilate the knowledge and skill of life sciences in the practical 19fe and to create interest and favorable attitude towards its

studies. The audio-visual aids help the teacher to win the interest and attention of the pupils. They motivate the students to physical and mental activity. The role science teacher is very important here. The success of failure of the programme depends upon his enthusiasm, resourcefulness and ingenuity. He is the pivot of all activities. It is also the responsibility of the physical science teacher to encourage the students to take part in science fairs at district, state or national level. It very important to include field trips in the curriculum of physical sciences.

10.5 Answers to Self-Check Exercise:

Self-Check Exercis-1

Ans-1: Teaching 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. Teaching aids should be used to supplement the process of teaching Most of teaching aids are sensory aids and their function is to make teaching correct, effective and interesting.

Self-Check Exercis-2

Ans-1: Smart classrooms are the amalgamation of technology used at the teacher's desk and in front of the classroom, technology in the hands of the student and a physical environment that allows the successful use of that technology.

Ans-2: Sound amplifier

10.6 Glossary:

Inductive: It is a method of drawing conclusions by going from the specific to the general.

Rainforests: These are the forests characterized by a closed and continuous tree canopy, moisture-dependent vegetation etc.

Monotony: The state of being always the same

10.7 References and suggested readings:

- School Science (Quarterly), NCERT, New Delhi.
- Baez, Albert B. Innovations in Science Education - World Wide. Paris: The Unesco Press, 1976.
- Kuhn, David J. "Science Education in a Changing Society". Science Education, 56(3), 1972.
- Misra, K.S. Perspectives of Science Education. Agra: Arya Book Depot, 1997.

1.8 Terminal Questions:

1. What are the objectives of teaching aids? Discuss the role of science teacher in organizing teaching aids.
2. What are importances of smart classroom in science?

UNIT-11
METHODS OF TEACHING SCIENCE-I

Structure:

11.1 Introduction
11.2 Learning objectives
11.3 Methods of Teaching General Science
Self- check Exercise-1
11.4 Principles for Selecting Methods
Self- check Exercise-2
11.5 Lecture Method
Self- check Exercise-3
11.6 Demonstration Method
Self- check Exercise-4
11.7 Problem Solving Method
Self- check Exercise-5
11.8 Summary
11.9 Glossary
11.10 Answers to self- check Exercise
11.11 References / Suggested Readings
11.12 Terminal Questions

11.1 Introduction:

Many of us think teaching is an art and there are born teachers. But there are majority of teachers, who can improve upon by experience of practice and utilization of various methods of teaching science. The basic aim of teaching any subject is to bring about desired change in behavior. The change in behavior of child will be indicated through children's capacity to learn effectively. This is only possible by adopting various methods of teaching. The teacher cannot utilize any method to any type of students in any type of environment. He/ She have to choose and adopt the right method of teaching keeping in mind the capability of the students and the curriculum. Thus, method is a way of presentation of the content in the classroom. But, it is however very important to keep in mind that a method is not an end in itself but is used to achieve the set aims of teaching. You should also keep in mind that, same method should not be

used at all times but there should be flexibility in using it as for as situations circumstances, and condition in a particular case. You should use various depending upon demand of the situation. The method which is suitable for one teacher in a particular class under a particular circumstance may be a total failure for other teacher.

11.2 Learning Objectives

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

- Develop an understanding of different methods of teaching science.
- Develop an understanding of Lecture Method.
- Explain the Demonstration Method.
- Develop an understanding of Problem Solving Method.

11.3 Methods of Teaching General Science

Teaching science effectively involves engaging students with the subject matter, promoting critical thinking, and fostering a deep understanding of scientific concepts. Here are several methods that educators commonly use to achieve these goals:

Hands-on Experiments and Activities: Practical demonstrations and experiments allow students to directly observe scientific principles in action. This method encourages curiosity, engagement, and a deeper understanding of concepts through direct experience.

Inquiry-Based Learning: This approach involves posing questions, problems, or scenarios that prompt students to investigate and explore scientific concepts on their own. It encourages critical thinking, problem-solving skills, and a deeper understanding of the scientific method.

Collaborative Learning: Group activities, discussions, and projects promote collaboration among students. Working together allows them to share ideas, discuss concepts, and learn from each other's perspectives, enhancing their understanding of science through social interaction.

Use of Visual Aids: Visual tools such as diagrams, charts, graphs, and videos can help students visualize abstract concepts and processes in science. Visual aids make complex information more accessible and facilitate better comprehension.

Integration of Technology: Utilizing educational technology, such as simulations, virtual labs, and interactive multimedia resources, can enhance students' engagement and understanding of scientific concepts. Technology also allows for access to current research and real-world applications of science.

Connecting to Real-World Applications: Relating scientific concepts to everyday experiences or real-world issues helps students see the relevance and practical applications of what they are learning. This approach fosters a deeper appreciation for the importance of science in their lives.

Differentiated Instruction: Recognizing that students have diverse learning styles and abilities, teachers can vary their instructional methods to accommodate different learners. This might include adjusting the pace of instruction, providing additional resources, or offering alternative ways for students to demonstrate their understanding.
Scaffolding: Breaking down complex concepts into smaller, more manageable parts and building upon students' prior knowledge helps them grasp difficult concepts more effectively. Scaffolding involves providing support and guidance as students progress in their understanding of scientific concepts.
Formative Assessment: Ongoing assessment techniques, such as quizzes, discussions, and informal feedback, help teachers gauge students' understanding in real-time. This allows for timely intervention and adjustments to teaching strategies to ensure all students are mastering the material.
Promoting Critical Thinking: Encouraging students to ask questions, analyze information, evaluate evidence, and draw conclusions fosters critical thinking skills essential to scientific inquiry. Teachers can facilitate this by posing thought-provoking questions and encouraging reasoned discussion.
All the methods of teaching science can be classified into two types.

(i) Teacher-Centered and (ii) Pupil-Centered

(i) Teacher-Centered Methods-

This type of teaching methods focuses on telling, memorizing, and recalling information The student's participation is very limited where in they only ask questions or answers questions. Most of the time the students are passive listeners and receive the knowledge. The teacher is centre of process that goes on in the classroom.

(ii) Pupil-Centered Methods:-

This process emphasizes on need, requirement, interest and capability of students. The students are active participants, where in their skills and abilities are developed. The climate in the classroom is conducive where in flexibility is there. Teacher and students jointly explore the different aspects of problem. The role of the teacher is to create a problematic situation, have materials and resources available to the students, and help them identify issues, state hypotheses, clarify and test hypotheses and draw conclusions.
Methods of teaching science can be classified into teacher-centered and pupil-centered approaches based on where the focus of instruction and learning primarily lies:

Teacher-Centered Methods:
Lecture: The teacher delivers information through a structured presentation. Students primarily receive knowledge passively.
Demonstration: The teacher shows experiments, models, or examples to illustrate scientific concepts, and students observe and learn from these demonstrations.

Expository Teaching: The teacher explains scientific principles and concepts directly to students, often using textbooks, diagrams, or multimedia presentations.
Direct Instruction: The teacher provides clear instructions and guidance on what students should learn and do, emphasizing control over the learning process.
Recitation: Students answer questions posed by the teacher, demonstrating their understanding of scientific concepts through verbal responses.

Pupil-Centered Methods:
Inquiry-Based Learning: Students explore scientific concepts through questioning, investigating, and conducting experiments, with the teacher acting as a facilitator.
Problem-Based Learning: Students solve real-world or simulated problems that require scientific knowledge and reasoning, fostering critical thinking and problem-solving skills.
Project-Based Learning: Students work on extended projects that involve research, experimentation, and presentation of findings, promoting collaboration and application of scientific knowledge.
Cooperative Learning: Students work in groups to complete tasks or projects related to science, promoting teamwork, communication skills, and shared understanding.
Discovery Learning: Students discover scientific principles through firsthand exploration and experimentation, with minimal direct instruction from the teacher.
In teacher-centered methods, the teacher plays a central role in delivering content and structuring the learning experience. These methods are often used to ensure that students receive foundational knowledge and essential concepts from an expert source.
In contrast, pupil-centered methods prioritize active participation, critical thinking, and student autonomy in the learning process. These methods aim to engage students more deeply by encouraging them to explore, question, and apply their understanding in meaningful ways.
Effective science teaching often combines elements from both teacher-centered and pupil-centered approaches, depending on the learning objectives, content complexity, and student needs. Balancing these approaches can create a dynamic and supportive learning environment that meets diverse learning styles and encourages lifelong learning in science.

Self- Check Exercise-1
Q.1 Teacher-centred methods focus on telling, memorizing, and _____ information.

Q.2 In pupil-centred methods, the role of the teacher is to:

a) Lecture and give tests
b) Be the centre of the process

c) Create a problematic situation and help students explore solutions
d) Make students passive listeners

11.4 Principles for Selecting Methods:

Selecting an appropriate teaching method for physical sciences involves considering several principles to ensure effective learning and engagement. Here are key principles to guide the selection of teaching methods for physical sciences:

Alignment with Learning Goals: Choose teaching methods that align with the specific learning objectives of the physical science curriculum. Consider whether the method will effectively help students achieve the desired knowledge, skills, and understanding.

Student-Centered Approach: Prioritize methods that actively engage students in the learning process. Encourage critical thinking, problem-solving, and inquiry-based activities where students explore and discover scientific principles on their own.

Hands-On Learning: Physical sciences often involve experimentation and practical application. Incorporate methods that allow students to conduct experiments, manipulate materials, and observe phenomena firsthand. This approach enhances understanding and retention of scientific concepts.

Differentiation: Recognize the diverse learning needs and styles of students. Select methods that can be differentiated to accommodate various learning preferences, abilities, and prior knowledge levels.

Authenticity and Relevance: Choose methods that connect physical science concepts to real-world applications and experiences. Engage students by demonstrating how scientific principles are relevant to everyday life, technology, and global issues.

Interactivity and Engagement: Opt for methods that promote active participation, collaboration, and discussion among students. Use interactive tools, simulations, debates, and group activities to foster engagement and deeper learning.

Assessment and Feedback: Ensure that the selected method allows for ongoing assessment of student understanding. Use formative assessment techniques to monitor progress, provide timely feedback, and adjust instruction as needed to support student learning.

Integration of Technology: Utilize educational technology tools, such as virtual labs, simulations, multimedia resources, and online research platforms, to enhance teaching and learning experiences in physical sciences.

Teacher Flexibility and Adaptability: Be prepared to adjust teaching methods based on student feedback, learning outcomes, and classroom dynamics. Flexibility allows teachers to optimize learning opportunities and address challenges effectively.

Reflective Practice: Continuously evaluate the effectiveness of teaching methods through self-reflection, student feedback, and assessment data. Adapt and refine approaches to improve student engagement, understanding, and achievement in physical sciences.

By applying these principles, educators can select teaching methods that foster a deeper understanding of physical sciences, promote student engagement, and prepare learners to apply scientific knowledge in diverse contexts.

In addition to these there are some more guiding principles for determining teaching methods. They are as follows:-

- Principle of sense of achievement through interest and purpose.
- Principle of active cooperation.
- Principle of capability of students of particular class.
- Principle of realization of meaning of education i.e., "I bring up". "I nourish". "Drawing art".
- Psychological principle i.e., need, interest and aptitude of students.
- Principle of individual difference i.e., different potentialities of students.

Self- Check Exercise-2

Q.1The principle that emphasizes the need, interest, and aptitude of students is known as the _____ principle.

Q.2 Which principle focuses on the different potentialities of students?

a) Principle of active cooperation
b) Principle of individual difference
c) Principle of sense of achievement through interest and purpose
d) Principle of realization of meaning of education

11.5 Lecture Method:

Lecture means teaching a lesson in the form of speech or talk. The teacher delivers a lecture on a particular topic and students keeps listening in an idle manner. This method is useful at the higher level classes. In this method the information can be given regarding the content of the topic but the students cannot be motivated to attain knowledge themselves and they cannot be made capable to make use of the acquired knowledge. By the lecture method it is difficult to find out the extent to which the students have been able to learn.

Merits:-

- Useful for higher classes.
- It is easy, brief and attractive for teacher.
- More information can be given in a short time period.
- More number of students can listen and prepare notes.
- The argumentative flow of the subject is retained.
- This method gives a sense of fulfillment as regards the progress of the subject both to the teacher and the taught.

- It is a convenient method for the teacher.
- The teacher is always alert.
- A large number of students are taught at the same time.
- If the teacher makes the lesson interesting, the students are attracted towards it and interest in the topic is developed.

Demerits:

- Acquiring information about certain facts is not only the study of Physical Sciences.
- The students remain inactive.
- This method is not suitable and unpsychological for smaller classes.
- The students are not motivated towards learning
- The mental level of the students is not developed.
- The knowledge imparted is temporary.
- If the student is unable to understand in the middle of the lecture he is unable to follow the rest.
- It is difficult to get down all the points during the lecture.
- Principle of teacher taught relationship is neglected.
- Except sense of hearing no other senses are used.
- Experimental part of topic is neglected.
- The teacher becomes an 'orator' rather than a 'teacher'.
- This is not a psychological method.

Suggestions for Improvement:

The teaching can be made more effective using the following principles while teaching by lecture method:

- Make use of the black-board where and whenever required.
- Proper teaching aids should be used.
- More stress should be laid on the principle of generalization.
- The students should be given work to do, so that they make use of their previous knowledge and acquire more knowledge on basis of their hard work and experience.
- In order to keep them active, questions should be put up to the students from time to time.

Self- Check Exercise-3

Q.1 The lecture method is considered useful for _____ classes because it allows a large amount of information to be delivered in a short period of time.

Q.2 Which of the following is a demerit of the lecture method?

a) It is easy and convenient for the teacher
b) The argumentative flow of the subject is retained

c) The students remain inactive and are not motivated towards learning
d) More information can be given in a short time period

11.6 Demonstration Method:

In the field of Physical Sciences the Experiment Demonstration method is very important In this method both the teacher and taught are active. The teacher makes a theoretical Investigation in the class and proves it. The teacher performs the experiment while teaching and the students acquire knowledge while careful observation of the experiment. The students also put forth their queries and doubts.

Merits:

- This method is appropriate for small classes.
- The experiment is conducted by the teacher, so there is less breakage of apparatus.
- Less time consuming.
- Students learn by seeing and observing.
- The sight and hearing sense of the students is more active.
- The students develop the power of observation, thinking and reasoning.
- The students are able to understand the principles clearly and the knowledge acquired is permanent
- The teaching is effective even if the numbers of apparatus are less.

Demerits:

- The students do not get a chance to perform experiment.
- Some students are not able to observe properly.
- Sometimes the teacher is not able to perform the experiment properly and this creates a lot of doubts about the subject in the minds of the students.
- By this method only general knowledge about physical sciences can be demonstrated.

Suggestions for Improvement:

- The teacher should practice performing the experiment himself prior to demonstrating before the students.
- The articles required for the demonstration should be kept on the demonstration table.
- The aim of the demonstration should be stated before the students clearly.
- The students should have previous knowledge of the experiment to be performed, the articles and apparatus being used so that the students do not have problem in understanding the demonstration.
- All Experiments should be performed in front of the students. The place for experiment should be such that all students are able to watch it.

- The help of students should be taken during the performing of experiment. Their doubts should be cleared simultaneously.
- The teacher should use the black-board and other teaching aids as and when required along with the demonstration.
- The students should emphasize on the correctness of the script of the observation.
- The apparatus should be cleaned carefully and kept after the completion of the experiment.
- They should use easy and simple language during performance of the experiment.
- After the completion of the experiment the teacher should discuss the observation and result of the experiment.

SELF- CHECK EXERCISE-4

Q.1 The demonstration method is particularly suitable for _____ classes because it involves active participation and careful observation by students.

Q.2 Which of the following is a merit of the demonstration method?

a) Students get hands-on experience with experiments
b) The experiment is performed solely by the teacher, reducing breakage
c) It is time-consuming and requires extensive preparation
d) Students primarily learn through lectures

11.7 Problem Solving Method:

Science subject is one of the important subjects in school education. However, really the traditional teaching methods are challenged for their inability to foster critical thinking holistic learning environment among children. The science subject must develop science process skills where children observe, measure, classify, process information, interpret think on solving problems, analyze, synthesize, formulate conclusions, etc. but, it should be kept in mind that, creativity in an essential element of Problem Solving.

In a problem solving method, children learn by working on problems. This enables the students to learn new knowledge by facing the problems to be solved. The students are expected to observe, understand, analyze, interpret, find solutions and perform applications that lead to a holistic understanding of the concept. This method develops scientific process skills. This method helps in developing brainstorming approach to learning concepts.

The students thinking on problem and their understanding of the science behind it is based on common sense. It does not start from textual knowledge. Rather it

proceeds from experiencing to gradually forming concepts through books at later stage. It is a process from practice to theory not vice versa. Knowledge here is not a goal but a natural outcome of working on tasks. Students live in the real world and like to deal with concrete things where they can touch, feel and manipulate things then the method is useful in igniting the process of science learning.

Principles of Problem Solving Method:

- Principle of learning by doing
- Principle of purpose.
- Principle of freedom of thought.
- Principle of learning by experiencing.
- Principle of utility
- Principle of scientific attitude.
- Principle of interest.
- Principle of reality.
- Principle of concreteness.
- Principle of objectivity

Steps in Problem Solving Method:

1) Selection of the Problem: A number of problems are confronted by the students in the class or outside. They are made to select a problem as per their capacity and interest.

2) Presentation of Problem. Each student is made to feel responsible for presenting the problem in front of the teacher and class as per his insight. The students are free to give their suggestions on the problem.

3) Collection of Facts: All the facts related to problem are collected either by a student or group. As a number of facts will be collected, it will help the students to keep the most pertinent facts and discard rest.

4) Drawing an Outline: This is most important phase as a proper outline at this stage will lead to purposeful activity. The teacher will guide students to draw exact plan and follow it properly so that the solution to problem is reached. It is more or less like planning stage, where in a clear indication of outline leads to better result.

5) To Reach a Satisfactory Conclusion: It is the longest step and requires utmost patience. The tentative solutions which are offered by students are properly noted down. A good number of arrangements, discussion brainstorming results in reaching a satisfactory conclusion. The teacher has to be very careful at this stage as, it may lead to wrong conclusions. The discussions must be healthy and conducive atmosphere must be provided in the classroom for it.

6) Evaluation: The students review the entire process and find out each and every stage where in they have made any mistakes. Self-criticism and Self-realization will give training of self confidence. The teacher must see that objective have been achieved.

7) Writing Report. A complete report must be written by students. This will include, how they planned, what discussions were held, how duties were assigned, how satisfactory conclusion was reached etc. the writing of report will be maintained as a record which will be used in future course of time.

Role of Teacher:

- Teacher must work as a facilitator
- Teacher must keep in mind that it is a child-directed learning not teacher-directed.
- Teacher must provide situation for all students to come forward and contribute towards the success of the activity.
- He must be alert and active to arouse interest among students.
- Teacher must provide democratic atmosphere.
- He must be initializing, tactful and experienced

Merits:

- Students develop democratic feeling.
- This method follows the principle of learning by doing.
- They learn to use old facts in new references.
- They become capable to generalize.
- Students learn to find solution to their problem.

Demerits:

- It is not economical from time and money point of view.
- There is always a doubt of drawing wrong conclusions.
- There is short of talented teachers to practice this method.
- This is not suitable for all level students.

Suggestions to Improve:

- The time period must be fixed.
- The objective should be fixed for a problem.
- Proper attention must be given by teacher towards students' activities.
- All students should be given equal opportunity to put forth their problems and ideas.
- As far as possible the process of group formation should be psychological.
- Apart from improvement of teaching the objective of this method should be development of routine problem solving skills.

11.8 Summary

As we have seen all above methods have their pros and cons. But, effectiveness of teaching depends upon the method that teacher adopts. Group teaching does not happen over right. For effective teaching, knowledge of different methods of teaching science in essential. The teacher however must be free to choose any method that he

thinks is suited to the students. For many decades now, which is not practiced i.e., creating excitement of science, use of new and innovative methods must be practiced now. Same are discussed here.

Lecture-cum-discussion method is best suited for all lords of students. The basic purpose of this method is to disseminate and encourage them to take part in the discussion. However, teacher has to see that all students are given equal chance or else this will lose its charm.

The demonstration method teaches by exhibition and explanation. It is of utmost importance in the teaching of science. The creative teacher knows how to use the demonstration method to modify concepts and skills and to maximize the possibilities for transfer of learning so that the students can use previously acquired knowledge in new contexts. As more skills are developed, new kinds of knowledge also develop, leading to the creation of new ideas.

Problem solving method develops skill of finding solutions to the problem on their own. The students thinking on problem and their understanding of the science behind anything helps them to solve problems of their life objectivity. Students live in the real world and like to deal with concrete things.

At the end, we can conclude that it is you teachers who have to keep in mind, which method is suitable to which type of students under what circumstance. Every method has its merits and demerits. The choosing of methods depends upon your intelligence, resourcefulness.

11.9 Glossary

- **Activity-Based Technique:** A teaching method that involves engaging students in activities to promote learning through experience and participation.
- **Brainstorming:** A technique where students generate ideas and solutions in a free-flowing, creative process.
- **Continuous and Comprehensive Evaluation (CCE):** A system of evaluation that assesses a student's overall development on a continuous basis through various tools and techniques.
- **Drill and Practice:** A technique that involves repeated exercises to reinforce skills and knowledge.
- **Heuristic Method:** A discovery-based approach to learning where students investigate and solve problems using critical thinking and inquiry.
- **Lecture Method:** A traditional teaching method where the teacher delivers a spoken presentation of the subject matter to the students.
- **Lesson Planning:** The process of outlining the objectives, materials, activities, and assessments for a specific lesson.
- **Pedagogy:** The art and science of teaching and instructional methods.

- **Play-Way Technique:** A method of teaching that uses play and playful activities to engage students and facilitate learning.
- **Problem Solving Method:** A student-centered approach where learners actively engage in finding solutions to problems, promoting critical thinking and application of knowledge.
- **Project Method:** An experiential teaching method where students work on projects that require investigation, planning, and execution.
- **Psychological Principle:** The principle that emphasizes the need, interest, and aptitude of students in the learning process.
- **Pupil-Centered Methods:** Teaching methods that focus on the needs, interests, and capabilities of students, encouraging active participation and collaboration.
- **Scientific Attitude:** A mindset that involves curiosity, skepticism, and critical thinking in the pursuit of knowledge and understanding.

11.10 Answers to Self- Check Exercises

Self-Check Exercise-1

Answer 1: recalling

Answer 2: c) Create a problematic situation and help students explore solutions

Self-Check Exercise-2

Answer 1: psychological

Answer 2: b) Principle of individual difference

Self-Check Exercise-3

Answer 1: higher

Answe 2: c) The students remain inactive and are not motivated towards learning

Self-Check Exercise-4

Answer 1: small

Answer 2: b) The experiment is performed solely by the teacher, reducing breakage

11.11 References / Suggested Readings

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11.12 Terminal Questions:

Q1. Discuss briefly the advantages and disadvantages of lecture method.

Q2. "Observation develops reasoning and concentration power" Explain?

Q3. Identify a topic where in you can adopt problem solving method.

UNIT-12
METHODS OF TEACHING SCIENCE-II

Structure:

12.1 **Introduction**
12.2 Learning outcomes
12.3 Project Method
Self- check Exercise-1
12.4 Laboratory Method
Self- check Exercise-2
12.5 Heuristic Method
Self- check Exercise-3
12.6 Summary
12.7 Glossary
12.8 Answers to self- check Exercise
12.9 References / Suggested Readings
12.10 Terminal End Questions

12.1 Introduction

The word '**method**'has been taken from the Latin word which means mode or way. Therefore here it says, the technique of delivering knowledge and transmitting scientific skills by a teacher to his or her students and their comprehension and application by them in the process of learning science.

Every approach has some virtue in it, and no way is entirely good, according to Valtaire and Spancer, students should be given as little information as possible and encouraged to learn as much as they can.

12.2 Learning outcomes

After going through this Unit, learners will be able to:

- Develop an understanding of importance of Project Method in science teaching.
- Develop an understanding of Laboratory Method and its utilization in teaching of science.
- Develop an understanding of and apply the Heuristic Method in Science Teaching.

12.3 Project Method:

Project method is a whole hearted, problem solving and purposeful activity carried to completion in a social environment. This is the most concrete of all types of activity methods. It is the revolt against the traditional, bookish passive environment of school. The project method of teaching is the practical outcome of the John Dewey's Philosophy of Pragmatism. Pragmatism has made a unique contribution in the shape of Project method enunciated by the Kilpatrick the follower of Dewey. In project method, study through workshop and source methods are also studied, concrete activity rather than academic work take the dominant place in the project method. The project method also transcends the subject barrier which is not done by other methods.

In project method the teacher instead of following the lecture method substitutes "The subject with few outstanding problems and proceeds to solve the same by Experiment method with the active co-operation of the students. The purpose of this method is to learn pupils into the trained investigators and prepare them for learning by living.

"A project is a whole-hearted purposeful activity proceeding in a social environment"

Dr. William Kilpatrick

"A project is a problematic act carried to completion in its natural setting"

- **Stevenson.**

"A project is a bit of real life that has been imported into school. - **Ballard.**

Thus, project is a purposeful activity and planned activity which is achieved in social, natural situations created in schools.

Principles of Project Method:

- The Principle of freedom.
- The Principle of purpose.
- The Principle of activity.
- The Principle of interest.
- The Principle of utility.
- The Principle of correlation.
- The Principle of sociability.
- The Principle of experience.
- The Principle of reality
- The Principle of learning by doing.

Types of Project:

According to WH. Kilpatrick projects are of four project.

i) Producer projects

ii) Consumer projects

iii) Problem projects

iv) Drill projects.

Producer Project. Here the emphasis is on actual construction of a material object or article.

Consumer Project: Here the emphasis is given on obtaining either direct or vicarious, experience, such as reading and learning stories, listening to a musical delectation etc.

Problem Projects: The main purpose is to solve a problem using intellectual process, such as determining the density of a certain liquid.

Drill Projects: This type of project emphasizes on attaining a certain degree of skill in a reaction as learning a vocabulary.

Steps of Project Method:

1. **Providing a Situation:** The teacher provides a situation to the students which must create same problems and students must feel interested to work.
2. **Choosing And Purposing:** The students are tempted to choose a project. The teacher should stimulate discussion by suggestion. While choosing the project the teacher should bear in mind that it should be of real need to students. The purpose of project must be clearly defined to the students. The project must be common and acceptable to all. In case of wrong choosing, teacher must help students tactfully to see that the students choose a better project. They should be asked to write down the reasons for selection.
3. **Planning:** The success of the project lies in the good planning. The students should plan out the whole project under the guidance of teacher. Every child must be encouraged to participate in the discussion and make suggestion. All the students are encouraged to write down the plan neatly and properly.
4. **Executing:** Execution of different activities to different students on the basis of their capacity leads to successful completion of the project work. It is the longest step and requires meticulous assignment of duties to different students or groups the teacher must guide and encourage students. It is the duty of the teacher to keep watch on the process of activities and instruct as and when required.
5. **Evaluation:** This is very important step as the students review the project and find out mistakes if any. is very important at this stage. The students discuss their work and rectify their mistakes and recollect useful knowledge. The teacher sees that the objectives of the project have been achieved.
6. **Recording:** The students keep a complete record of entire activity. How they planned discussions were held, how duties are assigned, how criticism were made, which will help them in their future work

Examples of Projects:

- Arrangement of science fair.
- Preparation of soap/chalk/candle/ink etc.
- Improvise apparatus
- Beautifying campus.

- Establishing science museum.
- Establishing physical science laboratory.
- Painting iron apparatus to preserve it from rusting

Role of Teacher:

- Teacher must be a friend, guide and working partner
- Teacher must have thorough knowledge of individual student and allot work accordingly.
- Provide democratic atmosphere.
- He should learn with students and should not claim to know everything.
- He must be experienced, initializing and process tacting for creating positive ambience.

Merits of Project Method:

- It promotes Co-operative activity.
- It arouses and maintains interest of students.
- It keeps the students on freedom of thought and action while doing the work.
- It develops scientific attitude.
- It widens the mental horizon of student.
- It develops dignity of labour.
- The students learn by self activity.
- It supports all the laws of learning Le, law of readiness, law of exercise, law of effect.
- The correlation of subjects is best followed in this method. The subjects are not treated as water tight compartments.
- This is a psychological method.

Demerits of Project Method:

- The knowledge is not acquired in a sequential manner.
- There may be a chance of overlapping of subject matter.
- If not planned and executed properly then it may not be completed in time.
- It is a time consuming process.
- It may be a costly affair where in some items/things may not be available at times.
- There may be over development of individualism and under development of co-operation and group responsibility.
- If the topic in wrongly selected then the objective may not be achieved.
- It gives to students a superficial knowledge of many things. Therefore it is not suitable for all types of students.
- This method is not suitable for a mature teacher.
- The whole syllabus, for higher classes cannot be accomplished with this method.

Suggestions to Improve:

- The topic should have some educational value.
- Project should be selected according to the student's interest.
- Entire course should not be planned only using this method.
- The objectives of the project must be clear and defined.
- Students should be assigned various duties according to their capabilities.
- The students should be given freedom to interact among themselves.

Self- Check Exercise-1

Q.1 The success of the project lies in the _____.

Q.2 The purpose of the project must be clearly defined to the _____.

Q.3 What is the teacher's role during the planning stage?

a) To plan the entire project alone

b) To encourage every child to participate in the discussion and make suggestions

c) To assign tasks without discussion

d) To monitor students silently

Q.4 What should the teacher do if a project is wrongly chosen by students?

a) Ignore the mistake

b) Select the project for the students

c) Tactfully guide them to choose a better project

d) Cancel the project

12.4 Laboratory Method:

This method in commonly thought of as a hands on and minds on approach to teach science where in students have the opportunity to gain some experience with phenomena associated with their course of study. In this method either student participates alone or in small groups. They produce or manipulate various variables that are under exploration. The degree to which student has control over exploration can vary over a wide range. Here the students learn by actual doing rather than by observing the experiments. As young children do it by themselves, the experience is impressed more firmly in their minds. Thus this method in psychologically sound as it satisfies the natural urge for activity. This method broadens Interest of the students.

They learn many virtues through laboratory activity. The experience in a laboratory is very rich in personal satisfaction as they gain it firsthand. The sense of excitement and challenge help them to achieve tangible thing.

Principles of Laboratory Method:

- It follows the principle of learning by doing.
- It follows psychological principle, where students' age, mental level and interest is taken into consideration.
- The work should be Pre-organized and Pre-selected.
- Teacher must see that, students are allowed to work independently without much interference.
- The teacher must ensure that apparatus and equipments should be checked prior hand.
- Teacher must see that students are able to follow instruction and record their observation properly.

Role of Teacher:

- Teacher must be a facilitator of the process of doing experiments by students.
- Teacher must check the apparatus previously, so that it goes on smoothly.
- The practical work must be Pre-organized and Pre-selected.
- The skills of handling apparatus, drawing, diagrams, careful observations taking necessary precautions, must be developed among students.
- The teacher must see that the student is doing experiment properly by following proper procedure.

Merits of Laboratory Method:

- This method follows child-centered approach
- It makes students active and alert.
- It gives scope for learning by doing and students do a lot of thinking themselves.
- Different skills are developed.
- It paves way for exploration, experimentation and verification of scientific facts and principles.
- It inculcates good virtues like, honesty, truthfulness, dignity of labour etc.
- It helps in developing sprit of enquiring.
- It helps in developing higher order thinking capacities like reasoning, analyzing, synthesizing etc.

Demerits of Laboratory Method:

- It is expensive and uneconomical
- It is time consuming as it takes much time in some experiments to come to conclusion.
- It expects a lot from students and teacher.

- It does not guarantee that students would be equally efficient in solving problems outside laboratory.
- All students cannot be expected to be skilled workers.
- Most of the students are either not ready or lack ability to undertake original work.

Suggestions for Improvement:

- This method should not be considered independently but should form a part of the total science programme.
- The practical work must be pre-planned.
- It is imperative that same individual laboratory work must be done by every student.
- Instead of performing the experiments stated in the book should be little modified for better result.
- Before experiment is performed the purpose must be clarified to the students.

Self- Check Exercise-2

Q.1 The laboratory method is thought of as a hands-on and _____ approach to teaching science.

Q.2 In the laboratory method, how do students primarily learn?

a) By observing the experiments

b) By reading textbooks

c) By actual doing

d) By listening to lectures

12.5 Heuristic Method:

Heuristic - word meaning to discover.

The word "heuristic" is derived from the Greek word heurisco" meaning "I find out" and the "Heuristic Method" is one in which the pupils are left to find out things for themselves. Children are placed, as far as possible, in the position of discoverers and instead of being told the facts, they are led to find out things for themselves. Through this method the pupils are made to learn. The Heuristic method was, for the first time, coined by Dr. HE Armstrong (1888-1928), Professor of Chemistry at City and Guild Institute Kensington. This method of teaching is of a very recent origin. First it was used in Science and its success led it to be adopted in the teaching of all subjects in the school curriculum.

The aim of this method is to develop the scientific attitude and spirit in pupils. The spirit of enquiry prompts the pupils to learn. This method insists on truth, whose

foundation is based on reason and personal experiences. As a matter fact there is no spoon-feeding or more acceptances of facts which are given by the teacher. An eminent educationist has pointed out that the object of the heuristic method is "to make pupils more exact, more truthful, observant and thoughtful to lay this solid foundation for future self-education and to encourage the growth of spirit of enquiry and research." All the children in a class may be set to work simultaneously at the same problem by adopting the touristic method. Each child with all attention strives to find out something for himself. Hristic method aims at the pupils' own observations to satisfy as many questions as posle to be raised in the teaching- learning situation. Much is demanded of the teacher in the heuristic method of teaching. He should be a great reader of books in order to obtain varied information. The teacher should possess much curiosity, observation, interest and spirit of scientific investigation, because these are the qualities he wishes to develop in pupils. The teacher should realize the responsibility of fostering in his pupils good habits of reading and collecting various information from books.

Role of Teacher:

In the heuristic method, the teacher is a guide and also a working partner. As a friend of pupils, this teacher should proceed on the way to discover facts. He is to see that this class room is pervaded by an atmosphere of freedom and that the work provided to the children encourages self-development, spontaneity and self-expression. This method is used not only in scientific subjects like Mathematics, Physics, Chemistry and Nature Study, but in all subjects of the curriculum. A close study of this method reveals that it is in reality this heuristic attitude which should characterize teaching of all subjects. It is opposed to dogmatic techniques of teaching, where pupils are passive learners. This may be applied to inductive as well as deductive lessons and thus heuristic method in problem-solving According to its author Prof. Armstrong, "Heuristic methods of teaching are methods which involve placing students as far as possible in the position of discoverers-methods which involve their finding out instead of being merely told about things" This statement speaks very Cleary that telling is in no way teaching. The Heuristic method tends to set the learner himself on the track of invention to direct him into paths in which the author has made his own discoveries. Heuristic Method is learning by doing.

Procedure of the Method:

The method requires the students to solve a number of problems experimentally. Each student is required to discover everything for himself and is to be told nothing. The students are led to discover facts with the help of experiments, apparatus and books. In this method the child behaves like a research scholar. In the stage managed heuristic method, a problem sheet with minimum instructions is given to the student and he is required to perform the experiments concerning the problem in hand. He must follow the instructions, and enter in his notebook an account of what he has done and results

arrived at. He must also put down his conclusion as to the bearing which the result has on the problem in hand. In this way he is led to reason from observation.

Essentially therefore, the heuristic method is intended to provide training in method. Knowledge is a secondary consideration altogether. The method is formative rather than informational. The procedures and skills in science problem solving can only be developed in class rooms where searching is encouraged, creative thinking is respected, and where it is safe to investigate, try out ideas.

Teachers' Attitudes:

One of the most important aspects of the problem solving approach to children's development in scientific thinking is the teacher's attitude. His approach should be teaching science with a question mark instead of with an exclamation point. The acceptance of and the quest for unique solutions for the problem that the class is investigating should be a guiding principle in the teacher's approach to his programme of science. Teachers must develop sensitiveness to children and to the meanings of their behavior. Teachers should be ready to accept any suggestion for the solution of problems regardless of how irrelevant it may seem to him, for this is really the true spirit of scientific problem solving. By testing various ideas it can be shown to the child that perhaps his suggestion was not in accord with the information available. It can then be shown that this failure gets as much closer to the correct solution by eliminating one possibility from many offered by the problem.

In this method teacher should avoid the temptation to tell the right answer to save time. The teacher should be convinced that road to scientific thinking takes time. Children should never be exposed to ridicule for their suggestions of possible answers otherwise they will show a strong tendency to stop suggestions.

For success of this method a teacher should act like a guide and should provide only that much guidance as is rightly needed by the student. He should be sympathetic and courteous and should be capable enough to plan and devise problems for investigation by pupils. He should be capable of good supervision and be able to train the pupils in a way that he himself becomes dispensable.

Merits of Heuristic Method:

- It develops the habit of enquiry and investigation among Students.
- It develops habit of self learning and self direction.
- It develops scientific attitudes among students by making them truthful and honest for they learn how to arrive at decisions by actual experimentations.
- It is psychologically sound system of learning as it is based on the maxim "learning by doing".
- It develops in the student a habit of diligence.
- In this method of the work is done in school and so the teacher has no worry to assign or check home task.

- It provides scope for individual attention to be paid by establishing cordial relations between the teacher and the taught.

Demerits of Heuristic Method:

- It is a long and time consuming method and so it becomes difficult to cover the prescribed syllabus in time.
- It pre-supposes a very small class and a gifted teacher and the method is too technical and scientific to be handled by an average teacher. The method expects of the teacher a great efficiency, hard work, experience and training.
- There is a tendency on the part of the teacher to emphasize those branches and parts of the subject which lend varieties of the subject which do not involve measurement and quantitative work and therefore not so suitable.
- It is not suitable for beginners. In the early stages, the students need enough guidance which if not given, may greatly disappoint them and it is possible that the child may develop distaste for studies.
- In this method too much stress is placed on practical work which may lead a student to form a wrong idea of the nature of science as a whole. They grow up in the belief that science is something to be done in the laboratory, forgetting that laboratories were made for science and not science for laboratories.
- The gradation of problems is a difficult task which requires sufficient skill and training. The succession of exercises is rarely planned to fit into a general scheme for building up the subject completely.
- Sometimes experiments are performed merely for sake of doing them Learning by this method pupils leave school with little or no scientific appreciation of their physical environment. The romance of modern scientific discovery and invention remains out of picture for them and the humanizing influence of the subject have been kept away from them.
- Evaluation of learning through heuristic method can be quite tedious.
- Presently enough teachers are not available for implementing learning by heuristic method.

This method cannot be successfully applied in primary classes but this method can be given a trial in secondary classes' particularly in higher secondary classes. However, in the absence of gifted teachers, well equipped laboratories and libraries and other limitations this method has not been given a trial in our schools. Even if these limitations are removed this method may not prove much useful under the existing circumstances and prevailing rules and regulations. Though not recommending the use of heuristic method for teaching of science it may be suggested that at least a heuristic approach prevails for teaching of science in our schools. By heuristic approach we mean that students be not spoon fed or be given a dictation rather they be given opportunities to investigate, to think and work independently along with traditional way of teaching.

Self- Check Exercise-3

Q.1 The word "heuristic" is derived from the Greek word "heurisco," meaning "_____."

Q.2 Who first coined the heuristic method?

a) John Dewey

b) Maria Montessori

c) Dr. H.E. Armstrong

d) Jean Piaget

12.6 Summary

As we have seen all above methods have their pros and cons. But, effectiveness of teaching depends upon the method that teacher adopts. Group teaching does not happen over right. For effective teaching, knowledge of different methods of teaching science in essential. The teacher however must be free to choose any method that he thinks is suited to the students. For many decades now, which is not practiced i.e., creating excitement of science, use of new and innovative methods must be practiced now.

Project method has certain steps to be followed by students. This method in based on philosophy of pragmatism. The sense practical's develops an attitude to undertake the activity and complete it scientifically.

In laboratory method, the student controls and observed the changes under investigation. Students learn by actual activity Students leam many virtues through laboratory activity.

Heuristic method of teaching is a very helpful and fun teaching approach that can help students to easily identify their interests and then work on learning more about them. This teaching approach has many benefits and teachers have vital roles to play as to help their students grow and succeed.

At the end, we can conclude that it is you teachers who have to keep in mind, which method is suitable to which type of students under what circumstance. Every method has its merits and demerits. The choosing of methods depends upon your intelligence, resourcefulness.

12.7 Glossary

Project Method: A teaching approach emphasizing learning through hands-on, real-world projects rather than traditional classroom instruction. It promotes interdisciplinary learning, student-centered exploration, collaboration, and practical application of knowledge.

Heuristic Method: A problem-solving approach that encourages learning through discovery, experimentation, and trial-and-error rather than following strict procedures. It aims to develop critical thinking, creativity, and problem-solving skills by allowing students to explore concepts independently.

12.8 Answers to self- check Exercise

Self-check Exercise-1

Answer1: planning

Answer2: students

Answer3: b) To encourage every child to participate in the discussion and make suggestions

Answer4: c) Tactfully guide them to choose a better project

Self-check Exercise-2

Answer1: minds-on

Answer2: c) By actual doing

Self-check exercise -3

Answer1: I find out

Answer2: c) Dr. H.E. Armstrong

12.9 References / Suggested Readings

- Das, R.C. Science teaching in schools, sterling publishers Pvt. Ltd, 1985.
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12.10 Terminal End Questions

1. Discuss the project method for teaching science. .
2. Describe the laboratory method of teaching science keeping its merits and demerits in mind.
3. What are the merits and demerits of Heuristic method of teaching science?

UNIT - 13
TECHNIQUES AND STRATEGIES OF TEACHING SCIENCES-I

Structure:

13.1 Introduction
13.2 Learning Outcomes
13.3 Drill and Practice
Self- check Exercise-1
13.4 Brain Storming
Self- check Exercise-2
13.5 Quiz Technique
Self- check Exercise-3
13.6 Summary
13.7 Glossary
13.8 Answers to self- check Exercise
13.9 References / Suggested Readings
13.10 Terminal End Questions

13.1 Introduction:

In recent years there has been a trend towards individualized instruction. Its main objective is that each child's learning is self-initiated and self-directed. The child should learn to learn independently at his own pace according to his interests and abilities. No two individuals are the same in their physical and intellectual make up, cognitive experiences or past learning, psychomotor skills, past successes and failure in learning, perception of the self etc. Since children differ in their prior experiences, they differ in what they need to learn and in what they already know. Thus, the only sole procedure in working with children is to give them opportunities to approach the learning things. Judicious guidance by the teacher plus ample planning with the children is the key to the organization of learning situations where children do what they need to do to learn best.

13.2 Learning Objectives

After going through this Unit, the learners will be able to:

- Develop an understanding of different techniques of teaching science.
- Develop an understanding of Drill and Practice.
- Explain the Brain Storming Technique.
- Understand Quiz technique and its types.

13.3 Drill and Practice:

The old saying "practice makes perfect" is applicable to teaching. Traditional instruction incorporated practice and drills for students to memorize or adopt concepts Practice, which can be defined as the use of an idea to gain familiarity and expertise, is still important in instruction. Drills, which are the repetitious and paced reviews of concepts, also have a place in the classroom. However, both methodologies should be applied strategically.

One level up from direct instruction is drill and practice. Though it might seem that this technique is even more rote in nature than direct instruction, the implication is that something has already been learned, or at the very least been presented, and now the emphasis is on repetition to sharpen the skill or provide a strong link to the information to improve remembering it.

With this particular technique there is not a great emphasis on abstraction or on the synthesis of new understanding. Your own experience with multiplication tables would be an example of drill and practice. There was not much mathematical theory being taught when you were required to memorize those products.

The Advantage of Practice:

Students benefit from practice because they are able to apply knowledge through interaction. Students connect with the material when they work with texts and concepts beyond a one-time exposure. When students practice using the knowledge through application, they connect with information on a deeper level. For instance, when learning about writing, students have to write. They have to hone the voice, tone and style of their writing. This cannot happen unless they revise, see examples and learn to improve their own work Students cannot transfer a lecture on good essay writing into an actual good essay without practical application.

The Advantage of Drills:

While drills are associated with a regimented style of instruction, they do have a place. Drills are used successfully when teaching students technique. For instance, when young people are learning their multiplication tables, they can do drills on each number set to help them memorize; they can then proceed to more difficult concepts that use the information obtained from drills In physical education and music, coaches and teachers use drills as a method to hone skills that need repetition for improvement. Additionally students can use this technique with one another for shared learning opportunities.

The Hurdles with Practice and Drills:

There are potential drawbacks to practice and drills. Teachers need to make sure that when having students practice, there is a clear link between concept and action. Students must be able to relate what they are doing to what they are learning. Similarly, drills are not effective when students are not prepared enough; they will not be able to maintain a pace if they are still unclear about a concept. Furthermore, drills are typically

for more basic knowledge or for a more physical understanding. If teaching about more abstract concepts, a drill methodology would not be appropriate.

Self- Check Exercise-1

Q.1 Drill and practice emphasize _____ to sharpen skills.

Q.2 What is the main focus of drill and practice in education?

A. Abstract thinking

B. Skill development through repetition

C. Creative problem-solving

D. Theoretical understanding

13.4 Brain Storming:

This is a strategy for generating ideas. In a classroom, the teacher can select a problem- oriented topic and ask the students to express themselves freely on various aspects of the topic. The teacher assures the students that their expression will not be criticized or commented upon a negative way. The views/opinions of the participants would not be viewed as relevant or irrelevant but the students are encouraged to come out with their ideas, opinions, feelings, expressions and comments. Brainstorming, founded in 1953 was popularized by A.F.Osborn.

Procedure:

Brainstorming is an instructional procedure similar in many ways to an exploratory discussion Brainstorming is used to generate a wide variety of creative ideas concerning a problem in a short period of time. The major purpose is to stimulate thinking and bring out a range of ideas. Students are encouraged to come up with exciting and radical ideas without fear of criticism or evaluation. The strategy is easily operationalised.

- Divide the class into small groups consisting of 5 to 8 members. Let them select a record and a chairperson.
- Explain the basic rules of brainstorming.
- Present the issue to be brainstormed. The recorder should record all ideas. Brainstorming does not include critical judgment and/or editing of ideas.
- At the first stage of brainstorming, even far out or wild ideas are also accepted.
- After students have had sufficient time to generate ideas, list all ideas on a chalkboard.
- A number of creative activities can be framed out of the brainstorming session such as presentation, discussion of ideas and making bulletin board displays.

For encouraging creative thinking and co-operation, brainstorming is an excellent strategy.

Guidelines for using Brain Storming:

- Identify the problem or issue to be brainstormed and present it in simple language.
- Write everything down, do not judge it or evaluate the ideas.
- Consider using more than one recorder so that no ideas are lost.
- Emphasize some basic rules, which should be enforced.

Stages in Brain Storming:

1. Warm-up: Attracting the members to the subject, arousing air interest and preparing them for free expression is the first stage. This is the duty of the anchor. The teacher can act as the anchor at the beginning to give an idea of this role toe student. The warm-up can be done through the narration of an appealing incident or a short story.

2. Ideation: This stage is of free expression of ideas. Ensure that all ideas are recorded.

3. Evaluation: In this stage, ideas expressed are evaluated Using the criterion formed through discussion, each idea is evaluated and the appropriate idea for problem solving is found out.

Principles of Brain Storming:

Brainstorming, to become effective is carried out on the basis of four principles.

1. Freewheeling: Once started, the brainstorming session should progress like the lubricated wheel. That is, expression of opinions should be possible without interruption. The idea may irrational, comical or strange. But all such ideas may be accepted.

2. No criticism. It must be ensured that expressions and gestures do not reflect a critical attitude.

3. Quantity breeds quality. The more number of ideas generated the number of qualitative ideas alos increase. Hence maximum number of ideas ld be collected person may be given opportunity to present ideas again. Prompting those students who remain silent, without hindering others is the duty of the anchor.

Rules

- No judgment or evaluation of ideas
- The sky is the limit. (Thinking is unlimited)
- The more ideas, the better.
- Keep the brainstorming process informal and relaxed
- Record all ideas.
- Use brainstorming when a lot of ideas are needed, or when time is limited.

Merits:

- It makes the pupil creative and innovative.
- It gives opportunity for pupils for analyzing and solving a problem.

- Useful in problem oriented themes.
- Recording of all ideas of pupils is considered.
- Encourages participation and can be used by all students.

Demerits:

- Difficulty in selecting a problem oriented topic
- Problem of discipline
- Lack of adequate library and laboratory
- Finding out a tentative solution is challenging.

Self- Check Exercise-2

Q.1 Brainstorming is a strategy for _____ ideas.

Q.2 Who popularized the technique of brainstorming?

A. John Dewey

B. William Kilpatrick

C. A.F. Osborn

D. Maria Montessori

13.5 Quiz Technique:

When the time comes to evaluate the amount of learning taking place in your class, don't forget the quiz. Short by definition, a quiz is a quick way of gathering information on how well your students are meeting their learning objectives.

A well designed quiz will help motivate your students, highlighting the subject areas and skill-sets in which they are particularly strong, while pointing out those in which they would benefit by spending more time.

Here are a few guidelines you may find useful:

- Match the quiz material to your teaching content.
- Keep it simple. Even thoughtful, one question quizzes can be informative.
- Think about the utility of pop-quizzes versus those given with advance notice.
- Assess net gains in knowledge by quizzing both before and after new material is presented.
- Provide timely and constructive feedback.
- Design quizzes that evaluate more than just student-recall.

The results of a well designed quiz often provide valuable insight on how effectively the course material is being presented. Poor across-the-board results may indicate areas

that would benefit from a pedagogical review and a change in teaching techniques or style.

Remember, in addition to keeping your finger on the pulse of your students' learning progress, quiz results help you assess your own teaching accomplishments as well.

Five Types of Quizzes That Deepon Engagement with Course Content:

1) Mix up the structure - To change up quiz structures on a regular basis Sometimes it's the usual objective questions, other times its short-answer questions, or it might be a question that asks for an opinion response to the reading Some quizzes are open-book: a few are taking home. What an interesting way to give students experience responding to different kinds of test questions and to keep quiz experiences from becoming stale.

2) Collaborative quizzing - Lots of different options are being used here. Students do the quiz, turn it over, stand up and talk with a partner, to others in a small group, or with whomever they choose. After the discussion, they return to their quiz and may change any of their answers. Alternatively, students do the quiz individually, turn it in, and then do the same quiz in a small group. The two quiz scores are combined with the individual score counting for 75% of the grade and the group quiz 25% (or some other weighted variation) Collaborative quizzing is an effective way to generate enthusiastic discussion of course content and reduce test anxiety.

3) Quizzing with resources - Students take detailed notes on the reading because they're allowed to use those notes during the quiz. The same approach works with quizzes that cover content presented during class. Students may use their class notes while taking the quizzes. The pay-off is a good (or better) set of notes for use doing exam preparation. Open-note quizzing coupled with collaboration resulted in significantly higher final exam scores in his quantitative research methods course.

4) Quizzing after questioning - Before the quiz occurs, students are given the opportunity to ask questions about potential quiz content. The instructor and the class work on finding the right answer or discussing the merits of possible responses. If someone asks a question that stimulates a lot of good discussion, that question becomes the quiz question and students have the designated amount of time to write an answer. Or if a variety of good questions have been asked, answered, and discussed by a variety of students, the professor who shared this option may tell students they've just had their quiz and everyone present gets full credit. This approach encourages students to ask better questions and facilitates substantive classroom discussions.

5) Online quizzes completed before class - Students complete an online quiz before class. The quizzes are graded electronically with a compiled summary going to the professor so there's enough time to look at the most frequently missed problems and/or to identify areas of misunderstanding. Then class time can be used to address those that are giving students the most trouble.

The advantage of regular quizzes is that they provide ongoing opportunities for retrieval practice and much cognitive psychology research documents the benefits of frequent testing. Regular quizzing does improve class attendance and it gets more students coming to class prepared. Those are not trivial benefits, but with a few different design features quizzes can also promote deeper engagement with the content, further the development of important learning skills, and provide teachers and students with feedback that promotes learning.

Self- Check Exercise-3

Q.1 A quiz is a quick way of gathering information on how well your students are meeting their _____ objectives.

Q.2 What is one advantage of using quizzes in teaching?

A. They replace other forms of assessment entirely.

B. They are lengthy and detailed.

C. They motivate students and provide quick feedback.

D. They require extensive preparation.

13.6 Summary

Thurber and Collete have rightly stated that, "Science can justify its place in the curriculum only when it produces important changes in young people changes in their ways of thinking, in their habits of action and in the values they assign, to what they have and what they do. Hence it is true that the cultivation of scientific attitude among the learners is an important aspect of science education.

13.7 Glossary:

Drill and Practice: A teaching and learning technique that involves repetitive exercises and activities designed to reinforce and solidify knowledge or skills. It typically involves structured repetition of tasks, such as solving mathematical problems, memorizing vocabulary, or practicing musical scales. The goal is to enhance mastery and automaticity by providing repeated exposure to the material, which can improve retention and fluency in the subject matter. This approach is often used in educational settings to help students achieve proficiency in foundational concepts before advancing to more complex tasks or topics.

Brainstorming: A creative problem-solving technique used to generate a large number of ideas or solutions to a specific problem or challenge. Participants in a brainstorming session are encouraged to express their ideas freely, without criticism or evaluation at the initial stage. The goal is to foster creativity, encourage diverse perspectives, and

stimulate innovative thinking by leveraging the collective knowledge and creativity of the group. Brainstorming sessions can be structured or informal and often involve techniques to spark ideas, such as mind mapping, rapid ideation, or free association.

Quiz Techniques: Various methods used to assess knowledge, understanding, and retention through structured questioning formats. Quiz techniques can include multiple-choice questions, short-answer questions, true/false statements, and more interactive formats like quizzes with multimedia elements or gamified elements. They are commonly used in educational settings to reinforce learning, gauge comprehension, and identify areas needing further review or clarification.

13.8 Answers to Self- Check Exercise

Self-check Exercise-1

Answer1: repetition

Answer2: B. Skill development through repetition

Self- Check Exercise-2
Answer1: generating

Answer2: C. A.F. Osborn

Self-check Exercise-3

Answer1: learning

Answer2: C. They motivate students and provide quick feedback.

13.9 References / Suggested Readings

- Das, R.C. Science teaching in schools, sterling publishers Pvt. Ltd, 1985.
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13.10 Terminal Questions

1) What do you mean by the techniques of teaching sciences?
2) Enumerate the different Techniques and strategies used for teaching science.
3) Explain the importance of drill and Practice in of Sciences.

UNIT - 14

TECHNIQUES AND STRATEGIES OF TEACHING SCIENCES-II

Structure

14.1 Introduction
14.2 Learning Objectives
14.3 Play Way Technique
Self- check Exercise-1
14.4 Activity Based Technique
Self- check Exercise-2
14.5 Ways of Developing Scientific Attitude and Aptitude among Children
Self- check Exercise-3
14.6 Summary
14.7 Glossary
14.8 Answers to self- check Exercise
14.9 References / Suggested Readings
14.10 Terminal Questions

14.1 Introduction

Teaching techniques are the unique ways of carrying out a particular task, in the teaching and learning process. Thus, it's the individual teachers' unique way of applying a strategy. For instance, two teachers may decide to use small group discussions as their means of delivering a lesson but each may have a unique way of conducting the process of the discussion. One may decide to use two pupils to conduct the discussion; the other may decide to employ four pupils for that. Teaching strategy is a careful plan of teaching activities to be undertaken which ensures effective teaching and learning. It is a plan of action designed to achieve a specific goal or series of goals. At the planning stage of every lesson the teacher decides what method of teaching to adopt, whether teacher centered or child centered.

14.2 Learning Objectives:

After going through this Unit, the Learners will be able to:

- Develop an understanding of importance of Play Way Technique.
- Develop an understanding of and apply the Activity Based Technique in Science Teaching.
- Describe ways of Developing Scientific Attitude and Aptitude among Children

14.3 The Play-Way Method of Education: Make Learning Fun

Play way in education aims to introduce the spirit of play in all educational institutions. The methods and techniques used for imparting education must be able to create an environment in which the child can learn his lesson or acquire the desired knowledge.

The Importance of Play in Education:

We know the spirit of childhood is play and thus play-way in education insists on child centered education. It advocates educating children through activities in which children can put their heart and soul and work in an atmosphere of freedom and spontaneity.

The modern of teaching like kindergarten method, Montessori Method, Dalton plan, Heuristic method, Project method and our craft-centered basic education are all attempts to imbibe play spirit in education.

Education should be fun and not forced. Any activity done in a spirit of fun is not work at all, on the other hand, activities in which the spirit of play is forced or absent should be considered work.

Games as Learning:

Activities undertaken in school in the form of hobbies, dramatization, scouting, girl guides, self government, excursion and other curricular activities, teach the important concept that for education to be most effective, education should be fun and not forced.

The Play Way Method is a pedagogical approach that emphasizes learning through play and practical activities. When applied to teaching sciences, especially to younger students, this method leverages their natural curiosity and desire to explore the world around them. Here's how the Play Way Method can be used effectively in teaching sciences:

1. **Hands-on Activities:** Provide students with hands-on experiments and activities that allow them to directly interact with scientific concepts. For example, conducting simple experiments like observing plant growth, mixing substances to observe chemical reactions, or exploring magnets and their properties.
2. **Role Play and Simulations:** Encourage students to role-play as scientists, engineers, or even as elements of nature (like water molecules or planets). This helps them understand scientific processes and phenomena from different perspectives.
3. **Games and Puzzles:** Integrate educational games and puzzles that reinforce scientific principles. This could involve board games, interactive online quizzes, or puzzles related to topics such as anatomy, physics laws, or environmental science.
4. **Field Trips and Outdoor Learning:** Take students on field trips to natural habitats, museums, science centers, or even just outside in the schoolyard to observe and explore scientific phenomena in real-world contexts.

5. **Storytelling and Narratives:** Use storytelling to explain scientific concepts in a narrative format. This could involve creating stories about famous scientists, historical discoveries, or imaginary scenarios related to the scientific topic being studied.
6. **Art and Creativity:** Integrate art projects with scientific learning. For example, asking students to create models of the solar system, draw biological diagrams, or design eco-friendly inventions encourages them to apply their scientific knowledge in creative ways.
7. **Collaborative Learning:** Encourage collaborative learning through group projects where students work together to solve scientific problems or present their findings to their peers.
8. **Experiential Learning:** Emphasize learning by doing. Allow students to explore and experiment with materials and tools under guided supervision to develop their scientific skills and understanding.

Overall, the Play Way Method fosters a positive and engaging learning environment where students actively participate in their own learning process. By making science enjoyable and accessible through play, students are more likely to develop a lifelong interest in scientific exploration and discovery.

Educational games serve a good purpose in this direction.

For example, stage play can be used for history and mother tongue. Mathematical games can be used to learn or practice various mathematical facts. We can arrange competition between groups in the class or between different classes in the school and thus make the children interested in knowing so many things of general interest or related with some specific subjects.

In this way play can be used as an effective medium or platform for imparting valuable education to our youngsters. Not only does it pave the way for imparting effective and enduring education; it helps in realizing the broader aims of education. It helps bring the harmonious development of the personality of children by taking care of their physical, mental, emotional, social and moral development. It also provides opportunities for the modification of their behavior and prepares them for getting adjusted to their environment and life. Thus play and the play way can be regarded as an effective means of educating children.

Self- check Exercise-1

Q.1 What is the primary aim of the play-way method in education?

A) To enforce strict discipline

B) To introduce the spirit of play

C) To focus solely on academic achievement

D) To minimize physical activities

Q.2 Which of the following educational methods shares similarities with the play-way method?

A) Lecture method

B) Drill and practice method

C) Project method

D) Examination method

Q.3 The play-way method insists on _____ education, emphasizing activities where children can engage freely.

Q.4 Educational games and activities like stage plays and mathematical games help in making learning _____.

Q.5 What is the main concept emphasized by the play-way method in education?

Q.6 Give an example of an educational activity that embodies the spirit of play.

14.4 ACTIVITY BASED TECHNIQUE:

Activity method is a technique adopted by a teacher to emphasize his or her method of teaching through activity in which the students participate rigorously and bring about efficient learning experiences. It is a child-centered approach. It is a method in which the child is actively involved in participating mentally and physically. Learning by doing is the main focus in this method. Learning by doing is imperative in successful learning since it is well proved that more the senses are stimulated, more a person learns and longer he/she retains. Pine G (1989) mentions that in an activity-based teaching, learners willingly with enthusiasm internalize and implement concepts relevant to their needs.

So, our understanding on the activity method by now should mean any learning that is carried out with a purpose in a social environment, involving physical and mental action, stimulating for creative accession or expression.

Activity-based teaching and learning in sciences emphasizes hands-on, experiential approaches to engage students actively in the process of learning scientific concepts. Here's how activity-based teaching can be effectively applied in science education:

Principles of Activity-Based Teaching and Learning:

1. **Hands-On Experiments and Activities:**
   - **Example:** Conducting experiments such as observing chemical reactions, measuring plant growth, or exploring the principles of force and motion through practical demonstrations.
2. **Inquiry-Based Learning:**
   - **Example:** Encouraging students to ask questions, design investigations, and seek answers through their own exploration and experimentation.
3. **Problem-Solving Tasks:**
   - **Example:** Presenting students with real-world problems related to scientific concepts, where they need to apply their knowledge and skills to find solutions.
4. **Collaborative Learning:**
   - **Example:** Engaging students in group activities where they work together to solve problems, discuss findings, and share insights, fostering teamwork and communication skills.
5. **Use of Models and Simulations:**
   - **Example:** Using physical models, digital simulations, or interactive apps to illustrate complex scientific phenomena that are difficult to observe directly.
6. **Field Trips and Outdoor Learning:**
   - **Example:** Taking students on field trips to natural environments, science museums, or local laboratories to observe and explore scientific concepts in real-world contexts.
7. **Integration of Technology:**
   - **Example:** Utilizing tools such as virtual reality (VR), augmented reality (AR), or online simulations to enhance understanding and engagement in scientific topics.

Benefits of Activity-Based Teaching and Learning in Sciences:

- **Enhanced Engagement:** Students are more actively involved in their learning, which can increase motivation and interest in science.
- **Deepened Understanding:** Hands-on experiences allow students to visualize abstract concepts and develop a deeper understanding of scientific principles.
- **Critical Thinking Skills:** Activities that involve problem-solving and inquiry encourage students to think critically, analyze data, and draw conclusions based on evidence.
- **Retention of Knowledge:** Active participation in learning activities helps students retain information better than passive learning methods.
- **Promotion of Skills:** Collaborative activities promote communication, teamwork, and leadership skills, which are valuable in both academic and real-world settings.

By implementing activity-based teaching and learning strategies, educators can create a dynamic learning environment that sparks curiosity, promotes exploration, and cultivates a deeper appreciation for the sciences among students.

Why do we need to use activity-based learning method?

The information processing theory in psychology views learners as active investigators of their environment. This theory is grounded in the premise that people innately strive to make sense of the world around them.

In the process of learning, they experience, memorize and understand. Students need to be provided with data and materials necessary to focus their thinking and interaction in the lesson for the process of analyzing the information. Teachers need to be actively involved in directing and guiding the students' analysis of the information.

It requires active problem solving by students in finding patterns in the information through their own investigation and analysis. With continued practice in these processes, students learn not the content of the lesson but also develop many other skills.

- It enhances creative aspect of experience
- It gives reality for learning.
- Uses all available resources.
- Provides varied experiences to the students to facilitate the acquisition of knowledge, experience, skills and values.
- Builds the student's self-confidence and develops understanding through work in his/her group.
- Gets experiences, develop interest, enriches vocabulary and provides stimulus for reading.
- Develops happy relationship between students and students, teachers and students.
- An activity is said to be the language of the child. A who lacks in verbal expression can make up through use of ideas in the activity.
- Subjects of all kind can be taught through activity.
- Social relation provides opportunity to mix with others.

Kinds of activities:

The activities used in this strategy can be generalized under three main categories:

Exploratory - gathering knowledge, concept and skill.
Constructive - getting experience through creative works.
Expressional - presentations.

The Activities you could focus on:

Experiencing: watching, observing, comparing, describing. questioning, discussing. investigating, reporting, collecting, selecting, testing, trying, listening, reading, drawing, calculating, imitating, modeling, playing, acting, taking on roles, talking, writing about what one can see, hear, feel, taste, experimenting and imagining.

Memorizing: Sequencing ordering, finding regularities and patterns, connects with given knowledge, use different modes of perception, depict.

Understanding: Structuring, ordering, classifying, constructing, solving, planning, predicting, transferring, and applying knowledge, formulating ones individual understanding, interpreting, summarizing, evaluating, judging, explaining and teaching.

Organizing activities:

The process of organizing activities must be based on curricular aims bringing together the needs, ideas, interests and characteristics of the children with the knowledge, skill, experience, and personality of the teacher within a given environment. The extent to which the teacher works with students individually or in groups affect the relation the teacher has with each child.

Steps for Effective It is a child-centered approach

- Planning.
- Involving children in the learning process.
- Each child is made an active learner.
- For each activity ensure you follow the principles of:
- What?
- How? Work directions step by step, including:
- With whom? Where? How long?
- What after?
- Ensure you give clear instructions before each activity.

Role of a Teacher in an Activity Based Method:

A planner, an organizer and evaluator

- Facilitator.
- Decision maker.
- Knowledge imparter
- Disciplinarian

Self- check Exercise-2

Q.1 What is the main focus of the activity-based technique?

A) Memorization

B) Learning by doing

C) Lecture-based learning

D) Testing and exams

Q.2 According to Pine G (1989), how do learners engage with concepts in an activity-based teaching environment?

A) Passively and without interest

B) Reluctantly and with hesitation

C) Willingly and with enthusiasm

D) Solely through listening to lectures

Q.3 The activity-based technique is a _____-centered approach where students participate actively in learning.

Q.4 In an activity-based technique, learning is carried out with a purpose in a _____ environment, involving physical and mental action.

Q.5 What is the key phrase that describes the main focus of the activity-based technique?

Q.6 Who mentioned that learners internalize and implement concepts relevant to their needs in an activity-based teaching environment?

14.6 SUMMARY

In modern times the chief aim of education is to enable a citizen to develop a scientific attitude of mind to think objectively and base one's conclusions on tested data With the development of such a scientific attitude an individual is able to have the understanding and the individual integrity to sift truth from falsehood, facts from propaganda, and to reject the dangerous appeal of fanaticism and prejudice. In short, the more the scientific attitude of an individual is developed, the more would be the integrity of that person. Of all the different means and techniques which influence cultivation of scientific attitude, I consider that the values, the quality, the character and the attitude of the science teachers are undoubtedly the significant factors.

14.7 Glossary

 Play **Way Method:** A pedagogical approach that utilizes play and games to engage students in learning activities, promoting natural curiosity and exploration.

 Activity**-Based Learning (ABL):** A teaching strategy that emphasizes hands-on activities, experiments, and problem-solving tasks to facilitate learning and understanding.

14.8 Answers to self- check Exercises

Exercise -1

Answer1: B) To introduce the spirit of play

Answer2: C) Project method

Answer3: child centered

Answer4: fun

Answer5: Play

Answer6: Stage play

Exercise -2

Answer1: B) Learning by doing

Answer2: C) Willingly and with enthusiasm

Answer3: child

Answer4: social

Answer5: Doing

Answer6: Pine

14.9 References / Suggested Readings

1. Das, R.C. Science teaching in schools, sterling publishers Pvt. Ltd, 1985.
2. Kulshreshtha, S.P. Teaching of science, and pasricha H, surya publication, 2007.
3. Sharma, R.C, Modem Science teaching, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2006.
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5. Zaidi, S.M. Modern teaching of science Anmol Publications Pvt. Ltd, New Delhi, 2004.

14.10 Terminal Questions

 How **can you integrate play and exploration into science lessons to engage young learners effectively?**

 What **are some examples of role-playing activities that could be used to teach scientific concepts in an engaging way?**

 What **role does technology play in enhancing activity-based learning experiences in science education?**

 How **do you assess student learning effectively during hands-on activities without relying solely on traditional tests?**

 In **what ways can collaborative projects in science classes help students develop both scientific knowledge and interpersonal skills?**

UNIT-15

WAYS OF DEVELOPING SCIENTIFIC ATTITUDE AND APTITUDE AMONG CHILDREN

Structure:

15.1 Introduction
15.2 **Learning objectives**
15.3 Ways of Developing Scientific Attitude and Aptitude among Children
Self- check Exercise-1
15.4 Summary

15.5 Glossary

15.6 Answers to self- check Exercise

15.7 References / Suggested Readings

15.8 Terminal Questions

15.1 Introduction

Attitude and scientific attitude are foundational to how individuals perceive, engage with, and contribute to the realm of science. Attitude encompasses one's predisposition towards a subject or idea, comprising cognitive, affective, and behavioral components shaped by experiences, education, and societal influences. In contrast, scientific attitude specifically embodies traits such as curiosity, skepticism, open-mindedness, and a systematic approach to inquiry. This mindset encourages individuals to question assumptions, evaluate evidence rigorously, and embrace uncertainty in pursuit of knowledge. While attitudes can encompass a wide range of perspectives, scientific attitude focuses on cultivating skills and dispositions crucial for scientific exploration and discovery, fostering both individual growth and collective advancement in scientific understanding and innovation. Thus, nurturing positive attitudes towards science and promoting a scientific attitude are pivotal in fostering a society that values critical thinking, evidence-based reasoning, and informed decision-making.

15.2 Learning Objectives

After Completing this Unit, the Learners will be able to;

- Understand the Concept of Attitude and Scientific Attitude
- Differentiate Between Attitude and Scientific Attitude
- Know About the Different Ways of Developing Scientific Attitude

15.3 Attitude:

1. **Definition**: Attitude refers to a person's predisposition or tendency to respond positively or negatively toward a certain idea, object, person, situation, or event.
2. **Components**: Attitudes typically involve three components:
   Cognitive Component: This involves beliefs or knowledge about the object of the attitude. For example, believing that science is important for understanding the natural world.

   Affective Component: This is the emotional or feeling component related to the attitude. It includes feelings of liking or disliking toward science.

   Behavioral Component: This component involves actions or behaviors influenced by the attitude. For instance, actively participating in science-related activities or discussions.

3. **Formation**: Attitudes can be formed through direct experiences, social interactions, education, and cultural influences. They can also evolve over time based on new information and experiences.
4. **Impact**: Attitudes play a crucial role in shaping behavior, decision-making, and interactions with others. In educational contexts, attitudes toward subjects like science can significantly impact learning outcomes and career choices.

Scientific Attitude:

1. **Definition**: Scientific attitude refers to the mindset or disposition characterized by curiosity, skepticism, open-mindedness, and a systematic approach to inquiry and problem-solving.
2. **Key Characteristics**:

Curiosity: A desire to explore, investigate, and understand the natural world.**Skepticism**: A critical evaluation of information and claims, requiring evidence and reasoning to support beliefs.

Open-Mindedness: Willingness to consider new ideas, perspectives, and evidence even if they challenge existing beliefs.

Objectivity: Striving to be impartial and unbiased in evaluating evidence and drawing conclusions.

Systematic Approach: Using systematic methods, such as the scientific method, to conduct experiments, gather data, and analyze results.

3. **Development**: Scientific attitude is nurtured through education and exposure to scientific methods and practices. It involves developing skills in observation, experimentation, analysis, and communication of findings.

4. **Application**: Scientific attitude is crucial not only for scientists but also for informed decision-making in everyday life, addressing societal challenges, and promoting evidence-based reasoning in public discourse.

Relationship:

- **Overlap**: Attitudes can influence the adoption of a scientific attitude. Positive attitudes toward science can foster the development of a scientific mindset characterized by curiosity, skepticism, and a desire for evidence-based reasoning.
- **Mutual Reinforcement**: Cultivating a scientific attitude can, in turn, influence one's overall attitudes toward science and related fields, leading to deeper engagement and appreciation for scientific inquiry.

In summary, while attitudes encompass broader predispositions toward various aspects of life, scientific attitude specifically refers to the mindset essential for scientific inquiry, critical thinking, and evidence-based reasoning. Both are integral to fostering a supportive environment for science education and promoting a deeper understanding of the natural world.

Ways of Developing Scientific Attitude and Aptitude Among Children:

What is Attitude?

Attitude is a psychological constituent inferred from the observable responses to specific stimuli. It is personal disposition which impels an individual to react to an object, or situation in favourable and unfavourable ways.

What is scientific attitude?

Scientific attitudes are the most important outcomes of science teaching. Scientific Attitudes predispositions (tendency inclination, mental set or habit of mind) to think and act in a certain way. It can be just a 'mind set' in a particular direction or it can be a way of life Scientific attitudes have been described as what is left after everything else has been forgotten, eg. What is left from the chemistry, physics and biology courses.

Emina (1986) classified the various components of scientific attitude into five:

Rationality: These includes commitment to rationality in problem solving, seeking for natural causes of events and identification of cause-effect relationship, belief in science as a means of influencing environment, awareness of fallibility of human effort, challenge of authority.

Curiosity: These include desire for new knowledge or ideas, desire for additional information, seeking for evidence to support conclusions made from scientific materials, expression of interest in scientific discoveries and the desire for explanations.

Open Mindedness: These include willingness to subject data and opinion to criticism and evaluation to others, willingness to consider new evidence, rejection of singular and rigid approach to people, things and ideas.

Objectivity: These include preference for statements supported by evidence over unsupported ones, sensitivity to accuracy of data, preference for scientific generalization that have withstood the test of critical review.

Aversion to superstition: These include rejection of superstitious beliefs, and preference for scientific explanations.

Ways and Means to Cultivate Scientific Attitude:

- **Wide Reading:** Learners should be encouraged to read extra books and periodicals in science. Certain articles on scientific topic can be gathered and kept by students.
- **Study on Superstitions**: students may be encourage to investigate some common superstitions in the course of learning particular lessons, and come to their own conclusion by actual survey and study.
- **Practicals**: proper use of laboratory can offer many opportunities for developing scientific attitudes. Practical work should be done with intellectual honesty. The teacher should suggest projects for experimentation and problem solving.
- **Cocurricular activities:** club activities (science club, Eco club, forest club etc.) science related hobbies, science fairs, study tour and field trips, museum techniques, maintain garden, live corners etc. help to inculcate scientific attitudes.
- **The Class Room atmosphere**: child-centered methods, freedom of expression, internal setting, respecting student's views, encouraging intelligent questions etc. can create an atmosphere conducive to the development of scientific attitudes.
- **Personal Influence of The Teacher**: the teacher should encourage the spirit of creative criticism, enquiry and investigation among students. The personal example of the teacher, his/ her beliefs, and attitudes will help in the development of scientific attitudes.

Techniques to Inculcate Scientific Attitude:

- **Improvisation:** improvisation is the designing and production of ordinary laboratory apparatus and other instructional material from simple articles found in our surroundings. The learners are to be introduced to motivate their scientific attitude through the life examples of great scientists who in spite of lack of expensive apparatus and elaborate laboratories, carried out their experiments in the humblest of conditions with homemade apparatus.
- **Modern Technology:** Through the various applications of technology (video clippings, blog, web site etc) scientific attitude can be cultivated among learners.
- **Organizing conferences:** Science conferences can tie organized to discuss human scientific and technological problems and new innovations. This would enable the learners to develop the tendency to study a fact or concept in broader prospective.
- **Seminar**: it is an instructional technique which involves paper reading on a theme followed by the group discussion to clarify the complex aspects of the theme.

This would enable the learners to develop the sense of tolerance and respect the ideas of others.

- **Symposium:** this technique forum serves as an excellent device for informing an audience, crystallizing opinions and preparing the listeners to arrive at decision, value, judgment or understanding. Its main purpose is to provide understanding to the students/listeners on theme to develop certain values and feelings.
- **Workshop:** it is an assembled group of 10 to 25 persons who share a common interest or topic and meet together to improve their individual skill of a subject through intensive study, research, practice and discussion. It would enable the participants to develop the attitude of open mindedness.
- **Educational Panel Discussion**: Panel discussion would enable the learners to develop the manners of putting questions and answering questions.

15.6 Summary

In modern times the chief aim of education is to enable a citizen to develop a scientific attitude of mind to think objectively and base one's conclusions on tested data With the development of such a scientific attitude an individual is able to have the understanding and the individual integrity to sift truth from falsehood, facts from propaganda, and to reject the dangerous appeal of fanaticism and prejudice. In short, the more the scientific attitude of an individual is developed, the more would be the integrity of that person. Of all the different means and techniques which influence cultivation of scientific attitude, I consider that the values, the quality, the character and the attitude of the science teachers are undoubtedly the significant factors.

Self- check Exercise-1

Q.1 What is attitude inferred from?

A) Personal beliefs

B) Observable responses to specific stimuli

C) Cultural norms

D) Social interactions

Q.2 How does attitude influence an individual?

A) It determines their physical health

B) It impels them to react to an object or situation in favorable or unfavorable ways

C) It affects their social status

D) It dictates their daily routine

Q.3 Attitude is a _____ disposition which impels an individual to react to an object or situation.
Q.4 Attitude is inferred from the observable responses to specific _____.
Q.5 Which of the following is a component of scientific attitude according to Emina (1986)?
A) Superstition

B) Rationality

C) Bias

D) Rigidity

Q.6 What does open-mindedness in scientific attitude include?
A) Sticking to one's initial opinion

B) Rejection of new evidence

C) Willingness to subject data and opinion to criticism and evaluation

D) Preference for unsupported statements

Q.7 Scientific attitudes are the most important _____ of science teaching.
Q.8 Objectivity in scientific attitude includes preference for statements supported by _____ over unsupported ones.
Q.9 What is the term for the scientific attitude that includes the rejection of superstitious beliefs?
Q.10 Which component of scientific attitude involves the desire for new knowledge or ideas?

15.5 Glossary

Attitude: A predisposition or tendency to respond positively or negatively toward a certain idea, object, person, situation, or event.

Scientific Attitude: A mindset characterized by curiosity, skepticism, open-mindedness, and a systematic approach to inquiry and problem-solving.

15.6 Answers to self- check Exercise

Answer1: B) Observable responses to specific stimuli
Answer2: B) It impels them to react to an object or situation in favorable or unfavorable ways
Answer3: personal

Answer4: stimuli
Answer5: B) Rationality
Answer6: C) Willingness to subject data and opinion to criticism and evaluation
Answer7: outcomes
Answer8: evidence
Answer9: Aversion
Answer10: Curiosity

15.7 References / Suggested Readings

1. Das, R.C. Science teaching in schools, sterling publishers Pvt. Ltd, 1985.
2. Kulshreshtha, S.P. Teaching of science, and pasricha H, surya publication, 2007.
3. Sharma, R.C, Modem Science teaching, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2006.
4. Yadav, M.S. Teaching of Science, Anmol Publications Pvt Ltd, New Delhi, 2004.
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15.8 Terminal Questions

- What are the different ways and means to cultivate Scientific Attitude among students?

UNIT -16
UNIT PLANNING IN SCIENCES

Structure:

16.1 Introduction
16.2 **Learning Objectives**
16.3 Unit Planning in Science
Self- check Exercise-1
16.4 Criteria of a Good Unit Plan
Self- check Exercise-2
16.5 Steps of Developing a Teaching Unit
Self- check Exercise-3
16.6 Summary
16.7 **Glossary**
16.8 Answers to self- check Exercise
16.9 References / Suggested Readings
16.10 Terminal Questions

16.1 Introduction:

If you are keen in making lesson plans which may help you in achieving your identified objectives, then they should be stated clearly. If objectives are not clearly defined, it is impossible to evaluate a student, a lesson, a unit, a course or a programme effectively. This leads to teaching disaster. Unless you have clear picture of instructional intention, you will be unable to select test items. If the objectives are clearly defined, then students know which activities are relevant for success of the teaching learning process.

A meaningfully stated objective is that clearly communicate the readers the writer's intention- It states the behavioral outcome of students after completing a chapter. The most important characteristics of useful objectives are that it identifies the kind of performance that will be accepted as evidence that the learner has achieved the objective.

According to B.S. Bloom

"Educational objectives are not only the goals towards which curriculum is shaped and towards which instruction in guided, but they are also the goals that provide, the detailed specification for the construction and use of education techniques."

According to E.J. Frust,

An educational objective may be defined as a desired change in behavior in a person that we are trying to bring about through education".

If we look back at the objectives of teaching science in early twentieth century, then we see major stress was on teaching of facts. As the time passed and various committee and commissions recommended changes according to need of changing time, still we see the stress was on acquisition of knowledge.

16.2 LEARNING OUTCOMES

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

- Define a teaching unit of science.
- List down criteria of a good Unit Plan.
- Describe steps of developing a teaching unit

16.3 Unit Planning in Science:

Unit planning in science involves the systematic organization and preparation of instructional activities, assessments, and resources to effectively teach a specific topic or set of topics within the science curriculum. It begins with identifying clear learning objectives that align with curriculum standards and student needs, ensuring that these objectives are specific, measurable, achievable, relevant, and time-bound (SMART).

During the planning phase, educators design engaging and interactive lessons that cater to diverse learning styles and abilities. This often includes selecting appropriate instructional strategies such as hands-on experiments, demonstrations, simulations, inquiry-based investigations, and multimedia resources to enhance understanding and foster scientific inquiry. Integration of technology, including digital tools and online resources, can also enrich the learning experience by providing opportunities for virtual experiments, data analysis, and collaborative projects.

Assessment is an integral part of unit planning in science, with both formative and summative assessments used to monitor student progress, provide timely feedback, and evaluate learning outcomes. Formative assessments, such as quizzes, discussions, and observations during experiments, inform instructional adjustments and help identify areas where students may need additional support or clarification. Summative assessments, such as tests or projects, evaluate student mastery of the unit content and guide future instruction.

Furthermore, effective unit planning in science considers differentiation to meet the diverse needs of learners, including modifications in content, process, or product based on students' readiness, interests, and learning profiles. Collaboration with colleagues and stakeholders, such as parents or community experts, can also enrich unit planning by providing diverse perspectives, resources, and real-world applications of scientific concepts.

A Unit includes the procedure of presentation of the subject matter. It is both a block of content as well as method. 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.The meaningful activities are related are related to one another within a unit. These activities provide the purposeful learning experiences and the learner understands the whole concept. This theory originates the concept of "Unit Plan".

The unit plan is based on two streams of thoughts: Herbart propounds the first approach. He stresses on the content and information in a unit plan. John Dewy and Kilpatrick gave the second approach. They have emphasized on the experiences of learners in a unit plan rather than information.

B.F. Skinner has provided a recent approach to a unit plan. The focus of his unit plan is the modification of behavior. His major assumption about learning is that the student learns better if the content is provided in small units. The unit-plan is the crucial aspect of a lesson plan.

Definitions

"A unit is as large a block of related subject matter as can be over viewed b the learner".

Preston

"Outline of carefully selected subject matter which has been isolated because of its relationship to pupils' needs and interests".

Sanford

"The unit is an organized body of information and experience designed to effect significant outcomes for the learner"

Wisely

Thus, a teaching unit keeps in view the needs, capabilities and interest of pupils. It provides organized body of information and experience. This aims at significant outcome from the learners.

In summary, unit planning in science is a dynamic and collaborative process that aims to create engaging learning experiences, foster scientific curiosity and inquiry, and promote meaningful understanding of scientific concepts among students. It aligns instructional goals with assessment strategies and incorporates innovative teaching methods to support student learning and achievement in science education.

Self- check Exercise-1

Q.1 What is a unit in the context of education?

A) A single lesson

B) A block of related subject matter

C) An unrelated collection of topics

D) A method of discipline

Q.2 Who emphasized the modification of behavior in unit plans?

A) Herbart

B) John Dewey

C) B.F. Skinner

D) Kilpatrick

Q.3 A unit plan is based on the needs, capabilities, and _____ of pupils.

Q.4 According to Sanford, a unit is an outline of carefully selected subject matter isolated due to its relationship to pupils' needs and _____.

Q.5 Which educational theorist emphasized the content and information in a unit plan?

Q.6 What is the main focus of B.F. Skinner's approach to unit plans?

16.4 Criteria of a Good Unit Plan:

A good unit plan in education, including science, incorporates several key criteria to ensure effective teaching and learning experiences. Here are some essential criteria for a well-designed unit plan:

1. **Clear Learning Objectives**: Clearly defined and specific learning objectives that align with curriculum standards and articulate what students are expected to know, understand, and be able to do by the end of the unit.
2. **Alignment with Curriculum Standards**: Ensuring that the unit plan addresses relevant curriculum standards, learning outcomes, and educational goals appropriate for the grade level and subject area.
3. **Differentiated Instruction**: Providing opportunities for differentiation to accommodate diverse learner needs, including modifications in content, process, and product based on students' readiness, interests, and learning profiles.
4. **Engaging and Relevant Content**: Incorporating engaging and relevant content that connects to students' prior knowledge, interests, and real-world applications, fostering intrinsic motivation and curiosity.

5. **Varied Instructional Strategies**: Utilizing a variety of instructional strategies and methods, such as hands-on activities, inquiry-based learning, demonstrations, discussions, simulations, and use of technology, to cater to different learning styles and promote active student engagement.
6. **Assessment and Feedback**: Incorporating both formative and summative assessments throughout the unit to monitor student progress, provide timely feedback, and inform instructional decisions. Assessments should align with learning objectives and allow for demonstration of understanding through multiple means.
7. **Integration of Technology**: Integrating appropriate technology tools, resources, and digital platforms to enhance learning experiences, support inquiry, facilitate collaboration, and provide opportunities for virtual simulations, data analysis, and research.
8. **Cross-Curricular Connections**: Creating opportunities for interdisciplinary connections with other subjects, promoting a holistic understanding of concepts, and fostering critical thinking skills across different domains of knowledge.
9. **Real-World Applications**: Incorporating opportunities for students to apply their learning to real-world contexts, issues, or problems, fostering connections between classroom learning and the world outside the classroom.
10. **Collaboration and Reflection**: Encouraging collaboration among students and fostering opportunities for peer interaction, group work, and collaborative projects. Additionally, providing time for reflection on learning processes and outcomes to enhance metacognitive skills and self-awareness.
11. **Flexibility and Adaptability**: Maintaining flexibility in the unit plan to accommodate unexpected changes, student interests, and emergent learning opportunities, while still maintaining coherence and focus on learning goals.

By incorporating these criteria into the design of a unit plan, educators can create meaningful and impactful learning experiences that promote student engagement, understanding, and achievement in science education.

Points to Be Kept in Mind While Planning for A Unit:

- It must be related to social and physical environment of the pupils.
- It must consider the previous experiences of pupils.
- It must provide now experiences to the pupils.
- It must not be too lengthy, so that pupil's interest is sustained
- It should be flexible so as to allow different types of students to explore their capacities.
- It should be the result of cooperative planning of teacher and pupil as far as possible.

Unit plans follow much the same format as a lesson plan, but cover an entire unit of work, which may span several days or weeks. Modern constructivist teaching styles may not require individual lesson plans. The unit plan may include specific objectives

and timelines, but lesson plans can be more fluid as they adapt to student needs and learning styles.

Unit Planning is the proper selection of learning activities which presents a complete picture. Unit planning is a systematic arrangement of subject matter Samford "A unit plan is one which involves a series of learning experiences that are linked to achieve the aims composed by methodology and contents". Dictionary of Education: "A unit is an organization of various activities, experiences and types of learning around a central problem or purpose developed cooperatively by a group of pupils under a teacher leadership involving planning, execution of plans and evaluation of results".

Self- check Exercise-2

Q.1 Which of the following is a characteristic of a scientific attitude?

A) Blind acceptance of information

B) Curiosity and skepticism

C) Avoidance of experimentation

D) Rigid adherence to beliefs

Q.2 What is the first step in the scientific method?

A) Formulating a hypothesis

B) Collecting data

C) Making observations

D) Analyzing results

Q.3 Which assessment type is used during instruction to provide feedback on learning progress?

A) Formative assessment

B) Summative assessment

C) Diagnostic assessment

D) Benchmark assessment

Q.4 Which instructional strategy involves students actively participating in experiments or hands-on activities?

A) Lecture

B) Discussion

C) Inquiry-based learning

D) Demonstration

Q.5 What component of attitude involves the emotional response toward a subject?

A) Cognitive

B) Affective

C) Behavioral

D) Experiential

Q.6 The process of critically evaluating information and claims in science is known as _____.

Q.7 A well-designed unit plan should include clear and specific _____ that outline what students are expected to learn.

Q.8_____ involves adapting teaching methods to meet the diverse needs and learning styles of students.

Q.9 _____ is the systematic approach to gathering evidence, analyzing data, and drawing conclusions in scientific investigations.

Q.10 Formative assessments are used to monitor student _____ and provide feedback for instructional improvement.

16.5 Steps of Developing a Teaching Unit:

Developing a unit plan in education, particularly in science, involves a systematic approach to organize and structure instructional activities, assessments, resources, and learning experiences to achieve specific learning objectives. Here are the steps typically involved in developing a unit plan:

Steps in Developing a Unit Plan:

1. **Identify Learning Objectives:**
   - **Definition**: Clarify what students should know, understand, and be able to do by the end of the unit. Learning objectives should be specific, measurable, achievable, relevant, and time-bound (SMART).
   - **Example**: "Students will be able to explain the process of photosynthesis and its importance in plant growth."

2. **Assess Prior Knowledge:**
   - **Diagnostic Assessment**: Evaluate students' existing knowledge, skills, and misconceptions related to the unit topic. This helps tailor instruction to meet students' needs.
   - **Example**: Pre-assessment quiz or discussion to gauge understanding of basic concepts related to photosynthesis.
3. **Curriculum Alignment:**
   - Ensure that the unit plan aligns with curriculum standards, educational goals, and grade-level expectations. This ensures coherence and relevance of content.
   - **Example**: Verify alignment with state or national science standards on photosynthesis and plant biology.
4. **Develop Learning Activities:**
   - Design a variety of engaging learning experiences and instructional strategies that cater to different learning styles and abilities.
   - **Examples**: Hands-on experiments, inquiry-based investigations, discussions, simulations, multimedia presentations, and field trips related to photosynthesis.
5. **Select Resources and Materials:**
   - Choose appropriate textbooks, articles, videos, online resources, manipulatives, and technology tools that support and enhance learning objectives.
   - **Examples**: Science textbooks, educational websites, interactive simulations of photosynthesis processes, laboratory equipment.
6. **Assessment Strategies:**
   - Plan formative and summative assessments aligned with learning objectives to evaluate student understanding and progress throughout the unit.
   - **Examples**: Formative assessments (e.g., quizzes, observations during experiments) and summative assessments (e.g., unit test, project on photosynthesis).
7. **Differentiation Strategies:**
   - Incorporate methods to differentiate instruction based on students' readiness, interests, and learning profiles to ensure all students can access and achieve learning objectives.
   - **Examples**: Adjusting complexity of tasks, providing alternative reading materials, offering choice in project topics related to photosynthesis.
8. **Instructional Sequence:**
   - Organize the sequence of lessons and activities logically to scaffold learning, building upon prior knowledge and leading toward mastery of learning objectives.
   - **Example**: Begin with basic concepts of photosynthesis, progress to factors affecting photosynthesis, and culminate in application and significance of photosynthesis in ecosystems.
9. **Integration of Technology:**

- Utilize appropriate technology tools, digital resources, and online platforms to enhance instruction, engage students, and facilitate learning experiences related to photosynthesis.
- **Examples**: Virtual labs on photosynthesis, interactive simulations, multimedia presentations, and collaborative online platforms for group projects.

10. **Reflection and Revision:**

- Reflect on the effectiveness of the unit plan after implementation, gather feedback from students and colleagues, and revise instructional strategies and assessments as needed.
- **Examples**: Review student performance on assessments related to photosynthesis, analyze feedback on lesson effectiveness, and adjust future instruction accordingly.

By following these steps, educators can develop a cohesive and effective unit plan in science that promotes student engagement, deepens understanding of content such as photosynthesis, and supports achievement of learning goals. Each step emphasizes thoughtful planning, alignment with standards, differentiation, and integration of diverse instructional strategies and resources to enhance student learning experiences.

Important points to be kept in mind while preparing a unit plan:

1. Preparation or motivation: The pupils establish the purpose and one motivated to achieve it. The motivation must be self-directed. This is required throughout the lesson.

2. Knowing the previous experience: It is always advisable to start with the pupils where they are this is helpful in knowing the background so that duplication or danger of non-understanding can be arrived. This can be done by questioning.

3. Presentation :- In this step new experiences are given to the students. These may be direct and vicarious care must be taken to present adequate amount of new experience that can be digested by pupils.

4. Organization of learning:- The student should get opportunity to bring their learning together so that they may establish relationship between the new experiences and assimilate them.

5. Summarization:- This is usually done at the end of the teaching unit to bring together all the learning. This may be done at internals during the progress of the unit organization and summarizations go together.

6. Review and drill:- During the progress of unit, there is a chance of forgetting some part of it and not comprehending same. This requires reviewing or drilling the new content taught for better retention from time to time during the lesson.

7. Evaluation:- Evaluation should be done to know the level of achievement of students. This can be done either by written from or oral form after short intervals i.e., after a week or fortnight. This can also be done by interview self-check test, puzzles etc. The final test gives grades to the pupils and tests effectiveness of teaching.

Self- check Exercise-3

Q.1 What is the first step in developing a unit plan in science education?

A) Selecting instructional materials

B) Identifying learning objectives

C) Conducting formative assessments

D) Implementing differentiated instruction

Q.2 Which of the following is NOT a step in developing a unit plan?

A) Assessing prior knowledge

B) Integrating technology

C) Conducting summative assessments

D) Reflecting and revising

Q.3 What does differentiation in unit planning refer to?

A) Providing variety in assessment types

B) Adapting instruction to meet diverse student needs

C) Using a variety of instructional strategies

D) Aligning activities with learning standards

Q.4 Why is aligning the unit plan with curriculum standards important?

A) To increase workload for students

B) To ensure coherence and relevance of content

C) To limit creativity in teaching

D) To avoid using technology

Q.5 Which step involves organizing the sequence of lessons and activities logically?

A) Assessing prior knowledge

B) Differentiating instruction

C) Developing learning activities

D) Planning instructional sequence

Q.6 The first step in developing a unit plan is to identify clear and specific _____ that articulate what students are expected to learn.

Q.7 Unit planning involves assessing students' _____ related to the topic to tailor instruction to their needs and abilities.

Q.8 During the development of learning activities, educators design a variety of engaging _____ that cater to different learning styles and abilities.

Q.9 Integration of _____ in unit planning enhances learning experiences, engages students, and supports inquiry and collaboration.

Q.10 Reflection and _____ after implementation of the unit plan help educators evaluate effectiveness and make necessary adjustments.

16.6 Summary

A unit is a group of lesson plans that cover a particular topic and that is to be taught in a specified time. Unit planning involves deciding upon the unit or a complete topic that is to be taught in a week or so and this is done by daily lesson plans. A unit is a large segment of subject matter having a common fabric of knowledge. For example, reproduction is a unit in life science with different topics like a sexual reproduction, sexual reproduction in it. Lessons are the constituents of a unit. A well-planned unit integrates many types of learning activities.

16.7 Glossary

 Unit **Plan**: A comprehensive outline or framework that organizes instructional activities, assessments, resources, and learning experiences around a specific topic or set of learning objectives within a defined period of time.

 Learning **Objectives**: Clear and specific statements that describe what students should know, understand, and be able to do by the end of the unit. Objectives are typically aligned with curriculum standards and guide instructional planning.

 Curriculum **Standards**: Established guidelines or benchmarks that define what students are expected to learn and achieve at a particular grade level or in a specific subject area.

16.8 Answers to Self- Check Exercises

Exercise-1

Answer1: B) A block of related subject matter
Answer2: C) B.F. Skinner
Answer3: interests
Answer4: interests
Answer5: Herbart
Answer6: Behavior

Exercise -2

Answer1: B) Curiosity and skepticism

Answer2: C) Making observations

Answer3: A) Formative assessment

Answer4: C) Inquiry-based learning

Answer5: B) Affective

Answer6: skepticism

Answer7: learning objectives

Answer8: Differentiated instruction

Answer9: The scientific method

Answer10: progress

Exercise -3

Answer1: B) Identifying learning objectives

Answer2: C) Conducting summative assessments

Answer3: B) Adapting instruction to meet diverse student needs

Answer4: B) To ensure coherence and relevance of content

Answer5: D) Planning instructional sequence

Answer7: prior knowledge

Answer8: instructional strategies

Answer9: technology

Answer10: revision

16.9 References / Suggested Readings

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16.10 Terminal Questions

1. What do you mean by Unit Plan?
2. Explain the criterion for good unit planning.
3. Discuss the various steps of developing a teaching unit.

UNIT - 17
LESSON PLANNING IN SCIENCES

17.1 Introduction
17.2 Learning Objectives
17.3 Lesson Planning
Self- check Exercise-1
17.4 Steps for Preparing a Lesson Plan
Self- check Exercise-2
17.5 Approaches of Lesson Planning: Herbartian Approach
Self- check Exercise3
17.6 Summary
17.7 Glossary
17.8 Answers to self- check Exercises
17.9 References / Suggested Readings
17.10 Terminal Questions

17.1 Introduction

If you are keen in making lesson plans which may help you in achieving your identified objectives, then they should be stated clearly. If objectives are not clearly defined, it is impossible to evaluate a student, a lesson, a unit, a course or a programme effectively. This leads to teaching disaster. Unless you have clear picture of instructional intention, you will be unable to select test items. If the objectives are clearly defined, then students know which activities are relevant for success of the teaching learning process.

A meaningfully stated objective is that clearly communicate the readers the writer's intention- It states the behavioral outcome of students after completing a chapter. The most important characteristics of useful objectives are that it identifies the kind of performance that will be accepted as evidence that the learner has achieved the objective.

According to B.S. Bloom

"Educational objectives are not only the goals towards which curriculum is shaped and towards which instruction in guided, but they are also the goals that provide, the detailed specification for the construction and use of education techniques."

According to E.J. Frust,

An educational objective may be defined as a desired change in behavior in a person that we are trying to bring about through education".

If we look back at the objectives of teaching science in early twentieth century, then we see major stress was on teaching of facts. As the time passed and various

committee and commissions recommended changes according to need of changing time, still we see the stress was on acquisition of knowledge.

17.2 Learning Objectives

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

- Plan a lesson effectively according to different approaches.
- Know the process of developing Lesson Plan in general science.

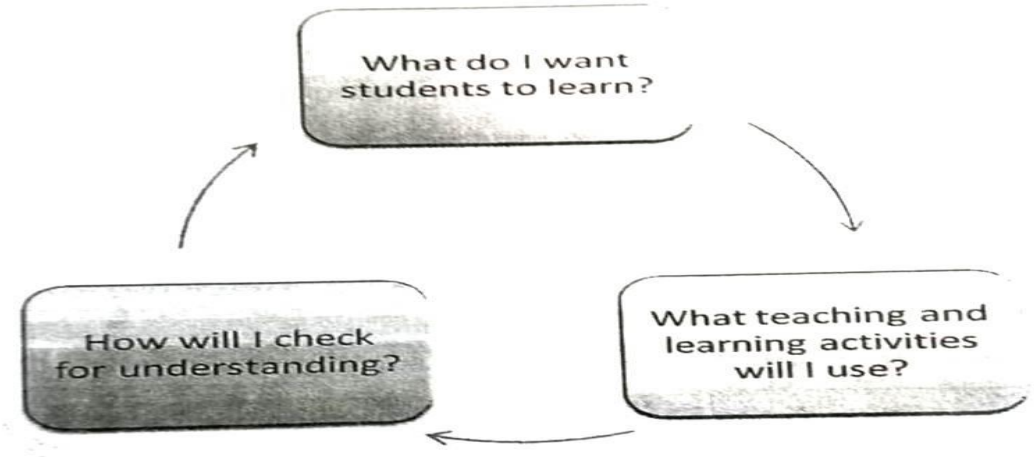
17.3 Lesson Planning

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, and 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 a systematic preparation done in a scientific manner. Without a lesson plan, even the most competent teacher is unsuccessful. There may be differences among the scholars regarding the form of 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 teacher, and by the help of what means and class activities they can be achieved within an hour.

A lesson plan is the instructor's road map of what students need to learn and how it will be done effectively during the class time. Before you plan your lesson, you will first need to identify the learning objectives for the class meeting. Then, you can design appropriate learning activities and develop strategies to obtain feedback on student learning.

A successful lesson plan addresses and integrates these three key components:

- Objectives for student learning
- Teaching/learning activities
- Strategies to check student understanding



Specifying concrete objectives for student learning will help you determine the kinds of teaching and learning activities you will use in class, while those activities will define how you will check whether the learning objectives have been accomplished.

Theoretical knowledge of teaching concept does not provide any guideline for classroom Instructional has to prepare an outline of his subject or topic in written for or at his cognitive level that is known as lesson planning. A teacher has to apply his theoretical knowledge in planning and administrating his lesson plan. A practical outline of a topic to be taught in a period is called the lesson plan. It is designed during the student teaching or teaching practice.

Origin of Lesson Plan

Lesson plan has originated from Gestalt psychology. The Gestalt theory of learning has a great influence on human learning. In the school the whole is perceived by a part. A unit plays an important role in learning. The learner usually takes help of the units in understanding and grasping the whole concept. The meaningful activities are related are related to one another within a unit. These activities provide the purposeful learning experiences and the learner understands the whole concept. This theory originates the concept of "Unit Plan".

Meaning and Definitions:

Teaching is organized in three phases: pre-active, interactive and post-active. All the activities of a teacher and his planning done prior of the timings of his class are called pre- active. Lesson planning is the pre-active phase of teaching.

N.L. Bossing has given a comprehensive definition of lesson plan. "Lesson plan is the title given to a statement of the achievement to be realized and the specific meaning by which these are to be attained as a result of the activities engaged during the period."

Binning and Bining have explained the structure and purpose of lesson planning in their definition. "All lesson planning involves defining the objectives, selecting and arranging the subject-matter and determining the method and procedure."

I.K. Davies has given four steps for management of learning, planning, organizing, leading and controlling. He has also given the greater importance of lesson planning in the first step of planning of teaching. He has defined in the following manner. "Lessons must be prepared for there is nothing so fatal to a teacher's progress than un-preparedness.

Ryburn considers that a teacher gains experience about his classroom work, through lesson planning so that he is able to perform his tasks successfully in his teaching. He has defined the concept in brief. To teach we must use experience already gained as starting point of our work.

We can also take a look at James Michael Lee's definition of lesson plan. He says." A lesson plan is an organized statement of general and specific educational

goals together the specific means by which these goals are to attained by the learners under the guidance of the teacher on a given day."

Why Teachers Need to Plan Lessons: *Fail to Plan = Plan to Fail*

When should we plan a lesson?

Avoid planning lessons several days or weeks ahead of time because a teacher will not be aware of the students' needs or what problems they might be faced with at that particular time. It is best to plan lessons daily and bring them into class because as the lesson is progressing (as students are interacting with their teacher and with the language they are studying) things evolve and develop, depending on what has happened and what is happening moment to moment, and this way the teacher as a better and more accurate understanding of what students need to focus on in future lessons.

Why should we plan a lesson?

Lesson planning is essential because:

- It helps the teacher conduct her lesson in an orderly fashion and it allows students to know what they are going to be learning and how it fits into the course syllabus.
- Students also feel that the lessons are sequenced properly. Having a good lesson plan will also increase confidence in the teacher; on the other hand, not having a plan will result in complete failure for both teacher and students. In addition, a detailed plan clearly demonstrates that the teacher has taken the time, as well as, put in the thought and effort into making the lesson.
- Teachers who do not produce a lesson plan are often lazy, or feel that they can create a lesson (known as jungle path lessons) based on what is happening in the room at that moment. This can sometimes work, but to continue to never have a lesson plan proves to be ineffective, besides, your students will become frustrated and feel a sense of negligence or carelessness on the teacher's part as well as not getting their money's worth.
- Planning detailed lessons will avoid problems in class. This will give the teacher confidence that they have done their best to plan for any eventuality, or at least minimize some problems.

Importance of Lesson Plan

If the trademark of a doctor is the stethoscope, the engineer is the calculator, the teacher cannot be able to teach without his or her lesson plan. Can be tedious on the part of the teachers especially when it is done for the first time, lesson plans are actually very essential in inculcating students and pupils necessary skills, knowledge and wisdom they need.

Essence of Having A Lesson Plan:

- It is a one step backward two steps forward approach. Although can be difficult to do and requires tonnes of effort to accomplish at first, it enables you to save much time

in the coming years, since the lesson plans that you just made can be employed over and over again, but If updates are necessary do so though.

- It allows you to manage your time, effort and resources efficiently.
- It gives you a bird's eye of view of things to be taught and learned everyday.
- It provides the teacher many ways to keep the teaching process not monotonous and redundant. Keep in mind that the time your students spent in paying attention to the class is just equivalent to half of their age, and a lesson plan is the best way to keep the interests of students and pupils interests all throughout.
- Since it is like a script in movies, lesson plans makes teaching mundane and easy.
- It makes you organized whilst teaching.
- You can able to determine when to insert icebreakers and interesting facts and lessons to keep your student and pupils glued to their lessons.
- Variations in the activities are easily whipped up which will benefit your students. Bear in mind that you are dealing with a class that has multiple intelligence, and different activities will cater to all types of students and pupils.
- Lesson plans will easily help you to achieve your goals and objectives, and same can be said on the part of your students or pupils.
- Lesson plans helps you get rid of problems or avoid them.
- It gives you a reality check of your everyday performance.
- It improves the habit and attitude of your students or pupils.
- It definitely improves your teaching skills.

A lesson plan is vital in teaching: it gives you the guide you need to pull through Remember, that teaching is difficult since you are dealing with children or teenagers with raw skills, knowledge, and wisdom.

Finally, with lesson plans you will be able to impart the things they need to learn, to the best of your abilities.

Self- Check Exercise-1

Q.1 What is the primary purpose of a lesson plan?

A) To strictly adhere to a blueprint

B) To guide classroom activities and teaching points

C) To evaluate the teacher's performance

D) To entertain students

Q.2 Which of the following is NOT a key component of a successful lesson plan?

A) Objectives for student learning

B) Teaching/learning activities

C) Strategies to check student understanding

D) Student seating arrangement

Q.3 A lesson plan is the instructor's road map of what students need to learn and how it will be done effectively during the _____.

Q.4 Specifying concrete objectives for student learning helps determine the kinds of teaching and learning _____ you will use in class.

Q.5 What is a lesson plan primarily considered as for the teacher?

Q.6 What component of a lesson plan helps to verify if the learning objectives have been achieved?

17.4 STEPS FOR PREPARING A LESSON PLAN:

Below are six steps to guide you when you create your first lesson plans. Each step is accompanied by a set of questions meant to prompt reflection and aid you in designing your teaching and learning activities.

(1) Outline learning objectives

The first step is to determine what you want students to learn and be able to do at the end of class. To help you specify your objectives for student learning, answer the following questions:

- What is the topic of the lesson?
- What do I want students to learn?
- What do I want them to understand and be able to do at the end of class?
- What do I want them to take away from this particular lesson?

Once you outline the learning objectives for the class meeting, rank them in terms of their importance. This step will prepare you for managing class time and accomplishing the more important learning objectives in case you are pressed for time Consider the following questions:

- What are the most important concepts, ideas, or skills I want students to be able to grasp and apply?
- Why are they important?
- If I ran out of time, which ones could not be omitted?
- And conversely, which ones could I skip if pressed for time?

(2) Develop the introduction

Now that you have your learning objectives in order of their importance, design the specific activities you will use to get students to understand and apply what they have learned. Because you will have a diverse body of students with different academic and personal experiences, they may already be familiar with the topic. That is why you might start with a question or activity to gauge students' knowledge of the subject or possibly, their preconceived notions about it. For example, you can take a simple poll:

"How many of you have heard of X? Raise your hand if you have. You can also gather background information from your students prior to class by sending students an electronic survey or asking them to write comments on index cards. This additional information can help shape your introduction, learning activities, etc. When you have an idea of the students' familiarity with the topic, you will also have a sense of what to focus on.

Develop a creative introduction to the topic to stimulate interest and encourage thinking. You can use a variety of approaches to engage students (e.g., personal anecdote, historical event, thought-provoking dilemma, real-world example, short video clip, practical application, probing question, etc.) Consider the following questions when planning your introduction:

- How will I check whether students know anything about the topic or have any preconceived notions about it?
- What are some commonly held ideas (or possibly misconceptions) about this topic that students might be familiar with or might suppose?
- What will do to introduce the topic?

(3) Plan the specific learning activities (the main body of the lesson)

Prepare several different ways of explaining the material (real-life examples, analogies, visuals, etc.) to catch the attention of more students and appeal to different learning styles. As you plan your examples and activities, estimate how much time you will spend on each. Build in time for extended explanation or discussion, but also be prepared to move on quickly to different applications or problems, and to identify strategies that check for understanding. These questions would help you design the learning activities you will use:

- What will I do to explain the topic?
- What will I do to illustrate the topic in a different way?
- How can I engage students in the topic?
- What are some relevant real-life examples, analogies, or situations that students understand the topic?
- What will students need to do to help them understand the topic better?

(4) Plan to check for understanding

Now that you have explained the topic and illustrated it with different examples, you need to check for student understanding-how will you know that students are learning? Think about specific questions you can ask students in order to check for understanding, write them down, and then paraphrase them so that you are prepared to ask the questions in different ways. Try to predict the answers your questions will generate. Decide on whether you want students to respond orally or in writing. You can also ask yourself these questions:

- What questions will ask students to check for understanding?
- What will have students do to demonstrate that they are following?

- Going back to my list of learning objectives, what activity can I have students do to check whether each of those has been accomplished?

An important strategy that will also help you with time management is to anticipate students' questions. When planning your lesson, decide what kinds of questions will be productive for discussion and what questions might sidetrack the class. Think about and decide on the balance between covering content (accomplishing your learning objectives) and ensuring that students understand.

(5) Develop a conclusion and a preview

Go over the material covered in class by summarizing the main points of the lesson. You can do this in a number of ways you can state the main points yourself (Today we talked about..."), you can ask a student to help you summarize them, or you can even ask all students to write down on a piece of paper what they think were the main points of the lesson. You can review the students' answers to gauge their understanding of the topic and then explain anything unclear the following class. Conclude the lesson not only by summarizing the main points, but also by previewing the next lesson. How does the topic relate to the one that's coming? This preview will spur students' interest and help them connect the different ideas within a larger context.

(6) Create a realistic timeline

GSIs know how easy it is to run out of time and not cover all of the many points they had planned to cover. A list of ten learning objectives is not realistic, so narrow down your list to the two or three key concepts, ideas, or skills you want students to learn. Instructors also agree that they often need to adjust their lesson plan during class depending on what the students need. Your list of prioritized learning objectives will help you make decisions on the spot and adjust your lesson plan as needed. Having additional examples or alternative activities will also allow you to be flexible. A realistic timeline will reflect your flexibility and readiness to adapt to the specific classroom environment. Here are some strategies for creating a realistic timeline:

- Estimate how much time each of the activities will take, then plan some extra time for each
- When you prepare your lesson plan, next to each activity indicate how much time you expect it will take
- Plan a few minutes at the end of class to answer any remaining questions and to sum up key points
- Plan an extra activity or discussion question in case you have time left
- Be flexible-be ready to adjust your lesson plan to students' needs and focus on what seems to be more productive rather than sticking to your original plan.

PRESENTING THE LESSON PLAN:

Letting your students know what they will be learning and doing in class will help keep them more engaged and on track. You can share your lesson plan by writing a agenda on the board or telling students explicitly what they will be learning and doing in

class You can outline on the board or on a handout the learning objectives for the class. Providing a meaningful organization of the class time can help students not only remember better, but also follow your presentation and understand the rationale behind in-class activities. Having a clearly visible agenda (e.g., on the board) will also help you and students stay on track.

Reflecting on Your Lesson Plan

A lesson plan may not work as well as you had expected due to a number of extraneous circumstances. You should not get discouraged-it happens to even the most experienced teachers! Take a few minutes after each class to reflect on what worked well and why, and what you could have done differently. Identifying successful and less successful organization of class time and activities would make it easier to adjust to the contingencies of the classroom. For additional feedback on planning and managing class time, you can use the following resources: student feedback, peer observation, viewing a videotape of your teaching, and consultation with a staff member at CRLT

Developing a lesson plan

While there are many formats for a lesson plan, most lesson plans contain some or all of these elements, typically in this order:

- Title of the lesson
- Time required to complete the lesson
- List of required materials
- List of objectives, which may be behavioral objectives (what the student can do at lesson completion) or knowledge objectives (what the student knows at lesson completion)
- The set (or lead-in, or bridge-in) that focuses students on the lesson's skills or concepts-these include showing pictures or models, asking leading questions, or reviewing previous lessons
- An instructional component that describes the sequence of events that make up the lesson, including the teacher's instructional input and, where appropriate, guided practice by students to consolidate new skills and ideas
- Independent practice that allows students to extend skills or knowledge on the own
- A summary, where the teacher wraps up the discussion and answers questions
- An evaluation component, a test for mastery of the instructed skits or concepts-such as a set of questions to answer or a set of instructions to follow
- A risk assessment where the lesson's risks and the steps taken to minimize them are documented
- Analysis component the teacher uses to reflect on the lesson itself-such as what worked, what needs improving
- A continuity component reviews and reflects on content from the previous lesson

Self- check Exercise-2

Q.1 What is the first step in preparing a lesson plan?

A) Develop the introduction

B) Plan the specific learning activities

C) Outline learning objectives

D) Create a realistic timeline

Q.2 Which component of a lesson plan involves summarizing the main points and previewing the next lesson?

A) Develop the introduction

B) Plan to check for understanding

C) Develop a conclusion and a preview

D) Create a realistic timeline

Q.3 The first step in preparing a lesson plan is to _____ learning objectives.

Q.4 When developing the introduction, you can use a variety of approaches to engage students, such as personal anecdotes, historical events, or _____ questions.

Q.5 What step involves planning various ways to explain and illustrate the topic?

Q.6 Which step involves anticipating and preparing for potential student questions?

17.5 Approaches of Lesson Planning

Lesson planning encompasses various approaches that educators employ to create effective learning experiences tailored to their students' needs and learning objectives.

The traditional approach to lesson planning typically revolves around a structured format where teachers deliver content through lectures, demonstrations, and direct instruction. It focuses on clear learning objectives, sequential presentation of information, and formal assessments to measure student comprehension and retention. This approach is often utilized in subjects requiring foundational knowledge and skill acquisition, where the teacher plays a central role in imparting knowledge and guiding students through the learning process.

In contrast, the constructivist approach shifts the focus towards active student engagement, inquiry, and discovery. Grounded in constructivist learning theory, lessons are designed to encourage critical thinking, problem-solving, and collaborative exploration of concepts. Teachers act as facilitators, guiding students through hands-on

activities, discussions, and investigations where students construct their own understanding of the material.

Another approach, inquiry-based learning, shares similarities with constructivism but places a stronger emphasis on student-driven exploration of questions or problems. Lessons begin with open-ended inquiries that prompt students to investigate, analyze data, and construct explanations or solutions collaboratively. This approach nurtures curiosity and encourages students to develop a deeper understanding of concepts through firsthand exploration and discovery.

Differentiated instruction caters to diverse learning needs by adapting content, process, and product to accommodate varied learning styles, abilities, and interests within the classroom. Teachers differentiate lessons through flexible grouping, personalized learning paths, and varied instructional strategies to ensure all students have opportunities to access and achieve learning objectives.

Cooperative learning fosters collaboration among students through structured group activities, discussions, and projects where they work together to achieve shared learning goals. This approach promotes teamwork, communication skills, and mutual support among peers, enhancing both academic achievement and social development.

Technology-enhanced approaches integrate digital tools, resources, and platforms into lesson planning to enhance teaching and learning experiences. Teachers leverage technology for research, simulations, multimedia presentations, virtual labs, and online collaboration, providing students with interactive and engaging learning opportunities that extend beyond traditional classroom boundaries.

In summary, effective lesson planning combines elements from various approaches based on educational goals, subject matter, student characteristics, and available resources. By incorporating diverse instructional strategies and methods, educators can create dynamic and meaningful learning experiences that cater to the needs and interests of all students while fostering their academic growth and engagement in the learning process.

Herbartian Approach: John Fedrick Herbert (1776-1841):

1. Preparation/Instruction: It pertain to preparing and motivating children to the lesson content by linking it to the previous knowledge of the student, by arousing curiosity of the children and by making an appeal to their senses. This prepares the child's mind to receive new knowledge. "To know where the pupils are and where they should try to be are the two essentials of good teaching lesson may be started in the following manner:

a. Two or three interesting but relevant questions
b. Showing a picture/s, a chart or a model

c. A situation Statement of Aim Announcement of the statement of the lesson in a clear, concise, like this "Today, we shall study the..."

2. Presentation/Development: The actual lesson commences here. This step should involve a good deal of activity on the part of the students. The teacher will take the aid of various devices, eg, questions, illustrations, explanation, expositions, demonstration and sensory aids, etc. Information and knowledge can be given, explained, revealed or suggested. The following principles should be in mind.

a. Principle of selection and division: This subject matter should be divided into different sections. The teacher should also decide as to how much he is to tell and how much the pupils are to find out for themselves.

b. Principle of successive sequence: The teacher should ensure that the succeeding as well as preceding knowledge is clear to the students.

c. Principle of absorption and integration: In the end separation of the parts must be followed by the combination for the understanding of the whole.

3. Association comparison:

It is always desirable that new ideas or knowledge be associated to daily life situation by citing suitable examples any by drawing comparison with the related concepts. This step is important when we are establishing principles or generalizing definitions.

4. Generalizing:

This concept is concerned with the systematizing of the knowledge learn. Comparison and contrast lead to generalization. An effort to be made that students draw the conclusions themselves. It should result, in student's own thinking, reflection and experience.

5. Application:

It requires a good deal of mental activity to think and apply the principles learn to new situations. Knowledge when it is put to use and verified becomes clear and a part of mental make-up.

6. Recapitulation:

Last step of the lesson plan, the teacher tries to ascertain whether the students have understood or grasped the subject matter or not. This is used for assessing/evaluating the effectiveness of the lesson by asking students questions on the contents of the lesson or short objectives types test to the class/to label the unlabeled sketch etc.

A Well-Developed Lesson Plan:

A well-developed lesson plan reflects the interests and needs of students. It incorporates best practices for the educational field. The lesson plan correlates with the teacher's philosophy of education, which is what the teacher feels is the purpose of educating the students.

Secondary English program lesson plans, for example, usually center around four topics. They are literary theme, elements of language and composition, literary history, and literary genre. A broad, thematic lesson plan is preferable, because it allows a teacher to create various research, writing, speaking, and reading assignments. It helps an instructor teach different literature genres and incorporate videotapes, films, and television programs. Also, it facilitates teaching literature and English together. Similarly, history lesson plans focus on content (historical accuracy and background information), analytic thinking, scaffolding, and the practicality of lesson structure and meeting of educational goals. School requirements and a teacher's personal tastes, in that order; determine the exact requirements for a lesson plan.

Creating a lesson plan on photosynthesis involves designing activities and instructional strategies that help students understand the process, importance, and factors affecting photosynthesis. Here's an outline for a lesson plan focused on photosynthesis for middle school students:

Lesson Plan: Photosynthesis

Grade Level: Middle School (6th-8th grade)

Subject: Science

Objective: By the end of this lesson, students will be able to:

- Define photosynthesis and identify its importance in plant growth.
- Describe the chemical equation for photosynthesis.
- Explain the factors that affect the rate of photosynthesis.

Materials Needed:

- Projector and screen
- Diagram of a plant cell
- Whiteboard and markers
- Internet access for research
- Worksheet on photosynthesis
- Plant leaves (optional for demonstration)

Lesson Outline:

1. Introduction to Photosynthesis (10 minutes)

- Begin with a brief discussion about plants and their role in ecosystems.
- Introduce the concept of photosynthesis as the process by which plants use sunlight to convert water and carbon dioxide into glucose and oxygen.

2. The Chemical Equation of Photosynthesis (15 minutes)

Display the chemical equation for photosynthesis:

$$6CO_2+6H_2O+light \rightarrow C_6H_{12}O_6+6O_2$$

- Explain each component of the equation and discuss the role of sunlight and chlorophyll.

- Discuss the products of photosynthesis (glucose and oxygen) and their importance to plants and other organisms.

3. Factors Affecting Photosynthesis (15 minutes)

- Discuss the factors that affect the rate of photosynthesis: light intensity, carbon dioxide concentration, and temperature.
- Explain how limiting factors can impact plant growth and productivity.
- Use diagrams or interactive simulations to illustrate the effects of these factors on photosynthesis.

4. Hands-on Activity: Photosynthesis Experiment (15 minutes)

- Divide students into small groups.
- Provide each group with a plant leaf and ask them to observe and predict how the leaf produces oxygen during photosynthesis.
- Guide students in setting up an experiment to demonstrate the production of oxygen in water using a plant leaf under light.

5. Discussion and Analysis (10 minutes)

- Have students share their observations and discuss their findings from the experiment.
- Emphasize the connection between the experiment and the concept of photosynthesis.
- Review key points about photosynthesis and clarify any misconceptions.

6. Assessment: Worksheet on Photosynthesis (10 minutes)

- Distribute a worksheet with questions related to the lesson content, including definitions, the chemical equation, and factors affecting photosynthesis.
- Review and discuss answers as a class to reinforce understanding.

7. Conclusion and Wrap-Up (5 minutes)

- Summarize the key concepts learned about photosynthesis.
- Discuss the importance of photosynthesis in maintaining life on Earth.
- Encourage students to connect their learning to real-life examples of photosynthesis in nature.

Extension Activity (Optional):

- Assign students to research and present on different types of photosynthesis (e.g., C3, C4, CAM) and their adaptations to different environments.

Homework (Optional):

- Ask students to observe and record examples of photosynthesis in their local environment (e.g., plants in their backyard, park, or school garden).

By following this lesson plan outline, educators can effectively engage students in learning about photosynthesis through a combination of direct instruction, hands-on experimentation, and interactive discussions. This approach helps students grasp the complex process of photosynthesis while fostering inquiry, critical thinking, and application of scientific concepts in real-world contexts.

Self- check Exercise-3

Q.1 What is the primary focus of the Preparation/Instruction step in the Herbartian approach?

A) Developing new knowledge

B) Motivating students by linking to their previous knowledge

C) Assessing student understanding

D) Drawing generalizations

Q.2 Which principle involves dividing the subject matter into sections and deciding how much information to give and how much students should discover themselves?

A) Principle of absorption and integration

B) Principle of successive sequence

C) Principle of selection and division

D) Principle of association and comparison

Q.3 In the Herbartian approach, the step where new ideas or knowledge are associated with daily life situations is called _____.

Q.4 The final step of the Herbartian lesson plan, where the teacher checks for student understanding, is known as _____.

Q.5 What step requires students to apply principles learned to new situations?

Q.6 Which step involves motivating children and preparing their minds to receive new knowledge?

Q.7 A well-developed lesson plan should primarily reflect the interests and needs of whom?

A) The school administration

B) The teacher

C) The students

D) The parents

Q.8 In a secondary English program, which of the following is NOT typically a central topic in lesson plans?

A) Literary theme

B) Historical accuracy

C) Elements of language and composition

D) Literary genre

Q.9 A broad, _____ lesson plan allows a teacher to create various research, writing, speaking, and reading assignments.
Q.10 The exact requirements for a lesson plan are determined by school requirements and a teacher's _____ tastes.

17.6 Summary

To be effective, the lesson plan does not have to be an exhaustive document that describes each and every possible classroom scenario. Nor does it have to anticipate each and every student's response or question. Instead, it should provide you with a general outline of your teaching goals, learning objectives, and means to accomplish them. It is a reminder of what you want to do and how you want to do it. A productive lesson is not one in which everything goes exactly as planned, but one in which both students and instructor learn from each other.

17.7 Glossary

Lesson Plan: A detailed outline or blueprint that guides educators in organizing instructional activities, assessments, and resources to achieve specific learning objectives within a defined timeframe.
Technology Integration: Incorporating digital tools, resources, and technologies into lesson planning and instructional practices to enhance learning experiences, engagement, and collaboration.

17.8 Answers to Self- Check Exercises

Exercise-1
Answer1: B) To guide classroom activities and teaching points
Answer2: D) Student seating arrangement
Answer3: class time
Answer4: activities
Answer5: Guide
Answer6: Strategies
Exercise -2
Answer1: C) Outline learning objectives
Answer2: C) Develop a conclusion and a preview
Answer3: outline
Answer4: thought-provoking
Answer5: Activities
Answer6: Understanding
Exercise -3

Answer1: B) Motivating students by linking to their previous knowledge
Answer2: C) Principle of selection and division
Answer3: association
Answer4: recapitulation
Answer5: Application
Answer6: Preparation
Answer7: C) The students
Answer8: B) Historical accuracy Answer9: thematic
Answer10: personal

17.9 References / Suggested Readings

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17.10 Terminal Questions

1) What do you mean by Lesson Planning?
2) How and why Lesson Planning is regarded as an important before Teaching?
3) Describe the various steps involved in planning a lesson plan?
4) Prepare a lesson plan on any topic of your own choice from Science.

UNIT-18

EVALUATION IN SCIENCES

Structure:

18.1 Introduction
18.2 Learning Objectives
18.3 Meaning/Concept of Evaluation
Self- check Exercise-1
18.4 Need and importance of Evaluation
Self- check Exercise-2
18.5 Principles of Evaluation
Self- check Exercise-3
18.6 Evaluation Process: Steps of Evaluation Process
Self- check Exercise-4
18.8 Summary
18.9 Glossary
18.10 Answers to self- check Exercise
18.11 References / Suggested Readings
18.12 Terminal Questions

18.1 Introduction:

Very often evaluation is confused with measurement. Measurement is the numerical representation of an object, whereas evaluation represents both measurement and magnitude. In other words, measurement tells us how much an object is, whereas evaluation tells us how good it is. In evaluation stress is laid down on the fact that the objective has been achieved up to what level eg, can Rita solve all types of up problems of Mathematics? Or Does Gita have interest in reading Hindi Literature? Or can she use the dictionary? Can she talk continuously? Without evaluation, measurement is incomplete e.g Measurement tells us that at the time of birth, Mohan weighed 03 Kg. Evaluation tells us how much was Mohan weight? Was he weak or strong? Was Mohan weight normal or abnormal? Thus, it can be said that "Measurement refers to observation that can be expressed quantitatively and answers the question "how much." Evaluation goes beyond the statement of how much to concern itself in question 'what value."

18.2 Learning Objectives

After going through this Unit, the learners will be able to:

- Understand the Concept of Evaluation in teaching science.
- Explain the concept of Formative Evaluation.
- Explain the concept of Summative Evaluation.
- Understand the importance of Diagnostic Evaluation.

18.3 Meaning/Concept of Evaluation:

Evaluation in sciences refers to the systematic assessment of students' understanding, skills, and knowledge in scientific concepts and practices. It involves measuring their ability to apply scientific principles, conduct experiments, analyze data, and solve problems. Evaluation serves to provide feedback to students and educators on learning progress, identify areas needing improvement, and ensure alignment with educational objectives. Through both formative assessments during instruction and summative assessments at the end of units or courses, evaluation promotes critical thinking, fosters scientific inquiry, and supports continuous improvement in science education. It aims to cultivate scientific literacy and prepare students to apply their knowledge effectively in scientific and real-world contexts.

"Evaluation may be defined as a systematic process of determining the extent to which educational objectives are achieved by pupils Evaluation depends on the educational objectives. The relation between evaluation and objectives is very deep. The extent to which the child has achieved the objectives-the same type of is possible in them. The changes in the behaviour and conduct of the child will be similar to the changes in him. The manner in the conduct and behaviour changes and the extent to which they change, on the basis of this it will be deduced/assumed as to how effective are the "learning experiences According to the booklet of NCERT named 'Concept of Evaluation the process of Evaluation decides about the following three things:

1. To what extent the objective has been achieved?
2. The 'Learning Experiences' provided in the class have been effective to what extent?
3. How well have the teaching objectives been accomplished/completed?

These three items complete the cycle of evaluation, teaching objective, learning experiences and behavioral changes are linked to each other by the process of evaluation. The absence of any one makes evaluation incomplete, Modern education makes teaching and examination objective, New types of syllabi have objective selected with utmost care. After the selection of the objectives are selected learning experiences to achieve them and other processes. Thus, syllabus of each subject, all types of teaching activities all types of teaching and examination are objective centered. To make educational objective centered is the main purpose of evaluation.

n the context of sciences, evaluation refers to the systematic process of assessing students' understanding, skills, and knowledge in scientific concepts, principles, and practices. Evaluation serves several essential purposes in science education:

1. **Assessment of Learning**: Evaluation in sciences is primarily used to measure what students have learned and achieved in terms of scientific knowledge and skills. It includes assessing their ability to apply scientific principles, solve problems, conduct experiments, and analyze data.

2. **Feedback Mechanism**: Evaluation provides feedback to both students and educators about the effectiveness of teaching methods, instructional materials, and learning activities. It helps identify areas where students may need additional support or clarification.
3. **Monitoring Progress**: Through evaluation, educators monitor students' progress over time in mastering scientific concepts and skills. It allows for tracking individual and group performance, identifying strengths and weaknesses, and adjusting instructional strategies accordingly.
4. **Promotion of Critical Thinking**: Evaluative assessments in sciences often require students to demonstrate higher-order thinking skills, such as critical analysis, synthesis of information, and evaluation of scientific evidence. This promotes deeper understanding and application of scientific knowledge.
5. **Alignment with Learning Objectives**: Evaluation ensures that assessment methods and tasks are aligned with the intended learning objectives and outcomes of science education. It verifies whether students have achieved the desired competencies and understandings specified in the curriculum.
6. **Formative and Summative Assessment**: Evaluation in sciences includes both formative assessment (ongoing assessments during instruction to inform teaching and learning) and summative assessment (final evaluations at the end of a unit or course to measure overall learning outcomes).
7. **Authentic Assessment**: In sciences, evaluation often incorporates authentic tasks and performance-based assessments that mirror real-world scientific practices. This can include conducting experiments, analyzing scientific data, presenting findings, and drawing conclusions based on evidence.
8. **Continuous Improvement**: Evaluation contributes to the continuous improvement of science education by providing data and insights that inform curriculum development, instructional design, and professional development for educators.

Overall, evaluation in sciences plays a crucial role in promoting scientific literacy, understanding, and proficiency among students. It supports the development of critical thinking skills, fosters inquiry-based learning, and ensures that students are prepared to apply scientific knowledge in both academic and real-world contexts.

Self- Check Exercise-1

Q.1 What is the primary difference between measurement and evaluation?

A) Measurement is qualitative, while evaluation is quantitative.

B) Measurement provides numerical data, while evaluation assesses quality and achievement.

C) Measurement is subjective, while evaluation is objective.

D) Measurement is used in science, while evaluation is used in arts.

Q.2 Which of the following is NOT a question that evaluation aims to answer?
A) How much does an object weigh?

B) How good is the object?

C) Has the objective been achieved?

D) What value does the object hold?

Q.3 Measurement answers the question "how much," while evaluation answers the question "_____."
Q.4 The booklet of NCERT names three main aspects of evaluation: achievement of objectives, effectiveness of learning experiences, and completion of _____.
Q.5 What is the systematic process of determining the extent to which educational objectives are achieved by pupils?
Q.6 What are the objectives in the cycle of evaluation closely linked with?
Q.7 Which type of evaluation is focused on assessing student learning at the end of an instructional unit?
A) Formative Evaluation

B) Summative Evaluation

C) Diagnostic Evaluation

D) Continuous Evaluation

Q.8 Which type of evaluation is used to identify students' existing knowledge and skills before instruction begins?
A) Formative Evaluation

B) Summative Evaluation

C) Diagnostic Evaluation

D) Continuous Evaluation

Q.9 The primary purpose of _____ evaluation is to monitor student learning and provide ongoing feedback.
Q.10 Summative evaluation aims to assess the _____ of students at the end of an instructional unit.

18.4 NEED AND IMPORTANCE OF EVALUATION

Why we need to Evaluate?

According to encyclopedia of Educational Research, "Evaluation is relatively a new technical term, introduced to designate a more comprehensive concept of measurement than is implied in conventional test and examination".

To test the knowledge acquired by students is known as examination. Evaluation is examination but is an extensive and general word. Evaluation signifies the extent to which the students have acquired the imparted knowledge, as per the objectives how much change has taken place in their linking and behavior, how much is their linking and interest in Science. What is their mental level? Evaluation actually is the collective report of examination and measurement. Its need in science is as following;

- To classify the students on the basis of their achievement
- To help the teacher to identify the difficulties, problems and weaknesses of the students and provide them their solution
- To assess the work- effectiveness of teaching methods and selecting and compiling the subject matter.
- To stimulate the students and give them the inspiration to study.
- To give guidance to the teacher.
- To help to make the body and mind disciplined.
- To clarify the objectives of teaching.

Importance of Evaluation Evaluation holds significant importance in education, particularly in the field of sciences, for several compelling reasons:

1. **Assessment of Learning Outcomes**: Evaluation allows educators to measure and assess what students have learned and achieved in terms of scientific knowledge, skills, and competencies. It provides evidence of students' understanding of scientific concepts and their ability to apply them in practical contexts.
2. **Feedback for Improvement**: Through evaluation, both students and educators receive valuable feedback on strengths and areas needing improvement. This feedback informs instructional decisions, curriculum adjustments, and personalized learning strategies to enhance student learning outcomes.
3. **Monitoring Progress**: Evaluation serves as a tool to monitor students' progress over time. It helps educators track individual and group performance, identify learning gaps, and intervene promptly with additional support or enrichment activities as needed.
4. **Alignment with Learning Objectives**: Evaluation ensures that assessments are aligned with the intended learning objectives and outcomes of science education. It verifies whether students have achieved the desired competencies, knowledge, and skills specified in the curriculum.
5. **Promotion of Critical Thinking**: Assessments in sciences often require students to demonstrate critical thinking skills such as analyzing data, drawing conclusions, and evaluating scientific evidence. Evaluation promotes deeper understanding and application of scientific principles beyond rote memorization.

6. **Accountability and Quality Assurance**: Evaluation provides accountability in education by measuring the effectiveness of instructional methods, curriculum materials, and educational programs. It helps educational stakeholders, including policymakers and parents, gauge the quality and impact of science education initiatives.
7. **Continuous Improvement**: By analyzing evaluation data, educators can identify trends, strengths, and areas for improvement in science instruction. This continuous improvement cycle supports professional development for teachers, curriculum refinement, and innovation in teaching practices to better meet the needs of students.
8. **Preparation for Future Learning and Careers**: Effective evaluation in sciences prepares students for further education and careers by developing essential skills such as problem-solving, scientific inquiry, data analysis, and communication of findings. It equips students with the competencies needed to succeed in STEM fields and contribute to scientific advancements.

In summary, evaluation plays a crucial role in enhancing the quality of science education by assessing learning outcomes, providing feedback for improvement, monitoring progress, promoting critical thinking, ensuring accountability, supporting continuous improvement, and preparing students for future academic and career success in scientific fields.

Need of evaluation: Evaluation in science education is indispensable for several reasons that underscore its necessity and benefits:

1. **Assessing Understanding and Mastery**: Evaluation allows educators to gauge students' comprehension of scientific concepts, theories, and principles. It measures how well students can apply their knowledge to solve problems, analyze data, and make informed conclusions, providing insights into their mastery of scientific content.
2. **Feedback for Learning Improvement**: Through evaluation, students receive constructive feedback on their strengths and areas needing improvement. This feedback informs their learning process, enabling them to adjust their study strategies, seek clarification on misunderstood concepts, and deepen their understanding of scientific phenomena.
3. **Monitoring Progress and Growth**: Evaluation serves as a tool for monitoring students' progress over time. It tracks their development in scientific inquiry skills, critical thinking abilities, and application of scientific methods. This continuous monitoring helps educators identify learning gaps and tailor instruction to meet individual student needs effectively.
4. **Validation of Learning Objectives**: Evaluation ensures that educational objectives in science curricula are met. By aligning assessments with learning outcomes, educators verify whether students have acquired the specified knowledge, skills, and competencies essential for scientific literacy and proficiency.

5. **Promotion of Scientific Inquiry and Exploration**: Assessments in science encourage students to engage in scientific inquiry, experimentation, and exploration. They stimulate curiosity, foster a spirit of discovery, and cultivate a deeper appreciation for the scientific process, motivating students to explore complex scientific phenomena with curiosity and rigor.
6. **Quality Assurance and Accountability**: Evaluation provides a means for quality assurance in science education. It allows educational institutions, policymakers, and stakeholders to assess the effectiveness of science curriculum, instructional practices, and educational programs. This accountability ensures that students receive a high-quality science education aligned with academic standards and societal expectations.
7. **Preparation for Future Endeavors**: Effective evaluation prepares students for future academic and career pursuits in science, technology, engineering, and mathematics (STEM) fields. It equips them with essential skills such as critical thinking, problem-solving, data analysis, and communication—skills that are fundamental for success in scientific research, innovation, and professional careers.

In conclusion, evaluation in science education is essential for assessing learning outcomes, providing feedback for improvement, monitoring student progress, validating educational objectives, promoting scientific inquiry, ensuring quality assurance, and preparing students for future academic and professional endeavors in the sciences.

Self- Check Exercise-2

Q.1 Which statement best defines the term "evaluation" as used in educational research?

A) It is the same as taking a test.

B) It measures the extent to which students have acquired knowledge and changed in behavior.

C) It is a simple measurement of student knowledge.

D) It focuses solely on student interest in science.

Q.2 What is one of the main purposes of evaluation in the context of teaching?

A) To entertain students.

B) To classify students based on their achievements.

C) To conduct research on new teaching methods.

D) To simplify teaching objectives.

Q.3 Evaluation helps teachers identify the _____, problems, and weaknesses of students to provide appropriate solutions.

Q.4 Evaluation provides a _____ report of examination and measurement.

One Word Answer Type Questions

Q.5 What term designates a more comprehensive concept of measurement than conventional tests and exams?

Q.6 What does evaluation help to stimulate in students?

Q.7 Which of the following is NOT a reason for the need of evaluation in science?

A) To classify students based on their achievements.

B) To inspire students to study.

C) To assess the effectiveness of teaching methods.

D) To simplify the science curriculum.

Q.8 How does evaluation help teachers in their instructional methods?

A) By making the teaching methods more complex.

B) By assessing the work-effectiveness of teaching methods.

C) By eliminating the need for teaching methods.

D) By ignoring the difficulties faced by students.

Q.9 Evaluation helps in making the body and mind _____.

Q.10 Evaluation helps in providing _____ to the teacher.

18.5 PRINCIPLES OF EVALUATION:

The principles of the evaluation process in education, including in sciences, encompass several key guidelines and considerations that ensure assessments are fair, effective, and meaningful. Here are the fundamental principles of evaluation:

1. **Validity**: Evaluation instruments and methods should measure what they are intended to measure. In the context of sciences, assessments should accurately assess students' understanding of scientific concepts, application of scientific principles, and proficiency in scientific skills.
2. **Reliability**: Evaluations should yield consistent results over time and across different assessors. Reliability ensures that assessments are dependable and free from inconsistencies or biases, allowing for reliable interpretations of student performance in sciences.
3. **Fairness**: Evaluation processes should be fair and unbiased, treating all students equally regardless of background, ability, or circumstances. In science education, fairness ensures that assessments accurately reflect students' knowledge and skills without being influenced by irrelevant factors.

4. **Authenticity**: Assessments should mirror real-world tasks and scenarios relevant to science education. Authentic evaluation tasks in sciences may include conducting experiments, analyzing data, solving scientific problems, or communicating findings—tasks that reflect the genuine application of scientific knowledge and skills.
5. **Transparency**: Evaluation criteria, methods, and expectations should be clear and transparent to both students and educators. Clear communication of assessment objectives and criteria helps students understand what is expected of them and how their performance will be evaluated in sciences.
6. **Alignment with Learning Objectives**: Evaluations should be closely aligned with the intended learning objectives and outcomes of science education. This alignment ensures that assessments effectively measure students' achievement of specific knowledge, skills, and competencies outlined in the science curriculum.
7. **Formative and Summative Assessment**: The evaluation process should include both formative assessment (ongoing feedback during instruction to inform learning) and summative assessment (final evaluations to measure overall achievement). This dual approach supports continuous improvement in science learning while providing comprehensive feedback on student progress.
8. **Multiple Methods**: Utilizing a variety of assessment methods and tools—such as written tests, practical experiments, projects, presentations, and peer evaluations—enhances the validity and reliability of evaluations in sciences. Different methods cater to diverse learning styles and allow for a holistic assessment of students' scientific knowledge and skills.
9. **Ethical Considerations**: Evaluation practices should uphold ethical standards and respect students' privacy, confidentiality, and rights. Ethical considerations in science evaluation include ensuring the integrity of data collection, maintaining confidentiality of student information, and avoiding discriminatory practices.
10. **Continuous Improvement**: The evaluation process should be iterative, with opportunities for reflection, adjustment, and improvement based on feedback from students, educators, and stakeholders. Continuous improvement ensures that assessment practices in sciences evolve to better support student learning and achievement.

    By adhering to these principles, educators can design and implement evaluation processes in science education that are valid, reliable, fair, transparent, aligned with learning objectives, and supportive of student learning and growth in scientific knowledge and skills.

Points to be kept in mind for Evaluation:

1. Selection of Tools - Unless and until the objective of evaluation has been defined carefully, it is not advisable to select the tools of evaluation or to develop them. When the aim of evaluation is clear before us, then only the appropriate tools to achieve

them should be selected according to the aims and objectives. If suitable tools are not available then, preparation of suitable tools should be tried/worked upon.

2. Use of Tools - The evaluation tools should be used for the completion of those objectives which are being evaluated There are various tools of evaluation, each tools helps in achieving a particular objective and is not suitable for other types of objectives. Thus, the evaluation tools should be used for our fixed/predetermined objectives of evaluation.

3. Variety of tools - The evaluation of an individual is not possible through a single tool. Thus, for complete evaluation various methods and tools of evaluation should be used.

4. Merits and Demerits of tools - While using the various methods and tools of evaluation, the evaluator should have a complete.

5. Evaluation as Means - the evaluation should not be done for the sake of evaluation but as a mean to achieve a fixed objective. Evaluation should not be considered the end mean to achieve other things.

6. Work - the evaluator should work very diligently/carefully, while evaluating and should try to escape errors as far possible.

7. Ethics - the principle and ethic of evaluation should be kept in mind.

Self- Check Exercise-3

Q.1 **What should be clearly defined before selecting the tools of evaluation?**

A) The number of students

B) The schedule of the evaluation

C) The objective of the evaluation

D) The format of the evaluation

Q.2 Why is it important to use a variety of tools in evaluation?

A) To increase the duration of the evaluation process

B) To evaluate different aspects of an individual comprehensively

C) To make the evaluation more difficult

D) To simplify the evaluation process

Q.3 Evaluation tools should be selected based on the _____ and objectives of the evaluation.

Q.4 The principle and _____ of evaluation should be kept in mind by the evaluator.

Q.5 What is the term for using evaluation to achieve a fixed objective rather than as an end itself?

Q.6 What should evaluators work diligently to escape during evaluation?

18.6 Evaluation Process: Steps of Evaluation Process

Evaluation Process:

The evaluation process in education, particularly in sciences, is a structured and systematic approach to assessing students' understanding, knowledge, and skills. It begins with clearly defining learning objectives that align with curriculum standards and educational goals. Assessment methods, such as written tests, practical experiments, projects, and presentations, are chosen based on their ability to measure students' proficiency in scientific concepts, application of scientific principles, and critical thinking skills.

Throughout the evaluation process, validity and reliability are paramount, ensuring that assessments accurately measure what they are intended to measure and yield consistent results over time. Fairness is also crucial, with assessments designed to be impartial and free from biases, treating all students equitably regardless of background or circumstances.

The evaluation process typically includes both formative assessments, which provide ongoing feedback to guide instruction and support student learning, and summative assessments, which evaluate overall achievement at the conclusion of a unit or course. This dual approach allows educators to monitor student progress, identify areas needing improvement, and celebrate academic successes.

Ethical considerations, such as maintaining confidentiality and respecting student privacy, are integral to the evaluation process. Educators strive to create transparent assessment criteria and communicate expectations clearly to students, empowering them to understand and engage with the evaluation process effectively.

Ultimately, the evaluation process in sciences serves to inform teaching practices, curriculum development, and educational decision-making. By providing meaningful feedback and measuring learning outcomes against established standards, it supports continuous improvement in science education and prepares students for future academic and professional endeavors in scientific fields.

Evaluation is a complicated process having three dimensions. These have been explained with the help of following diagram-

The process of evaluation has three important points- Objectives, Learning and Tools of Evaluation. The most important of these are objectives. These three points are interdependent. Some scholars have considered behavioural change as the third point of evaluation.

Steps of Evaluation Process:

The evaluation process in education, including sciences, typically involves several key steps to ensure thorough and effective assessment of student learning. Here are the steps commonly followed in the evaluation process:

1. **Setting Clear Objectives**: Define specific learning objectives and outcomes that align with curriculum standards and educational goals. These objectives guide the assessment process by identifying what students are expected to know, understand, and be able to do in terms of scientific concepts and skills.
2. **Selecting Assessment Methods**: Choose appropriate assessment methods based on the learning objectives and the nature of scientific content being assessed. Common assessment methods in sciences include:
   - Written tests and quizzes to assess knowledge and understanding.
   - Practical experiments and laboratory reports to evaluate application of scientific principles and skills.
   - Projects, presentations, and portfolios to assess creativity, critical thinking, and communication skills.
3. **Designing Assessment Instruments**: Develop assessment instruments, such as rubrics, scoring guides, and criteria sheets, that clearly outline expectations and criteria for evaluation. These instruments ensure consistency in grading and provide transparency to students regarding assessment criteria.
4. **Administering Assessments**: Administer assessments according to the defined schedule and procedures. Ensure that assessment conditions are fair and conducive to demonstrating student knowledge and skills, while maintaining integrity and preventing academic dishonesty.
5. **Collecting Data**: Collect data from assessments, including student responses, performance outcomes, and observational notes. Use multiple sources of evidence to

provide a comprehensive view of student learning, such as formative assessments, classroom observations, and student work samples.

6. **Analyzing Results**: Analyze assessment data to interpret student performance and identify patterns, strengths, and areas for improvement. Compare student achievement against predetermined standards and benchmarks to determine whether learning objectives have been met.
7. **Providing Feedback**: Provide timely and constructive feedback to students based on assessment results. Feedback should be specific, actionable, and focused on helping students understand their strengths and areas needing improvement in relation to scientific concepts and skills.
8. **Using Assessment Results**: Utilize assessment results to inform instructional decisions, curriculum adjustments, and intervention strategies. Identify instructional strategies that support areas of weakness and build upon students' strengths to enhance learning outcomes in sciences.
9. **Communicating Results**: Communicate assessment results to students, parents, and stakeholders in a clear and understandable manner. Discuss progress, areas of growth, and opportunities for further development to foster a collaborative approach to student learning.
10. **Reflecting and Improving**: Reflect on the effectiveness of the evaluation process and assessment methods used. Continuously refine assessment practices based on feedback from students and colleagues to improve the validity, reliability, and fairness of future assessments.

    By following these steps, educators can effectively evaluate student learning in sciences, promote academic growth and achievement, and support continuous improvement in science education.

In another words we can also specify/understand the steps involved in Evaluation process in the following points:

- **Identifying and Defining Objectives-** Prior to setting the objectives, attention should be focused on the child, society, objectives- matter and standard of teaching. Keeping The evaluator should be very clear as to what type of changes does he want, and to what changes? Thus, while identifying and defining objectives, the method of identifying and defining objectives should be studied well, then only evaluation should be done. While defining objectives, the subject matter and behavior changes should be considered important.
- **Planning Learning Experiences-** After the objectives identified, attention should be paid to the learning experiences, which signify the creation of a situation in which the child can express the desired reaction. The evaluator should design the learning experiences on the basis of the objectives and similar experiences should be selected and designed.

A number of experiences are to be planned for achievement of the single objective. While planning, the level of the child, age, sex, surroundings, background etc. is kept in mind. Through the medium of teaching aids, teaching methods and means, the experiences are arranged/selected.

- **Providing Evidence Through Various Tools Of evaluation** - After the identification of objectives and planning learning experiences, the evaluator starts the work of selecting or developing suitable tools.
  If readymade tools are available, they should be used. If they are not appropriate or tools are not available, then the teacher has to construct the tools himself.
- **Apply the Tool and Record the evidence.** When the tool is ready, apply it on students to have the record of their behavior in a written test, written responses are evidences. In observation- situations, it is expected to prepare systematic records of observations. Tools should be applied to collect and record evidences.
- **Interpret the Evidences Recorded-** When the evidences or responses are collected they should be analyzed systematically, using proper statistics. The appraisal should be made in terms of objectives. The obtained values/results should be properly interpreted. These may be compared with initial performances or may be interpreted against some established norm or relative standard of desirable progress.
- **Suggestions for the future-** After analysis and interpretation of results, weaknesses and strong points may be chalked out, and accordingly relevant suggestions may be given for the future improvements.

SELF- CHECK EXERCISE-4

Q.1 What is the first step in the evaluation process?

A) Planning Learning Experiences

B) Providing Evidence Through Various Tools

C) Identifying and Defining Objectives

D) Interpreting the Evidences Recorded

Q.2 What should be considered important while defining objectives?

A) The number of students

B) The format of the evaluation

C) Subject matter and behavior changes

D) The time available for evaluation

Q.3 Which step involves designing the learning experiences based on the objectives?

A) Identifying and Defining Objectives

B) Planning Learning Experiences

C) Providing Evidence Through Various Tools

D) Interpreting the Evidences Recorded

Q.4 What is done after collecting responses during the evaluation process?

A) Interpreting the Evidences Recorded

B) Providing Evidence Through Various Tools

C) Identifying and Defining Objectives

D) Planning Learning Experiences

Q.5 After identifying and defining objectives, attention should be paid to the _____ experiences.

Q.6 When the evidences or responses are collected, they should be analyzed systematically using proper _____.

Q.7 What is created to allow the child to express the desired reaction during evaluation?

Q.8 What should be applied to collect and record evidence?

18.7 Summary

The evaluation process in science education involves several essential steps to effectively assess student learning and achievement. It begins with clearly defining learning objectives aligned with curriculum standards. Assessment methods are then selected based on these objectives, including written tests, practical experiments, and projects. Assessment instruments such as rubrics are designed to ensure consistency and transparency in grading. Assessments are administered under fair conditions, and data is collected from multiple sources. Results are analyzed to interpret student performance and provide constructive feedback. Assessment outcomes inform instructional decisions, curriculum adjustments, and intervention strategies. Finally, ongoing reflection and improvement ensure that assessment practices evolve to support continuous student growth and achievement in scientific knowledge and skills.

18.8 Glossary

 Evaluation: The systematic process of assessing and interpreting evidence to make judgments about the learning progress and achievement of students.

 Assessment: The process of gathering and interpreting information about student learning, typically through various methods such as tests, projects, and observations.

18.9 Answers to Self- Check Exercises

Exercise-1

Answer1: B) Measurement provides numerical data, while evaluation assesses quality and achievement.
Answer2: A) How much does an object weigh?
Answer3: what value
Answer4: teaching objectives
Answer5: Evaluation
Answer6: Learning experiences
Answer7: B) Summative Evaluation
Answer8: C) Diagnostic Evaluation
Answer9: Formative
Answer10: learning outcomes

Exercise-2

Answer1: B) It measures the extent to which students have acquired knowledge and changed in behavior.
Answer2: B) To classify students based on their achievements.
Answer3: difficulties
Answer4: collective
Answer5: Evaluation
Answer6: Inspiration
Answer7: D) To simplify the science curriculum.
Answer8: B) By assessing the work-effectiveness of teaching methods.
Answer9: disciplined
Answer10: guidance

Exercise-3

Answer1: C) The objective of the evaluation
Answer2: B) To evaluate different aspects of an individual comprehensively
Answer3: aims
Answer4: ethics
Answer5: Means
Answer6: Errors

Exercise-4

Answer1: C) Identifying and Defining Objectives
Answer2: C) Subject matter and behavior changes
Answer3: B) Planning Learning Experiences
Answer4: A) Interpreting the Evidences Recorded
Answer5: learning
Answer6: statistics
Answer7: Situation
Answer8: Tools

18.10 References / Suggested Readings

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18.11 Terminal Questions

- Discuss the importance of validity and reliability in assessment. Provide examples of how you would ensure these principles are upheld in evaluating student learning in science education.

UNIT-19

TYPES OF EVALUATION: FORMATIVE EVALUATION, SUMMATIVE EVALUATION, DIAGNOSTIC EVALUATION

Structure

19.1 Introduction
19.2 Learning Objectives
19.3 Types of Evaluation
19.4 Formative Evaluation
Self- check Exercise-1
19.5 Summative Evaluation
Self- check Exercise-2
19.6 Diagnostic Evaluation
Self- check Exercise-3
19.7 Summary
19.8 Glossary
19.9 Answers to self- check Exercise
19.10 References / Suggested Readings
19.11 Terminal Questions

19.1 Introduction

In education, assessments serve distinct purposes in evaluating student learning and guiding instructional practices. Formative, summative, and diagnostic evaluations are integral components of this process, each playing a crucial role in supporting educational goals. Formative evaluation occurs during the learning process, providing ongoing feedback to both educators and students to adjust instruction and enhance understanding. It focuses on identifying areas of strength and improvement, fostering student growth and mastery of concepts in real-time. In contrast, summative evaluation takes place at the conclusion of a unit or course, measuring overall achievement against predetermined standards or learning outcomes. It aims to assess cumulative learning and inform decisions regarding student progression or program effectiveness. Diagnostic evaluation, on the other hand, precedes instruction, assessing students' prior knowledge, skills, and misconceptions. It helps educators tailor their teaching approaches to meet diverse learning needs and scaffold understanding effectively. Together, these evaluation types form a comprehensive framework that supports continuous improvement in teaching and learning, ensuring educational outcomes are aligned with student needs and instructional objectives.

19.2 Learning Objectives

After completing this unit, the learners will be able to;

- learn the distinct purposes and goals of formative, summative, and diagnostic evaluations
- understand these evaluation types

19.3 TYPES OF EVALUATION

Evaluation practices in education encompass various types, each serving distinct purposes to assess student learning, inform instructional decisions, and improve educational outcomes.

Formative evaluation is crucial for providing ongoing feedback during the learning process. It helps educators monitor student progress, identify learning gaps, and adjust teaching strategies accordingly. By incorporating formative assessments such as quizzes, discussions, and peer reviews, teachers can promote active student engagement and guide them towards deeper understanding and mastery of content. Formative evaluation fosters a dynamic learning environment where feedback is timely and constructive, supporting continuous improvement and addressing students' individual learning needs.

Summative evaluation, on the other hand, focuses on measuring overall achievement at the end of a unit, course, or academic year. It provides a comprehensive assessment of students' cumulative learning outcomes against established standards or benchmarks. Summative assessments, such as final exams, standardized tests, and end-of-year projects, help educators gauge the effectiveness of instructional programs and curriculum implementation. They also play a crucial role in determining students' readiness for advancement and providing accountability to stakeholders, including parents, administrators, and policymakers.

Diagnostic evaluation serves as a precursor to instruction, aiming to assess students' prior knowledge, skills, and misconceptions. By administering diagnostic assessments at the outset of a learning unit or course, educators gain insights into individual students' starting points and learning profiles. This information enables teachers to tailor instructional approaches, differentiate learning experiences, and scaffold instruction effectively. Diagnostic evaluation promotes personalized learning by addressing specific learning needs and ensuring that instruction meets students at their current levels of understanding.

Each type of evaluation—formative, summative, and diagnostic—plays a critical role in supporting educational goals and enhancing student learning outcomes. By integrating these evaluation practices thoughtfully, educators can create inclusive and effective learning environments that cater to diverse student needs, promote continuous growth, and foster academic success.

19.4 Formative Evaluation:

Under formative evaluation, a teacher estimates his educational programme, method of teaching etc with a view to their quality, effectiveness and usefulness, so that educational programme method of teaching etc, can be made more effective and useful. It also explains that formative evaluation of the preliminary draft is done with a view to amend it in a desirable manner before giving it the final form. If some new method of teaching has to be developed, then a teacher uses that method of teaching on the representative sample group of students and by the evaluation of the data procured from it, he tries to reach the conclusion how far that new method of teaching is meaningful and useful for students. Evaluation and interpretation of the obtained data gives feedback to the teacher, on the basis of which necessary amendment and improvement is done to the method of teaching.

Often it is seen that a teacher keeps asking student different questions. These questions are helpful in learning the lesson and make teaching interesting and lively. These are called teaching questions. After a unit of a lesson has been finished, a teacher presents certain such questions before students by which he can know how far the students have learnt about that unit or topic. It helps a teacher to know how effective his method of teaching is. After getting feedback from this, he makes suitable changes in the method of teaching. When a teacher evaluates the achievement of students while teaching, it is called formative evaluation.

Formative evaluation is a continuous process that provides ongoing feedback to both students and educators during the learning process.

Key Steps Involved in Implementing Formative Evaluation Effectively:

1. **Setting Clear Learning Goals**: Define specific learning objectives and goals for the lesson, unit, or course. These goals should be measurable and aligned with curriculum standards and instructional objectives.
2. **Designing Formative Assessments**: Develop assessment activities and tasks that align with the learning goals. Formative assessments can include quizzes, exit tickets, class discussions, concept maps, journal entries, and peer/self-assessments.
3. **Administering Assessments**: Implement formative assessments regularly throughout the instructional period to gauge student understanding and progress. Ensure assessments are varied and reflect different aspects of the learning objectives.
4. **Providing Timely Feedback**: Provide immediate and specific feedback to students based on their performance in formative assessments. Feedback should be constructive, highlighting strengths, addressing misconceptions, and suggesting areas for improvement.

5. **Analyzing Assessment Data**: Collect and analyze data from formative assessments to identify patterns and trends in student understanding. Use this data to inform instructional decisions and adjustments in teaching strategies.
6. **Adjusting Instructional Strategies**: Based on the analysis of assessment data and feedback, modify instructional methods, materials, or pacing to better meet the needs of students. Adapt teaching approaches to address identified learning gaps and challenges.
7. **Promoting Student Reflection**: Encourage students to reflect on their learning progress and understanding based on the feedback received. Foster metacognitive skills by prompting students to self-assess their strengths and areas needing improvement.
8. **Monitoring Progress**: Continuously monitor student progress and engagement throughout the formative evaluation process. Use ongoing assessments to track individual and group performance over time, adjusting interventions as needed.
9. **Communicating Progress**: Share formative assessment results and feedback with students, parents, and stakeholders to keep them informed of student progress and learning achievements. Foster a collaborative approach to supporting student growth.
10. **Iterating and Improving**: Reflect on the effectiveness of formative evaluation practices and adjust as necessary. Continuously refine formative assessment strategies to enhance their impact on student learning outcomes.

By following these steps, educators can leverage formative evaluation to support student learning, guide instructional decisions, and promote continuous improvement in teaching and learning practices. Formative assessment not only enhances student engagement and understanding but also provides valuable insights for educators to tailor instruction effectively and facilitate meaningful learning experiences.

Self- check Exercise-1

Q.1 What is the primary purpose of formative evaluation in education?

A) To assign grades to students

B) To assess student learning at the end of a unit

C) To provide ongoing feedback to improve teaching methods

D) To determine eligibility for academic awards

Q.2 When does formative evaluation take place?

A) At the beginning of the school year

B) Throughout the teaching and learning process

C) Only during final exams

D) Once a semester

Q.3 Formative evaluation helps teachers _____ their educational programs and teaching methods.

Q.4 Teachers use _____ to gather feedback from students during lessons.

Q.5 What is the main purpose of using formative evaluation in education?

Q.6 How does formative evaluation benefit teachers?

19.5 Summative Evaluation

By summative evaluation is meant to examine the suitability of certain previously developed educational programme, curriculum, method of teaching, teaching aid etc. It helps to take a decision about the continuation of an educational programme, method of teaching etc. For example, supposing a science text-book has to be selected for high class students, then all those science text-books will have to be tested which have been written on science curriculum for high school students. Of these, the text-book to be selected will be the one which proves best from the viewpoint of educational objectives and curriculum etc. Here summative evaluation will be carried out in respect of the previously written text-books. In this situation, there is no possibility of affecting an amendment to the text-books written by different writers or published by different publishers. In the same manner, it we want to estimate the desirability of any specified admission procedure, educational programme, examination system etc, then it will be necessary to undertake summative evaluation so that it can be continued for the future years.

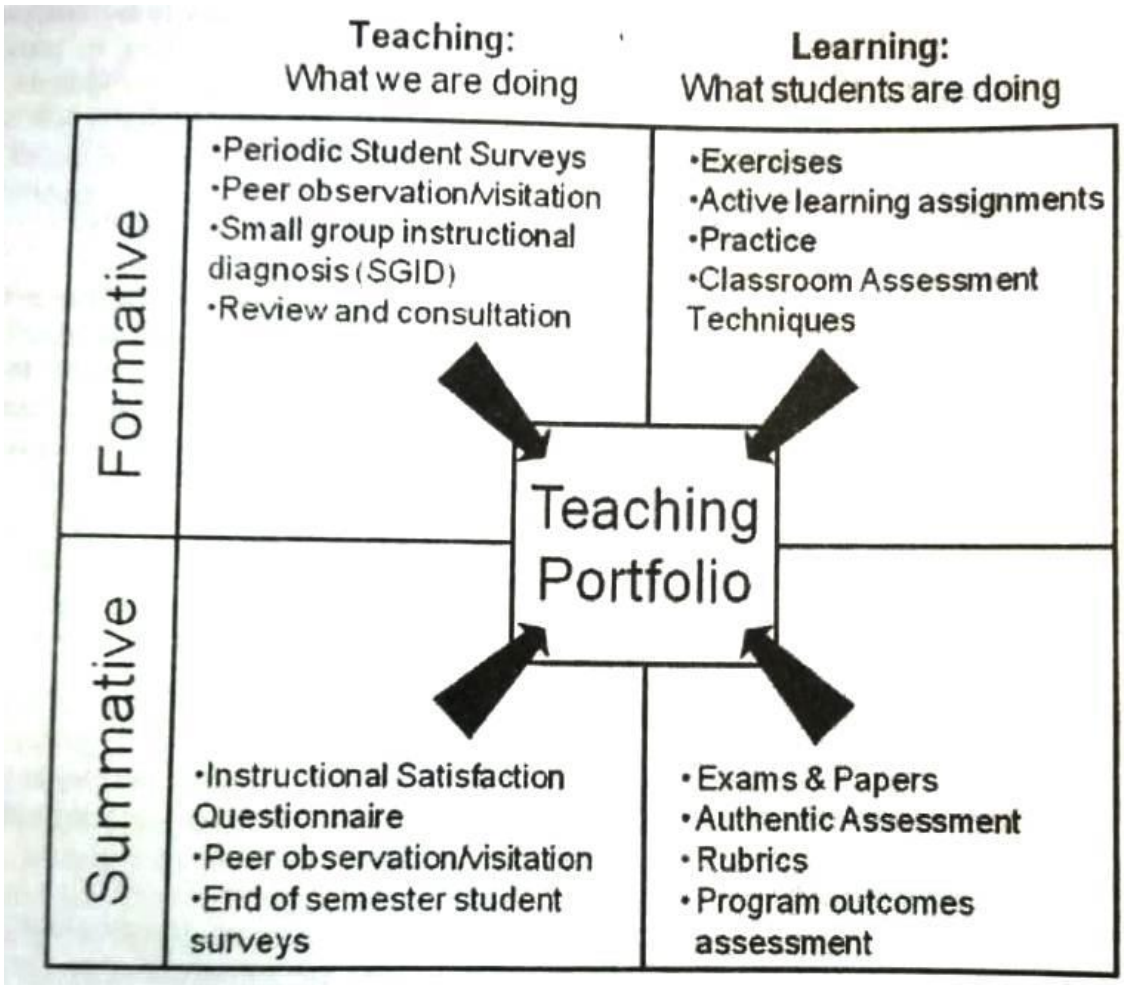
Summative evaluation is used to control the learning progress of students during the course of teaching. By it, both students and teachers get feedback about the successes or failures of the teaching-learning Successes encourage students and their behavior is strengthened in the desirable direction, while failure tells him where he has committed an error and where he has to amend his behavior. A teacher comes to know by feedback where he has to improve upon his method of teaching and when he has to provide remedial teaching to students. In this type of evaluation generally teacher-made tests are used. A teacher prepares a mastery test for proficiency of a small part, and through it, tries to know whether the students have assimilated the material taught to them. In order to find out the learning progress and learning errors a teacher can also use the observation technique too.

Summative evaluation is used to know how far the teaching objectives have been successfully achieved Its chief work is to classify or give divisions to students, but it also indirectly tells how far the objectives of the curriculum are suitable and how far the teaching technique has proved effective. For summative evaluation, generally teacher-

made tests are used. The nature of these tests depends on the teacher. The achievement tests, rating scales etc., are used chiefly for summative evaluation.

FORMATIVE ASSESSMENT	**SUMMATIVE ASSESSMENT**
-Assessment for learning	-Assessment of learning
-Focuses on the process	-Focuses on the outcome
-Monitor student learning to provide ongoing feedbacks that can be used by instructors to improve their learning.	-Provide teachers and students with information about the attainment of knowledge.
-Helps to identify students' strengths and weaknesses and largest areas that need work.	-The goal is to evaluate student learning at the end of an instructional unit by comparing it against some sort of standard or bench mark.
-Help faculties recognize where students are struggling and address problems immediately	-Assess whether the results of the objects being evaluated met the stated goals.
-Foster development and improvement within an ongoing activity.	-Assess the development after the activity.
-Low stakes- Low or no point value.	-High stakes or high point value.

Modes of Assessment of Teaching and Learning



Self- Check Exercise-2

Q. 1 What is the primary purpose of summative evaluation in education?

A) To provide ongoing feedback during the learning process

B) To assess the overall achievement at the end of a course or unit

C) To modify teaching methods in real-time

D) To diagnose individual student learning needs

Q. 2 Which assessment method is commonly used in summative evaluation?

A) Formative quizzes

B) Teacher-made tests

C) Peer assessments

D) Observational assessments

Q.3 Summative evaluation is used to make decisions about the _____ of educational programs and methods.

Q.4 _____ tests are often used to assess students' overall achievement in summative evaluation.

Q.5 What type of feedback does summative evaluation provide?

Q.6 How does summative evaluation assist in making decisions about educational programs?

19.6 Diagnostic Evaluation:

The meaning of the term 'Diagnosis' in the field of education is similar to its meaning in the medical field. A teacher locates the difficulties and weaknesses of educationally weak students using special techniques and methods. A teacher finds out the causes intensively, and then provides remedial teaching in order to eradicate those causes.

A diagnostic teaching is an educational approach on the basis of which the special qualities and shortcomings of a child are manifested in the minutest unit of the content. The diagnostic tests find out what part of the content has been learned in what amount, and what a student has found difficult to learn. Therefore, in a diagnostic test, students" weaknesses and shortcomings are found out in different subjects.

The meaning of a diagnostic test was explained by Yoakam and Simpson. In their words;

"A diagnostic test is the instrument developed by educational scientists for the purpose of difficulties and, if possible, revealing their causes".

A diagnostic test is used to find out specific abilities and shortcomings of a student in some subject, and its causes too are expressed.

Diagnostic evaluation in education refers to the process of assessing students' prior knowledge, skills, and understanding before instruction begins. Unlike formative and summative evaluations, which occur during or at the end of instruction respectively, diagnostic evaluation aims to gather baseline data about students' existing knowledge and abilities. Here are the steps typically involved in conducting a diagnostic evaluation:

1. **Identifying Learning Objectives**: Clearly define the specific learning objectives and outcomes that will be assessed through the diagnostic evaluation. These objectives should align with the curriculum standards and instructional goals.
2. **Selecting Assessment Tools**: Choose appropriate assessment tools and methods that can effectively measure students' knowledge and skills related to

the identified learning objectives. Assessment tools may include diagnostic tests, pre-tests, surveys, interviews, or performance tasks.

3. **Administering Assessments**: Administer the selected diagnostic assessments to students before the start of instruction on the targeted topics or subjects. Ensure that assessment conditions are conducive to accurate data collection and that students have sufficient time to complete the assessments.
4. **Analyzing Assessment Data**: Collect and analyze the data obtained from the diagnostic assessments. Look for patterns, strengths, and areas of improvement in students' knowledge, skills, and misconceptions related to the assessed content.
5. **Identifying Learning Needs**: Use the analysis of assessment data to identify individual students' learning needs and variations in their prior knowledge and understanding. Determine common areas of difficulty or misconceptions that may require targeted instruction or intervention.
6. **Informing Instructional Planning**: Based on the findings from the diagnostic evaluation, plan and adapt instructional strategies and approaches to meet the diverse needs of students. Tailor lessons, activities, and resources to scaffold learning effectively and address identified gaps.
7. **Differentiating Instruction**: Differentiate instruction by providing varied learning experiences and support strategies that cater to students' varying levels of readiness and understanding. Offer additional resources, enrichment activities, or remediation opportunities as needed.
8. **Communicating Findings**: Share diagnostic assessment results and insights with students, parents, and stakeholders to foster understanding of students' starting points and educational needs. Communicate the rationale behind instructional decisions and support collaborative efforts to support student learning.
9. **Monitoring Progress**: Continuously monitor students' progress and growth throughout instruction, using ongoing assessments to track improvements and adjustments in learning outcomes. Modify instructional strategies based on formative assessment data to address evolving needs.
10. **Reflecting and Adjusting**: Reflect on the effectiveness of the diagnostic evaluation process and its impact on instructional practices. Continuously refine assessment methods and strategies to enhance their validity, reliability, and relevance in supporting student learning and achievement.

Diagnostic evaluation plays a vital role in informing instructional planning and personalized learning approaches by providing educators with valuable insights into students' starting points and learning profiles. By conducting thorough diagnostic assessments and using the resulting data strategically, educators can create supportive learning environments that maximize student engagement, address learning gaps, and promote academic success.

Need and Importance of Diagnostic Test:

In the present age, education is being run as per psychological norms. A child's interests, mental ability, personality etc., are being given special importance in the teaching process today We consider individualized teaching as more effective and useful as compared to collective or group teaching. In fact, individualized teaching is possible only when a teacher diagnosis the learning difficulties of a child at the time of teaching. A diagnostic test can be used to locate the weaknesses and difficulties in learning. Therefore, a diagnostic test is necessary and useful for individualized teaching.

Diagnostic tests are very important in the teaching-learning processes. Its importance can be described under the following points;

- Useful for child-centred education: a teacher ascertains individual differences of his students with the help of a diagnostic test. A diagnostic test helps to know how far a student has learned the content and what he has not able to learn.
- Useful in instructional situation: In order to make teaching - learning situations effective, these diagnostic tests are widely used by teachers. They have proved immensely useful and important under instructional situations.
- Economy in time and effort: in the absence of diagnostic tests, a teacher has to spend time in repeated teaching of a topic. By a diagnostic test, he can locate the difficulties of students and remove them. It saves both time and effort of the teacher.

Diagnostic tests are required to know intensive and extensive details of students' difficulties and errors. So, regular testing of students should be done in the class.

SELF- CHECK EXERCISE-3

Q.1 What is the primary purpose of a diagnostic test in education?

A) To assign grades to students

B) To locate difficulties and weaknesses in learning

C) To determine students' height and weight

D) To promote students to the next grade

Q.2 According to Yoakam and Simpson, a diagnostic test helps in revealing students' _____ and their _____.

19.7 Summary

According to Vivekananda, "Education is the manifestation of divine perfection already existing in man". Evaluation methods when practiced will lead to this. Continuous and comprehensive evaluation facilitates students' effective learning as well

as their all round development of personality with its multiple evaluation tools and techniques and corrective measures By using this particular evaluation technique, the teacher can turn ordinary students into active learners. By facilitating all round development of students, providing all the students the same opportunity to display their individual potential, helping the teacher to realize the effectiveness of teaching learning process, continuous of teaching technique proves itself as a boost to student. Thus It is utmost important to make continuous and comprehensive evaluation as an integral part of teaching and learning process to promote standards of school education.

Life today has become so complex that examination have come to play an important part in one's educational career. Examinations are considered so important that most students are afraid of them. If there were no examinations, most scholars would have been less informed than they are today Examinations compel students to read as much as they can, and as they do so, they absorb knowledge unconsciously. Further, because of examinations, teachers have to confine themselves to the syllabuses which are aimed at imparting knowledge in a systematic manner, and thus develop mental discipline. Examinations are therefore an important part of academic studies. The present examination system in India is predominately focusing on the intellectual skills mainly and the and the society further supporting it, the psycho motor and affective domains of holistic learning have not received their due importance. The aim of education is developing the whole child' Holistic education demands development of all aspects of personality including cognitive, affective and psycho motor domains. But in the present scenario it is very stressful for the parents, teacher and students only to be working on cognitive aspects without learning the processes of learning. Teacher professional self esteem and promotions are geared to the scholastic marks attained by their learner.

Focusing on excellence in academics alone undoubtedly result in lop-sided development of personality In order to bring about the improvement in the quality of education and the holistic development of the child who is tomorrow's global citizen, evaluation process should focus adequately on both scholastic and non-scholastic areas of development. Hence the focus need to shift to comprehensive evaluation also needs to have continuity at regular intervals throughout the academic year.

19.8 **Glossary**

- **Formative Evaluation**: Assessment conducted during the learning process to provide ongoing feedback and guide instructional adjustments. It aims to monitor student progress and support continuous improvement in teaching and learning.

- **Summative Evaluation**: Assessment conducted at the end of a unit, course, or academic year to measure overall student achievement and mastery of learning outcomes. It provides a comprehensive evaluation of student learning against established standards.

 Diagnostic Evaluation: Assessment conducted before instruction begins to assess students' prior knowledge, skills, and misconceptions related to specific learning objectives. It informs instructional planning by identifying individual learning needs and variations in readiness.

19.9 Answers to Self- Check Exercises

Exercise-1

Answer1: C) To provide ongoing feedback to improve teaching methods

Answer2: B) Throughout the teaching and learning process

Answer3: improve

Answer4: questioning techniques

Answer5: Feedback

Answer6: Improvement

Exercise-2

Answer1: B) To assess the overall achievement at the end of a course or unit

Answer2: B) Teacher-made tests

Answer3: continuation

Answer4: Achievement

Answer5: Final

Answer6: Assessment

Exercise-3

Answer1: B) To locate difficulties and weaknesses in learning

Answer2: difficulties, causes

19.10 References / Suggested Readings

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19.11 Terminal Questions

1) What do you mean by Evaluation? What are its objectives?
2) Explain the term Formative Evaluation. How it can be done in Sciences?
3) Differentiate between Formative and Summative Evaluation.
4) What is meant by the term Diagnostic Evaluation? What is Its Importance in Sciences?

UNIT-20
CONTINUOUS AND COMPREHENSIVE EVALUATION

Structure

20.1 Introduction
20.2 Learning Objectives
20.3 Meaning and Concept of Continuous and Comprehensive Evaluation
Self- check Exercise-1

20.4 Objectives, Need and Functions of Continuous and Comprehensive Evaluation

Self- check Exercise-2

20.5 Advantages of CCE and Obstacles in implementation of CCE
Self- check Exercise-3

20.6 Remedial Measures and Techniques with Reference to Sciences
Self- check Exercise-4

20.7 Role of Teacher Educators/BRC/CRC Personnel In CCE
Self- check Exercise-5

20.8 Summary
20.9 Glossary
20.10 Answers to self- check Exercises

20.11 References /Suggested Readings

20.12 Terminal Questions

20.1 Introduction:

The purpose of assessment is necessarily to improve the teaching-learning process and material, and be able to review the objectives that have been identified for different school stages, by gauging the extent to which capabilities if the learners have been developed Examinations play an important part in one's educational career. The present examination system in India is predominately focusing on the intellectual skills mainly and the present and the society further supporting it, the psycho motor and affective domains of holistic learning have not received their due importance. But the aim of education is developing the whole child. Holistic education demands development of all aspects of individual's personality including cognitive, affective and psycho motor domains. In the present scenario it is very stressful for the parents, teachers and students only to be working on cognitive aspects without learning the processes of learning Teachers' professional self esteem and promotions are geared to

the marks attained by their learner. Focusing on excellence in academics alone undoubtedly result in lop-sided development of personality. In order to bring about the improvement in the quality of the education and the holistic development of the child who is tomorrow's global citizen, evaluation process should focus adequately on both scholastics and non-scholastic areas of development. Hence the focus needs to shift to continuous and comprehensive evaluation.

20.2 Learning Objectives

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

- Understand the Concept of Continuous and Comprehensive Evaluation.
- Explain the features of CCE.
- Explain the objectives of CCE.
- Understand the importance and Functions of CCE.
- Understand the Advantages of CCE.
- Apply the CCE technique with reference to Sciences

20.3 Meaning and Concept of Continuous and Comprehensive Evaluation:

Continuous and comprehensive Evaluation refers to a system of school-based assessment that covers all aspects of student's development. It helps in improving student's performance by identifying his/her learning difficulties at regular time intervals right from the beginning of the academic session and employing suitable remedial measures for enhancing their learning performance. By facilitating all-round development of students providing all the students the same opportunity to display their individual potential, helping the teacher to realize the effectiveness of teacher-learning process, continuous and comprehensive evaluation technique proves itself as a boost to students.

The National Policy on Education (NPE 1986), states that Comprehensive and Continuous Evaluation should incorporate both scholastic and non-scholastic aspects of evaluation, spread over the total span of instructional time"

The NCF 2005 also recommends that a school-based Continuous and Comprehensive Evaluation system be established in order to

(i) Reduce stress on the children,
(ii) Make evaluation comprehensive and regular,
(iii) Provide space for the teacher for creative teaching.
(iv) Provide a tool for diagnosis and for producing learners with greater skills.

Concept of Continuous and Comprehensive Evaluation:

Continuous and Comprehensive Evaluation was formulated by ministry of Human Resource Development to decrease the accumulated stress of board exams on the students and to introduce a more uniform and comprehensive pattern in education for the children all over the nation. It helps in improving student's performance by identifying his/her learning difficulties at regular time intervals right from the beginning of

the academic session and employing suitable remedial measures for enhancing their learning performance. Continuous and Comprehensive Evaluation refers to a system of school-based assessment that covers all aspects of student's development. Now according to of Education act Continuous Comprehensive Evaluation mandatory at primary level of education. Continuous Comprehensive Evaluation technique is useful to identify difficulties and weakness in learning of students. It is also useful for all round development of the student. But it is necessary to use variety of evaluation tools and technique. Evaluation is a process by which we can collect evidences for student progress. By analyzing collected data, we can record observations about an individual and them teacher can adopt corrective measures for better learning of student. In short, it involves systematic collection, analysis and interpretation of learner' progress both in scholastic and co-scholastic areas of learning to provide constant feedback about the effectiveness of course content, classroom processes and the growth in individual learner Continuous Comprehensive Evaluation means a method adopted to evaluate various aspects of development of students personality from various dimensions. It is comprehensive because the evaluation is exhaustive and is done on many levels and since the evaluation is all year round, it is continuous. Continuous Comprehensive Evaluation is divided in to 3 parallel parts:

Part-1:

This part deals with performance in academic subjects like Science, Math and English instead of marks, grades are given based on the performance all through the year. The academic year is divided into two sessions, in each session; there are Formative and Summative Assessments. The school has liberty in deciding the number of Formative assessments and their percentage by weight, but at the end of the evaluation, the students get a grade for each subject instead of marks.

Part-2:

This part deals with Co-scholastic areas such as life Skills, Attitude and Value. For each of the co-scholastic skills, teachers are again required to give a Grade and a descriptive indicator Schools can expand these; for example, life skills can include Thinking skills, Social Skills and Emotional skills. Attitude can be judged towards teachers, peers and environment. This part of the CCE aims to tell the students and parents that it is not just the education that is important for an overall development of a child during the schooling years.

Part-3:

This part deals again deals with Co-scholastic activities. The idea behind this part is to give simple grades based on activities performed/participated in during the year. This part is divided in two section a literary/Creative/Scientific/Aesthetic Skills, Performing Art, Clubs etc) Health and Physical Education. Teachers are expected to grades students on their involvement with these activities during the year Students can sticks with areas like literary skills like debates and Declamations or even showcase their

talents in more creative fields like art, craft and drama. This way, this part again promotes development of a child in areas other than academics. In the CCE grading system there will be dual formative assessment and single summative assessment for assessment of scholastic areas. In the formative assessment students will be given regular feedback and motivate them to actively involve themselves in self learning. This will help to increase the students' performance level and confidence level. The formative Assessment is not constrained only to the pencil paper tests. It also has various quizzes, oral testing, projects, assignments etc. The Summative assessment in the CCE is a way of assessment of student's performance at the end of the teaching. The evaluation is of pen- paper test and is carried out by the schools themselves. This will be held at the end of each term. There will be an evaluation of Co-Scholastic areas like students achievement, Attitudes, Creative and scientific skills, health and physical education and many more.

Features of Continuous and Comprehensive Evaluation:

The continuous aspect of CCE takes care of continual and periodicity aspect of evaluation. Continual means assessment of students in the beginning of instructions (placement evaluation) and assessment during the instructional process (formative evaluation) done informally using multiple techniques of evaluation. Periodicity means assessment of performance done frequently at the end of unit/term (summative)

The comprehensive component of CCE takes care of assessment of all-round development of the child's personality. It includes assessment in Scholastic as well as Co-Scholastic aspects of the pupil's growth.

Continuous and Comprehensive Evaluation (CCE) is a holistic approach to assessment that emphasizes the continuous nature of evaluating student learning and development throughout the academic year. Here are the key features of Continuous and Comprehensive Evaluation:

1. **Continuous Assessment**: CCE focuses on ongoing assessment throughout the year rather than relying solely on end-of-term or year-end exams. It involves regular formative assessments, such as quizzes, assignments, projects, and class discussions, to monitor students' progress and understanding in real-time.
2. **Comprehensive Assessment**: CCE considers various aspects of students' learning and development beyond academic performance. It includes evaluating cognitive, affective, and psychomotor domains to provide a holistic view of students' abilities, skills, and attitudes.
3. **Formative Assessment**: Formative assessments are integral to CCE, providing timely feedback to both students and teachers. These assessments help identify learning gaps, misconceptions, and areas needing improvement, enabling educators to adjust teaching strategies and interventions accordingly.
4. **Summative Assessment**: While CCE emphasizes continuous assessment, it also includes summative assessments to measure students' overall achievement at the end

of a specific period, such as a semester or academic year. Summative assessments provide a culmination of learning outcomes and help in determining students' progression to the next level.

5. **Multiple Assessment Methods**: CCE encourages the use of diverse assessment methods to accommodate different learning styles and preferences. These methods may include written tests, oral exams, practical assessments, peer assessments, self-assessments, and project-based evaluations.
6. **Skill-Based Assessment**: In addition to traditional knowledge-based assessments, CCE focuses on assessing students' skills, such as critical thinking, communication, collaboration, creativity, and problem-solving abilities. These skills are essential for students' holistic development and future success.
7. **Feedback and Remediation**: CCE promotes providing constructive feedback to students based on assessment results. Feedback helps students understand their strengths and weaknesses, encourages self-reflection, and guides them towards improvement. Remedial measures and support strategies are also integrated to address learning gaps and enhance student learning outcomes.
8. **Continuous Monitoring and Reporting**: Teachers continuously monitor students' progress and maintain records of their performance across various assessments. Regular reporting to parents and stakeholders ensures transparency and accountability in the evaluation process, fostering a collaborative approach to supporting student growth.
9. **Holistic Development**: The primary goal of CCE is to promote holistic development by nurturing not only academic excellence but also social, emotional, and physical well-being. It acknowledges that each student is unique and encourages personalized learning experiences tailored to individual strengths and needs.
10. **Reduction of Exam Stress**: By emphasizing continuous assessment and focusing on varied aspects of student development, CCE aims to reduce the stress associated with high-stakes exams and promote a more relaxed and conducive learning environment.

Overall, Continuous and Comprehensive Evaluation seeks to transform the assessment process into a positive and supportive experience that enhances student learning, encourages lifelong learning habits, and prepares students for success in diverse academic and real-world contexts.

Self- Check Exercise-1

Q.1 What was the primary reason for introducing Continuous and Comprehensive Evaluation (CCE) by the Ministry of Human Resource Development?

A) To increase stress on students

B) To standardize education patterns nationwide

C) To eliminate school-based assessments

D) To reduce board exam pressure

Q.2 Continuous and Comprehensive Evaluation covers all aspects of a student's _____.

Q.3 True or False: Continuous Comprehensive Evaluation involves evaluation only at the end of the academic session.

Q.4 How many parallel parts is Continuous Comprehensive Evaluation divided into?

20.4 Objectives, Need And Functions Of Continuous And Comprehensive Evaluation

Objectives Of Continuous And Comprehensive Evaluation

- To develop cognitive, psychomotor and affective skills.
- To lay emphasis on thought process and de-emphasis memorization.
- To make evaluation an integral part of teaching-learning process.
- To use evaluation for improvement of students' achievement and teaching learning the basis of regular diagnosis followed by remedial instruction.
- To use evaluation as a quality control devise to maintain desired standard of performance.
- To determine social utility, desirability or effectiveness of a programme and take appropriate decisions about the learner, the process of learning and the learning environment.
- To make the process of teaching and learning a learner-centered activity.

The comprehensive component of CCE takes care of assessment of all round well as Co- Scholastic aspects of the pupil's growth. Scholastic aspects include curricular areas or subject specific areas, whereas co-scholastic aspects include life skills Co-Curricular, attitudes, and values.

Need of Continuous and Comprehensive Evaluation:

Continuous and Comprehensive Evaluation is a boost to students. It helps in reducing streets of students by:

- Identifying learning, progress of students at regular time intervals on small portions of content
- Employing a variety of remedial measures of teaching based on learning needs and potential of different students.
- Avoiding from using negative comments on the learner's performance.
- Encouraging learning through employment of a variety of teaching aids and techniques.
- Involving learners actively in the learning process.

- Recognizing and encouraging specific abilities of students, who do not excel in academics but perform well in other co curricular areas.

Functions of Continuous and Comprehensive Evaluation:

- It helps the teacher to organize effective teaching strategies.
- Continuous and comprehensive evaluation helps in regular assessment to the extent and degree of learner's progress.
- Continuous and comprehensive evaluation serves to diagnose weaknesses and permits the teacher to ascertain in individual learner's strengths and weaknesses and their needs.
- It provides immediate feedback to the teacher, who can then decide whether a particular unit class or whether a few individuals are in need of remedial instruction.
- By continuous evaluation, children can know their strengths and weaknesses. It provides the child a realistic self assessment of how he/she studies.
- It can motivate children to develop good study habits, to correct errors, and to direct their activities towards the achievement of desired goals.
- It helps a learner to determine the areas of instruction in which more emphasis is required.
- Continuous and comprehensive evaluation identifies areas of aptitude and interest. It helps in identifying changes in attitudes, and value systems.
- It helps in making decisions for the future regarding choice of subjects, courses and careers.
- It provides information/reports on the progress of students in scholastic and co-scholastic areas and thus helps in predicting the future success of the learner.
- Continuous evaluation helps in bringing awareness of the achievement to the child, teachers and parents from time to time. They can look into the probable cause of the fall in achievement if any, and may take remedial measures of instruction in which more emphasis is required.

Self- Check Exercise-2

Q.1 What is one of the primary objectives of Continuous and Comprehensive Evaluation (CCE)?

A) Emphasize rote memorization

B) Develop cognitive, psychomotor, and affective skills

C) Minimize evaluation during teaching

D) Focus only on scholastic aspects

Q.2 CCE aims to use evaluation as a quality control device to maintain desired _____ of performance.

Q.3 True or False: Question: Continuous and Comprehensive Evaluation helps in identifying learning progress at irregular intervals.

Q.4 CCE encourages learning through the employment of a variety of _____ and techniques.

Q.5 Continuous evaluation provides immediate feedback to the teacher to determine whether remedial _____ are necessary.

Q.6 True or False: CCE helps in predicting the future success of the learner based on reports of progress in both scholastic and co-scholastic areas.

20.5 Advantages of Continuous and Comprehensive Evaluation (CCE):

1. **Holistic Development**: CCE focuses on evaluating various aspects of students' learning, including cognitive, affective, and psychomotor domains. It promotes holistic development by assessing not just academic knowledge but also skills, attitudes, and values.
2. **Continuous Feedback**: It provides ongoing feedback to students, parents, and teachers, helping to identify learning gaps and areas for improvement promptly. This feedback loop supports personalized learning and enables timely interventions to enhance student performance.
3. **Reduced Exam Stress**: By incorporating regular formative assessments throughout the academic year, CCE reduces the pressure associated with high-stakes exams. Students can focus on continuous learning and improvement rather than solely preparing for summative assessments.
4. **Enhanced Learning Outcomes**: CCE encourages active student engagement and participation in the learning process. It promotes deeper understanding, critical thinking, and problem-solving skills, which are essential for academic success and lifelong learning.
5. **Individualized Learning**: The emphasis on multiple assessment methods allows educators to tailor instruction to meet students' diverse learning needs and preferences. This personalized approach fosters inclusivity and supports students at different levels of proficiency.
6. **Comprehensive View of Student Progress**: CCE provides a comprehensive view of students' academic progress and development over time. It enables educators to track growth, identify trends, and make data-informed decisions to improve teaching practices.

Obstacles in Implementing Continuous and Comprehensive Evaluation (CCE):

1. **Time and Resources**: Implementing CCE requires adequate time and resources for designing, administering, and analyzing assessments. Educators may face challenges

in balancing assessment responsibilities with curriculum delivery and other instructional duties.

2. **Assessment Literacy**: Effective implementation of CCE depends on educators' proficiency in designing and using diverse assessment methods. Limited assessment literacy among teachers can hinder the accurate interpretation of assessment data and the delivery of constructive feedback.
3. **Standardization and Consistency**: Ensuring consistency and standardization across assessments can be challenging in CCE. Variability in assessment practices among educators may impact the reliability and comparability of assessment results.
4. **Administrative Burden**: Managing and documenting continuous assessments for each student can be administratively burdensome. Educators and administrators need efficient systems and tools to streamline assessment processes and maintain accurate records.
5. **Resistance to Change**: Introducing a shift towards CCE may face resistance from stakeholders, including teachers, parents, and policymakers, who are accustomed to traditional assessment practices. Overcoming resistance and gaining buy-in for CCE requires effective communication and professional development.
6. **Reliability and Validity**: Ensuring the reliability and validity of assessments used in CCE is essential. Educators need training and support to develop valid assessment tools that accurately measure learning outcomes and minimize bias.
7. **Accountability and Reporting**: Effective communication of assessment results and their implications for student learning and school improvement can pose challenges. Clear guidelines and frameworks for reporting assessment data are necessary to ensure accountability and transparency.

   Despite these obstacles, Continuous and Comprehensive Evaluation offers significant advantages in promoting student-centered learning, fostering holistic development, and preparing students for future challenges. Addressing challenges through professional development, resource allocation, and stakeholder collaboration can enhance the effectiveness of CCE in educational settings.

SELF- CHECK EXERCISE-3

Q.1 What is one advantage of the Continuous and Comprehensive Evaluation (CCE) system?

A) Emphasis on negative feedback

B) Focus on rote memorization

C) Encouragement of holistic education

D) Limited use of teaching aids

Q.2 CCE aims to reduce student _____ by evaluating learning progress at regular intervals.

Q.3 What is a major challenge faced in implementing CCE due to insufficient resources?

Q.4 True or False: CCE requires minute observations due to its reliance on grading rather than narrative feedback.

20.6 Remedial Measures and Techniques with Reference to Sciences

- Orientation to teachers about continuous comprehensive evaluation.
- Provisions in curriculum
- Planning of activities
- Time and work planning
- Development of Question Banks
- Development of Multiple-Choice Questions
- Development of Diagnostic and criterion referenced tests.

Techniques with Reference to Sciences

Students come to the classroom with their own ideas that are different from the scientifically accepted ones. They have arrived at these ideas by trying to make sense of their observations and experience and knowledge or information from many sources in their lives. Many concepts in science that students are introduce to in the elementary classroom are counter to what students have experienced - for example,

Earth is easily seen as flat from daily experience and roundness of earth is not intuitive at all. Many of their notions are unclear, not deeply thought about and are often different from the current scientific view.

Science teaching needs to take students from the everyday conceptions they have, to the scientifically accepted ones. This is a process that takes time and along the way students will pass through stages where input from the teacher is critical to helping them make the changes in their conceptions. The teacher thus needs to assess students' views continuously and identify their learning needs. It is helpful to remember that all knowledge in science is built starting from observations. If we encourage children to observe phenomena around them, notice patterns with the help of some mental or physical activity and report what they think, it will lead to many advantages. It will tell them that it is reality that they are trying to understand through science and science is not only knowledge residing in books. Reports of their own experiences and analysis are very good assessment guides for the teacher.

So, the first assessment strategy in science classes would be to allow children to speak, discuss, question each other and raise questions to the teacher. When they talk

about what they are observing and analyzing, you will know what they think about phenomena and in which direction you need to take them in your teaching. After observations, it is good to go towards the most important questions of science, namely the how and why questions. If one is noticing some phenomena, it is important to go through how it happens in nature, for example, how a seed grows into a plant or a bud turns finally into fruit or how phases of the moon vary with time or how a candle burns in air. Here, again, the learners' clear reports of the process or mechanism are important, which the teacher can assess and lead them towards clearly noticing what is happening, in what sequence or order or pattern. The teacher can ask for verbal/ written reports, charts, graphs or other representations, which can be either individual or collective. Coming to a collective view on a situation helps children discuss and argue amongst themselves and helps learners in assessing their understanding against their peers. Therefore collaborative and group work is a powerful tool in CCE, which leads to self and peer assessment. It also lightens the burden on the teacher.

The most challenging aspect, indeed the crux of science is, moving towards looking for explanations of the patterns observed. These emerge when looking for answers to questions on phenomena, for example, why a hole is present in the seed? Why the moon changes its phases or why wax melts easily on heating but iron does not. Since this is the essence of science, it is important to allow children to raise their own questions. Once again, the teacher can assess their level of interest or engagement from their questions. If sufficient questions/comments do not come from students, the teachers can draw attention towards some questions. If given freedom, children throw a large number of questions, particularly small children. The teacher also has to judge which questions can be handled at their current level of cognitive development. If some questions are of much higher order than their ages, the teacher can say that finding answers or explanations can be a prolonged process which may happen over many years. In finding answers appropriate at their ages, it is once again useful to let children make guesses at explanations. These guesses (or conjectures), which are called hypotheses in science, are a step towards finding explanations and allows children to learn to think scientifically. It is important not to judge these hypotheses by children as 'wrong' or 'right', since they are a very important step in knowledge building, in judging how children are currently reasoning. The teacher, through her teaching inputs has to build their knowledge from guesses to some explanation which makes sense to them, convinces them. Often teachers ask questions requiring only information and the vocal students raise their hands, often to jump at every opportunity to answer a teacher's question. It is important to see that often no learning is happening in such situations. The 'hand-raisers' are often giving pre-memorised answers, Else, they are trying to guess which correct answer the teacher is looking for. There is no deep thinking or reflection on the part of such extra-eager students and their motive is to just make a good impression on the teacher. Such

question-answer sessions are harmful for those who give such answers since they kill careful thinking. They are harmful for other quiet students too, since they interfere with knowledge building, and break their confidence and will to learn. Looking for a correct memorized answer, or seeking information, is anyway totally contrary to learning of science. What is actually learnt is the ability to memorize and guess what the teacher is looking for, rather than looking for an explanation of phenomena.

Self- Check Exercise-4

Q.1 What is the primary reason for encouraging students to observe and report their own experiences in science?

A) To compare with their classmates

B) To prove their knowledge from books

C) To understand reality through scientific inquiry

D) To memorize scientific facts

Q.2 In science education, the process of moving from observations to explanations involves forming _____, which are steps towards understanding natural phenomena.

Q.3 What is the purpose of encouraging students to ask 'how' and 'why' questions in science?

20.7 Role of Teacher Educators/BRC/CRC Personnel In CCE

While organizing professional development of teachers like in-service training, following points need to be addressed by educators:

1. Trainings are not to be organized in a top-down' manner, by telling teachers to implement methods or strategies suggested by them for CCE Teachers need to be suggested how to do assessment by taking examples so that they would get opportunities to discuss, reflect and share their problems.
2. Teachers must get the chance for peer discussion and sharing of school practices related to CCE. This process would facilitate mutual and participatory learning.
3. Clear understanding on purposes of assessment and evaluation procedures is required otherwise it would damage the learning process.
4. Under CCE, many states have developed various formats for recording and reporting progress of children. Clarity on different aspects of CCE is required while generating any kind of assessment data. Without such clarity, experience has shown that prescribed formats are not helping in teaching-learning process, rather wasting teaching-learning time.

5. Teachers are working in varied and often difficult situations, such as large-size classrooms, in difficult-terrain schools, multi-grade classrooms etc. A uniform recording and reporting format would not serve the purpose of CCE Prescriptive formats that do not give flexibility to the teacher go against the very spirit of CCE.

What Would We Expect a Science Classroom to be like?

Based on the discussion above, we expect students to engage with the processes of science. Specifically, they should:

- Observe things carefully
- Record their observations, make measurements
- Organise observations in a form that can be shared
- Discuss their observations with others
- Arrive at generalizations based on data

Further, we expect them to learn to:

- Frame hypotheses
- Design experiments to test hypotheses
- Carry out experiments designed by themselves or by others.
- Understand and critically evaluate the evidence and arguments leading to their conclusions

In all this, they will often be working in groups. Thus, we expect them to work together and learn from each other. Ideally the teacher will be facilitating the above, conducting whole class discussions, throwing challenges and provoking debate. The science classroom therefore cannot be a quiet place, or a place where only the teacher's voice is heard most of the time. While some special materials and equipment may be needed for some activities (eg. lenses, magnets, some chemicals), most of the above processes are not crucially dependent on the availability of such materials Thus, irrespective of resources, we expect some of these processes to be going on in a science classroom at any given time. CCE in science therefore will involve precisely these processes.

SELF- CHECK EXERCISE-5

Q.1 What is the primary purpose of facilitating peer discussions among teachers during CCE training?

A) To enforce top-down directives

B) To encourage mutual learning and sharing of practices

C) To reduce teaching workload

D) To exclude teachers' opinions

Q.2 Under Continuous and Comprehensive Evaluation (CCE), assessment formats should allow _____ to accommodate diverse teaching environments.

Q.3 What is one potential drawback of overly prescriptive assessment formats in CCE?

20.8 Summary

The CCE approach believes that teaching-learning is a continuous process that depends on dynamic interactions between the learner, her peers and the teacher. The teacher is the who spends the maximum time with children in the classroom. Therefore the teacher is the best person to judge children's learning needs, levels and progress. If any record is to be maintained in assessment, it should be mainly to inform the teacher and the choice as to what records he/she wants to keep, must be with him/her.

Recording of each and every classroom activity is burdensome, impractical and does not help teaching learning. The teacher should not be forced to record and report continuously, for all her classes or activities.

This would require that education officials, superiors and inspectors respect the teacher's autonomy, making her feel responsible and worthy of taking charge of children's learning. OCCE can only work in non-threatening situations, for both the teacher and the learners, where the charge of teaching-learning is given to them. Here administrators can encourage teachers to concentrate more on assessing the process and interaction in their classroom, rather than the product.

Besides this, the following can be done:

1. Short duration training of 4-5 days at one time may be considered, preferably during Vacations so that teachers' and children's learning time is not consumed for training.
2. Administrators need to know that they are also a part of teaching-learning process and their role is very important. Regular interactions with teachers to discuss their problems and find solutions can solve many difficulties.
3. It is necessary to give flexibility of time-table to the teacher for designing and evolving her teaching in CCE, CCE cannot work in rigidly bound time-schedules decided by people other than the teacher.
4. Teachers should be encouraged to use locally available resources and opportunities of learning outside the classrooms, which sometimes are not encouraged by administrators.
5. The essence of training programmes attended by teachers, head teachers and other educational personnel must be shared with all implementers. This process would help everyone update their knowledge and also make them understand the rationale of newly recommended changes.
6. Autonomy needs to be to teachers to undertake the syllabus in a sequence or manner they would like to take. For example, in most of the schools teachers have to

take chapters in a sequence suggested by schools Without this flexibility, a teacher cannot implement CCE or improve his/her teaching.

20.9 Glossary

 Continuous Assessment: CCE emphasizes the importance of ongoing assessment throughout the year rather than relying solely on traditional end-of-term or year-end exams. It involves regular formative assessments conducted during instructional periods to monitor students' learning progress and provide timely feedback.

 Comprehensive Assessment: CCE considers various aspects of students' learning and development beyond academic achievement. It includes assessing cognitive (knowledge-based), affective (emotional and social), and psychomotor (physical skills) domains to provide a holistic view of students' abilities and growth.

20.10 ANSWERS TO SELF- CHECK EXERCISE

Exercise-1

Answer1: D) To reduce board exam pressure

Answer2: development

Answer3: False

Answer4: 3

Exercise-2

Answer1: B) Develop cognitive, psychomotor, and affective skills

Answer2: standards

Answer3: False

Answer4: teaching aids

Answer5: instructions

Answer6: True

Exercise-3

Answer1: C) Encouragement of holistic education

Answer2: stress

Answer3: infrastructure

Answer4: True

Exercise-4

Answer1: C) To understand reality through scientific inquiry

Answer2: hypotheses

Answer3: explanations

Exercise-5

Answer1: B) To encourage mutual learning and sharing of practices

Answer2: flexibility

Answer3: rigidity

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20.12 TERMINAL END QUESTIONS

1. Who developed the CCE pattern? What are its main objectives?