(F.Y.B.Ed.)

Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 1

Unit 1: Basics of Academic Disciplines

a) Meaning of academic disciplines, Relationship between academic disciplines and Science subject.
b) Classification of academic disciplines: Becher -Biglan typology (pure-hard, pure soft, applied-hard, applied-soft types) with emphasis on nature of knowledge in each type.
c) Place of Science subject in the present school curriculum

a) Meaning of academic disciplines, Relationship between academic disciplines and Science subject.

Meaning & Definitions of Academic Disciplines –

Discipline and **Subject** are two words that relate **to** fields of knowledge. However, there's a lot of **difference between** them. **Discipline** refers **to** a branch of **academic** study. On the other hand, the **subject** refers **to** a branch of knowledge studied or taught.
Discipline is defined by the Oxford English Dictionary as "a branch of learning or scholarly instruction."

- An academic discipline is a branch of knowledge that is taught and researched as part of higher education.

- Discipline is defined by the *Oxford English Dictionary* as "a branch of learning or scholarly instruction."

- An academic discipline is clearly defined by its expertise, people, projects, communities, challenges, studies, inquiry, and research areas that are strongly associated with a given discipline.

- Arthur Dirks points out 'discipline in an academic sense, pertains to the practice of study of a certain category of experience, its methodologies, how it goes about its pursuit of truth. There is fundamental theory and fact (one might call it doctrine) that informs the practice of that pursuit, but it is the pursuit that counts.'

- According to Moti Nissani, a discipline can be conveniently defined as the study of "any comparatively self- contained isolated domain of human experience which possesses its own community of experts"

Characteristics of academic disciplines-

Disciplines generally exhibit the following characteristics:

1) Disciplines have ***a body of accumulated specialist knowledge*** referring to their object of research, which is specific to them and not generally shared with another discipline;

2) Disciplines have ***theories and concepts*** that can organise the specialised knowledge effectively. Take the discipline of Psychology for instance. The process of how learning occurs is elucidated by different theories. A single theory may not explain every kind of learning, yet when one examines different theories, one gains an understanding of the process of learning under different circumstances.
3) Disciplines use ***specific terminologies*** *or a specific technical language* adjusted to their research object. The discipline of Science has its own technical language. Specific terminologies are used in the discipline. For example words like 'consumer', 'ecosystem', 'producer' will have a definite meaning in Environmental Sciences but the same terms used in the discipline of Business Studies would mean something entirely different.

4) Disciplines have *a* ***particular object of research*** (e.g. law, society, politics), though the object of research may be shared with another discipline. For example 'human behaviour' is one object of research in the fields of Psychology, Education and Management.

5) Disciplines have developed ***specific research methods*** according to their specific research requirements. A discipline is defined by its method. For example if someone is studying Science.There is a particular method incorporated in the study. Disciplines defined by a particular method are capable of realizing genuine change and their scope is also concrete.

6) Disciplines must have ***some institutional manifestation in the form of subjects taught*** at universities or colleges, respective academic departments and professional associations connected to it. The discipline of Medicine for example is characterized by medical colleges. The association of doctors and publications in this field are part of the institutional manifestation of the discipline of Medicine.

Let us examine how History is a discipline. (Some experts state that while Humanities and Social sciences are disciplines, History is a sub discipline under Humanities). History is an example of a discipline because it meets several criteria ascribed to disciplines. It has a body of specialist knowledge which contains various events that have occurred in the past. It has definite key concepts like revolution, colonialism, racism, freedom etc. Theories such as Marxist Theory or the Great Man theory (which says that history is the impact of great people or highly influential individuals) are specific to History. History as a discipline uses specific terms for elucidation. Eg the term civilization has a definite connotation. When presenting historical events specific language is used. The objects of research in History are quite well defined. Events of the past, people movements, archeological remnants are some examples of areas of research in History. While pursuing research in History some definite steps are involved. The methodology to be followed is specified. Many universities have departments of history. One finds that history is included in the curriculum right from Primary stage. One comes across bodies of academicians connected with History. Since History exhibits all criteria associated with disciplines, it is classified as an academic discipline.

Thus each discipline has its own defining elements viz its phenomena, assumptions, epistemology, concepts, theories, and methods that distinguish it from other disciplines.

Academic disciplines and subjects
Different subjects share common areas of study and the nature of research. On the basis of these common aspects, subjects could be grouped under a specific discipline. If one looks at the courses offered by various universities one can see that broadly subjects are classified under the following disciplines.

a) Humanities (also called Arts and Humanities)

b) Social Sciences

c) Natural Sciences
d) Mathematics

e) Business

Natural Sciences as a discipline:

- Man always looks for ways to understand the environment around him, interpret various relationships and adapt to the changes in his surroundings. This human endeavour to build concepts to interact with the surrounding world is Science.
- Natural sciences refer to disciplines that seek to offer a systematic interpretation of the phenomena in the universe. Natural Sciences explain rules governing the natural world by applying scientific and empirical methods to the study of the universe.
- Sub disciplines as Physics, Chemistry, Geosciences(Oceanography, Ecology, Geology) , Life Sciences (Biology, Zoology, Botany) are some examples of Natural Sciences.
- The sciences are primarily concerned with the world as it is, and the arts are primarily concerned with the world man wants to live in.
- Science is dynamic with a body of knowledge that covers new domains of experience. Knowledge in Natural Sciences comes through the scientific method which includes hypotheses building, prediction, testing and review.
- Science always stands by objectivity and neutrality. The history of Natural Sciences is perhaps as old as our ancient civilizations. Natural Science as a discipline shows some unique features. It demands evidence. For example we accept that the earth is round because we have adequate evidence for the same.
- Science is unbiased. No subjectivity can creep into Science. It is based on observable facts which can be replicated, for example if we say that the density of mercury is 13.6 gm/cc, it will be so at any place on the earth.
- Science relies on evidence and this evidence is examined using logic. Science is non-dogmatic. Science never requires ideas to be accepted on belief or faith alone.
- Natural Science as a discipline has dispelled many myths and baseless beliefs. Life has become more comfortable thanks to the contribution of Science. Man has come out of the

shadow of ignorance due to Science.

- Logical thinking, decision making, scientific inquiry and scientific attitude are all by products of learning Science. We have been able to harness wind energy, move from one country to another and fight diseases due to Science.
- Science is predictive and has the power to explain the conditions that can follow a given condition. This provides warning signals and helps to take steps to prevent certain pitfalls. In fact the quality of life has significantly improved due to Science.

Science, in the contemporary world, is the basis for several vocations. Careers in nursing, medicine, industry, health care and production are all dependent on Science. Over the past few decades' new careers such as those Information Technology, Communication Technology, Food Technology and Environmental Sciences have carved a niche for themselves in the world of work.

The relationship between academic disciplines and subjects

Academic disciplines comprise subjects. The specific characteristics of different disciplines make it easy to classify specific subjects (or sub disciplines) to specific disciplines. The broad outline of a discipline gives an idea of what one can expect to learn in a given subject.

A subject is best understood against the background of the discipline that it is classified under. If one understands the basic characteristics of Natural sciences then one can understand its specific subjects like Chemistry and Physics.

- Subjects form a discipline. The scope of the discipline widens due to subjects. New subjects or sub disciplines may emerge with changing times. This can bring better understanding of subjects that pre exist in that discipline.
- Inter relationships exist between subjects clubbed under one discipline. Hence for better clarity of a subject one may need to refer to other subjects. The other subjects are understood effectively if one has clarity about the parent discipline.
- Students of a particular discipline share common goals, common content and common research methodology. Hence they should be aware of the main discipline and its component subjects as it lends clarity to the subject being studied.
- For example a researcher in Education will benefit if there is a firm grounding of the disciplines of Humanities and Social Sciences as Education draws from both these disciplines. If the topic being researched is something like 'Brain Based Learning' or 'Cognition', an understanding of a subject like Physiology will be beneficial.
- Research papers or academic writings on a subject are also guided by the discipline to which that subject belongs.
- A subtle difference between academic disciplines and subjects is that subjects normally pertain to syllabi, teaching –learning experiences and assessment. Subjects are generally associated with educational institutions. An academic discipline has wider connotations. It includes research done in the scope of that discipline; it includes communities of practice, emphasizes publication of work and thus goes beyond instruction and assessment.
- Subjects lend substance to a discipline. In turn the discipline fine tunes the subject lending it a distinct flavour. Those who pursue a particular subject should have a good

understanding of the discipline of the subject so that the subject is understood comprehensively. Academic disciplines and subjects are like ground and figure. One without the other is meaningless.

Why do teachers require an understanding of disciplines and subjects?

Most teachers are involved in teaching and learning activities that concern a particular subject. Yet the understanding of disciplines and subjects is extremely vital for the following reasons:

i. Adequate understanding of the discipline under which one's subject is classified helps a teacher ***to view the subject against the right background***. This helps to understand how the ***subject emerged and evolved*** over time. Every discipline has a specific focus and follows a definite system to build knowledge. This helps a teacher to do justice to the subject being taught. A teacher who teaches History must understand what the discipline of Social Sciences comprises of. Against the background of a thorough knowledge of Social Sciences, the teacher can deal with History in an elaborate manner.

ii. Subjects within a discipline ***bear a common thread among themselves***. An understanding of one's discipline promotes appreciation of other subjects within the discipline. External ***correlation*** between subjects is an integral part of the teaching-learning process. A teacher teaching Physics is able to appreciate the contribution of other subjects like Chemistry and Life Sciences if there is clarity about Science as a discipline.

iii. ***Learning experiences can be planned more meaningfully*** if one is aware of different disciplines. Inter disciplinary strategies and learning experiences can be planned to expand the horizons of the pupil's understanding. While teaching Economics, a teacher can take the help of subjects like Statistics, Mathematics and Commerce to facilitate the teaching learning process.

iv. Effective teachers have clarity regarding the concepts they teach. ***Concept clarity*** depends on how well one has understood one's own discipline and subject and how well one understands other subjects. Understanding and being able to apply discipline knowledge builds *self- confidence, and self-confidence* is central in the ***development of an effective teacher***. Discipline knowledge encompasses an understanding of the salient concepts, relations among concepts, ideas and skills of a subject and has always been acknowledged as the first prerequisite of ability to effectively teach a discipline. The effective teacher is more likely to chunk information, access relevant information, attach deeper meaning and extract more information from the environment in a more significant way. Discipline knowledge is a crucial prerequisite in the development of teacher self-confidence (Tisher, 1990)

v. Teachers often have ***to offer advice to students regarding the choice of subjects*** needed for a degree or the kind of professions available should one undertake a particular course. To provide such kind of guidance, teachers need to have an in-depth understanding of disciplines. For example a student interested in pursuing a career in Civil Services will be benefited by subjects like Economics, Political Science and Statistics. A career in Finance will need subjects from the Business Studies group , at the same time knowledge of Computers in Accounting Systems will also be useful. Thus a good understanding of what is included under each discipline will be advantageous while offering career guidance.

vi. Academicians are involved in research work. Every discipline has its own specific work style regarding research. ***Effective research is possible if one understands the research practices within a discipline***. This will help to select the area for research and decide the methodology and tools. A researcher with good knowledge of different disciplines can look at enriching the research by blending it with inputs from other disciplines. For example a research on 'Impact of Globalization on Education' will draw from varied subjects such as Education, Political Science and Economics.

vii. Teachers of a specific subject are ***bound to interact with one another regarding matters*** related to their subjects. These communities of practice are sustained by healthy contributions from teachers. These contributions are in the form of research, discussions, academic forums and publications in magazines and journals. A teacher with a firm foundation in one's own disciplines can contribute much to the community of practice.

vii. A good understanding of disciplines and subjects is useful ***to understand the world around us***. Events that affect us are better understood through knowledge of disciplines. The choices that one makes, the way one faces challenges and the vision that one develops are all impacted by one's knowledge of disciplines and subjects. Take for example investments made by an individual. A person with good knowledge of finance, world affairs and political conditions within one's nation will be able to make wise decisions about how to invest. Knowledge of Statistics, Economics and Business Studies will help to understand how the share market or banks function. A person with good knowledge of Psychology can handle problems with level-headedness. Thus the application of what one learns in various subjects can influence the quality of life.

b) Classification of academic disciplines: Becher -Biglan typology (pure-hard, pure soft, applied-hard, applied-soft types) with emphasis on nature of knowledge in each type.

There is no definite system with respect to classification of disciplines. Some experts classify disciplines based on the focus of their content as Arts and Humanities, Social Sciences, Natural Sciences, Mathematics, Business Studies. In the early 1970 Anthony Biglan carried out a study to investigate the faculty's judgement about similarities and differences between several academic fields. These perceptions were classified as

1. Pure vs Applied
2. Hard vs Soft
3. Concerned with life systems vs those not concerned with life systems.

Biglan's classification of disciplines

	Hard		**Soft**	
	Life	**Non-life**	**Life**	**Non-life**

Pure	Biology, Biochemistry, Genetics, Physiology, etc.	Mathematics, Physics, Chemistry, Geology, Astronomy, Oceanography, etc.	Psychology, Sociology, Anthropology, Political Science, Area Study, etc.	Linguistics, Literature, Communications, Creative Writing, Economics, Philosophy, Archaeology, History, Geography, etc.
Applied	Agriculture, Psychiatry, Medicine, Pharmacy, Dentistry, Horticulture, etc.,	Civil Engineering, Telecommunication Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, Computer Science, etc.	Recreation, Arts, Education, Nursing, Conservation, Counseling, HR Management, etc.	Finance, Accounting, Banking, Marketing, Journalism, Library And Archival Science, Law, Architecture, Interior Design, Crafts, Arts, etc.

Pure disciplines

Pure disciplines refer to those disciplines that tend towards fundamental research.

There is systematic observation of phenomena solely for the purpose of discovering unknown facts which may develop into theories.

The product of these disciplines is some kind of new knowledge. Simply put a pure discipline is a discipline that involves study purely for the sake of knowledge and not for its application.

Some examples are Pure Mathematics, pure Physics, pure Chemistry, Pure History.

Applied disciplines

Applied disciplines relate existing knowledge to real world situations.

These disciplines make significant contributions to the world by articulating the theoretical foundation in their field of study.

For example Human Resource Development is an applied discipline that draws heavily from pure disciplines like,psychology and Sociology.

Engineering is an applied science dependent on the pure sciences of Mathematics and Physics.

Hard disciplines

Disciplines that tend to use quantitative data. Tend to be predictive and use experimental methods are classified as a hard discipline.

Examples Physics, Chemistry, Engineering, Computing are all examples of hard disciplines as they deal with quantitative data.

They use experimental methods to build their repository of knowledge.

Soft disciplines

Soft disciplines are those disciplines that rely on qualitative data.

They generally do not use experimental methods and hence cannot make conclusive predictions concerning the future.

Examples of soft disciplines are Languages, Law, Anthropology and Education.

Biglan's work concentrated on the cognitive dimension of discipline, Becher in 1989 called attention to the social dimensions of academic discipline. From this emerged the Biglan- Becher typology of academic discipline. According to this typology 4 main types groups are possible

1. Hard and Pure disciplines
2. Hard and Applied disciplines
3. Soft and Pure disciplines
4. Soft and Applied disciplines

Table 2 Categorising the OU disciplines according to the Becher-Biglan typology

Hard Pure • Maths (including Statistics) • Science (including Chemistry and Analytical Sciences, Earth and Environmental Sciences, Life Sciences, Physics and Astronomy)	**Hard Applied** • Technology (including Computing, Design, Environment, Engineering)
Soft Pure • Social Sciences (including Economics, Geography, Politics and International Studies, Psychology, Sociology, Social Policy and Criminology). • Arts (including Art History, Classical Studies, English, History, Music, Philosophy and Religious Studies).	**Soft Applied** • Education • Modern Languages • Health and Social Care (including Nursing, Social Work and Youth Justice) • Business School (including Law)

1. **Hard and Pure disciplines**

- Hard and Pure disciplines involve general area of human understanding and are clustered around limited number of problems
- The nature of knowledge in these disciplines is cumulative and concerned with universal phenomena.
- The result of such knowledge is discovery of something new or expansion of already existing knowledge.
- As new knowledge keeps adding, the older form of knowledge is enhanced.
- The relationship between the knowledge seeker and knowledge is unbiased and very objective.
- There are very definite criteria to verify knowledge in such disciplines.
- There is a high degree of consensus over significant questions, for example- if two scientists are studying the effects of temperature on the state of matter, their results will be similar on matter which parts of the world they perform their experiments in.
- Academic communities in hard-pure disciplines are well organized, their work is quite competitive and publication rates are high.

Hard-Applied disciplines:-

- Hard-Applied disciplines are involved in purposive work.
- The emphasis is on application of theories resulting in creating techniques and products.
- These disciplines are practical in nature and are concerned with solving problems, addressing challenges and mastering the environment around us.
- The focus is on application and hence heuristic approaches find more importance in such disciplines.
- They used both quantitative and qualitative approaches. The criteria for judging the product of such disciplines are functional.
- Such disciplines result in new techniques and products being created.

- Engineering for example, is a hard-applied discipline which draws from mathematics, Physics and Chemistry.
- Clinical Medicine is a Hard-applied discipline dependent upon Biology and Chemistry.
- The ethos in such disciplines is entrepreneurial and dominated by professional values, Patents are submitted for publication.

Soft-Pure disciplines:-

- Soft-Pure Disciplines stress on understanding and interpretation of phenomena.
- Knowledge in these disciplines is reiterative which means there may be repetition of knowledge when examined in different situations.
- These disciplines are concerned with particular happenings rather than general occurrences.
- Unlike hard sciences, here data is qualitative.
- The researcher and knowledge share a personal relationship.
- There can be different views regarding what verification of data.
- Subjectivity can be high when interpretations are made.
- There is no definiteness as to what significant questions are to be answered.
- Anthropology and History are some examples of disciplines in this type.
- The academic communities of such disciplines tend to be less structured compared to those from hard-pure disciplines.
- Publication rate is also lower.
- It is interesting to note that while a discipline like Sociology is a soft-pure discipline, Sociometry, a subfield of Sociology, is hard-pure.

Soft Applied disciplines:-

- Soft-Applied Disciplines emphasizes processes and protocols.
- These are functional and utilitarian in nature.
- They are concerned with the enhancement of professional practice.
- Often their status is uncertain.
- They also appear to be dominated by intellectual fashions.
- They use a mix of qualitative and quantitative data for their growth.
- Case studies form an important tool in such disciplines.
- Law and education are examples of soft-applied disciplines.
- Education depends upon other soft disciplines like Psychology, Sociology and Philosophy; publication rates in these disciplines are low.

Thus the understanding of Biglan-Becher typology gives an overview of how different disciplines are similar and how they differ.One also sees how a particular group of disciplines has somewhat similar characteristics with respect to research carried out or publications made.

c) Place of Science subject in present school curriculum Place of the disciplines Science in present school curriculum Science:-

The word science has its roots in the Latin word Scientia, meaning knowledge"

Definition

1) "Science is a systematic and organized body of knowledge."
2) "Science can be defined as a systematic attempt to discover, by means of observations and reasoning. Particular facts about the world, and to establish laws connecting facts with one another, and in some cases, to make possible future occurrences.

Science is not only a mass of knowledge but the ultimate source of such accumulated knowledge.

Science is a body of empirical, theoretical and practical knowledge about the natural world. Produced by scientists who emphasize the observation, explanation and prediction of real world phenomena.

In its broadest sense, science refers to the systematic acquisition of knowledge or a prescribed practice that is capable of prediction in a controlled environment.

In this sense science may refer to a highly skilled techniques or practice,

Place of the disciplines Science in present school curriculum.

- Compulsory subject from Class 1 in school education.
- Basic to most professions hence important.

According to National Curriculum framework for school Education (2000), Science education at different stages is as follows"

Primary School:-

- Environmental studies as an integrated course.
- 1st, 2nd standard science as Environmental Studies.
- 3rd, 4th standard Science as General Science.

Upper Primary:-

- 5th to 8th Science as General science.

Secondary:-

- In 9th and 10th, science and technology as an integrated approach.

Higher Secondary:-

- Physics, chemistry & Biology as separate disciplines in 11th and 12th

Compulsory teaching of science and environmental orientation to science teaching up to secondary stage has been a common feature in science curricula OF ALL THE STATES.

Science education at Primary School:-

Science & Social Science is to be integrated as Environmental studies.

At this stage Science education should help to :

- Nurture the curiosity of the child about the world (natural environment, artifacts and people),
- Have the child engage in explanatory and hands-on activities for acquiring the basics cognitive and psychomotor skills through observation, classification, inference etc.:

- Emphasize design and fabrication, estimation and measurement
- Develop basic language skills: speaking , reading and writing not only for science but also through science.

Science Education at Upper Primary School:-
At this stage

- The child should be engaged in learning the principles of science through familiar experiences, working with hands to design simple technological units and models (e.g. designing and making a working model of a windmill to lift weights)
- Continue to learn more about the environment and health, including reproductive and sexual health, through activities and surveys.
- Scientific concepts are to be arrived at mainly from activities and experiments.
- Group activities, discussions with peers and teachers, surveys, organization of data and their display through exhibitions etc in school and the neighborhoods should be important components of pedagogy.

Science Education at Secondary School:-
At the secondary stage,

- Students should be engaged in learning science as a composite discipline.
- In working with hands and tools to design more advanced technological modules than at the upper primary stage, and
- In activities and analyses on issues concerning the environment and health, including reproductive and sexual health.
- Systematic experimentation as a tool to discover/verify theoretical principles.
- Working on locally significant projects involving science and technology are to be important parts of the curriculum at this stage

Science Education at Higher Secondary School:-
At the higher secondary stage,

- Science should be introduced as separate disciplines,
- With emphasis on experiments/technology and problem solving.

Unit 2: Place of Science in the Curriculum and Life

a) Meaning and Nature (Product & Process) of Science, Science Process skills - Basic and Integrated

b) Aims and Objectives of teaching science at upper primary, secondary and higher secondary level (NCF 2005)

c) Values of teaching science in socio-cultural context

a) Meaning and Nature (Product & Process) of Science, Science Process skills - Basic and Integrated

Definition:

What is Science?

The word science has its origin from a Latin word 'Scientia' meaning to know. Science is universal but has been defined in different ways.

e.g. "Science is a systematized body of knowledge."

Science is nothing but organized common sense."

Science is a heap of truth.

Definition of Science:

Science is a cumulative and endless series of empirical observations which result in the formation of concepts and theories being subject to modification in the tightness of further empirical observations.

Science is both a body of knowledge, and process of acquiring it by science man power

Science is an attempt to make the chaotic diversity of our sense experience correspond to logically uniform system of thought (Einstein)

Science in purest form is the simple extension of human curiosity (Arthur Clork)

Science as that human endeavor that seeks to describe with even increasing accuracy, the events and circumstances which occur or exist within our natural environment (John Woodbwen & E.O.obewn)

Science in both a body of knowledge and process of acquiring and refining knowledge.

Science is simultaneously a body of knowledge and a continuous self evaluative process of inquiry.

Science –

- Investigation and exploration of facts: **Process**
- Building of a systematic and organized of facts: **Product**

Science as a Product- Facts, Principles, Concepts, Laws, Relationships, Theories.

Science as a Process- Observation, Quantification, Classification, Measurement, Inferring and Predicting.

Science as a process –

In modern use, "science" more often refers to a way of pursuing knowledge, not only the knowledge itself.

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Experimentation –

It is a process in the sense it helps to explore the truth and involves certain systematic procedures and mental faculties as reasoning, analysis and synthesis.

- The process of science is the scientific method. This is the process of constructing an accurate, reliable, repeatable model of the real world, by scientists collectively working towards this goal over time.
- Scientific ideas are developed through reasoning.
- The process of science is not predetermined.

Nature of Science

Science has certain characteristics which distinguish it from other spheres of human endeavour.These characteristics define the nature of science. These also set the terms on which you can engage with science. These are discussed below.

1. **Science is a particular way of looking at nature**

   A morning walker looks at the rising sun, pays obeisance to the sun-god for bestowing the earth with light and energy and may offer prayer to propitiate him. /another walker with a scientific bent of mind or scientific attitude, while recognising it to be the source of all energy on the earth, may wonder where the sun gets its energy from, tries to understand the process of energy generation and may think of duplicating this process on the earth for the benefit of humankinds.

   A the time of an epidemic, people take to praying and seek divine intervention to save humanity, A scientist, on the other hand, seeks to isolate the pathogen responsible for the epidemic and develop preventive and curative strategies to fight the disease and save people

2. **Science is a rapidly expanding body of knowledge**

   Newer disciplines are being discovered and established every and the older ones are being enriched by researches being carried out in institutes of higher learning. Not only is the volume of knowledge increasing at a furious pace, but the newer knowledge is also replacing some of other older knowledge. Look around and you notice that the technology at the base of almost everything that you use has been overhauled in the last five to ten years. For example, the audio tape is now almost obsolete, its place has been taken by compact disc, which itself is being rapidly replaced by other media devices. In this respect science is a highly dynamic body of knowledge.

3. **science is an interdisciplinary area of learning**

   Science flourished in ancient cultures like Indians, Chinese, Greek, Egyptian and others, But the science as we know today is not older than a few hundred years. In fact the words science (meaning knowledge) and scientists are of relatively recent origin. Earlier, science was called Natural philosophy, alluding to the fact that science inquired into all natural phenomena. Be they on the earth, be they in the sky, be they under water in the oceans, or be they inside the human body. However, when the volume of knowledge became too large, scientists started specializing in certain areas. It is then that knowledge was organised for convenience into disciplines like physics, chemistry, biology, geology, astronomy etc. though no natural phenomena falls completely under just any one of these disciplines. Therefore, there cannot be any rigid demarcation of one discipline from another. Several scientific topics fall under more than one discipline. In fact at the present time the trend is towards studying more than one discipline, or interdisciplinary subjects.

4. **Science is a truly international enterprise**

   There is another aspect of modern science that needs consideration i.e. it is a truly international enterprise. Men and women of all countries participate in the progress of science and its applications. Most nog projects in science are undertaken by teams of scientists drawn from many countries. This is because the human and financial resources needed for most bog projects are beyond the reach of any single country.

5. **Science is always tentative**

   All theories, even the seemingly well-founded ones, can be revised or improved upon, or abandoned altogether whenever new evidence emerges, either as new experimental observations or as new theoretical developments. Since theories can change over time, all theories in science have the status as we know them at this instant, what happens tomorrow we cannot say. This should not be considered a weakness of science. It is actually its great strength.It is the tentativeness, or that the last word has not been said on any topic, that prompts scientists to keep striving to work for new theories or for the improvements of the existing theories, or for new explanations of the known phenomena. Scientists are always searching for evermore refined theories. That is how science prospers. If everything were final, there would be nothing new to discover, and science would never progress.

Characteristics of Science

1. **Science is a Process as well as Product** -It is a process in the sense it helps to explore the truth and involves certain systematic procedures and mental faculties as reasoning, analysis and synthesis. It is a product because it results in an organized body of systematic knowledge.

2. **Science helps to make descriptions**- It answers questions like how , where, when, under what circumstances.

3**. Science makes predictions**- Extending knowledge to further situations is prediction. It involves the use of generalizations or application of knowledge in new situations.

4. Science is based on observation- Meticulous observation followed by inference drawing is an essential part of science. These observations and their conclusions are objective in nature. Unbiased approach is followed in science.

5. Science is concerned with past, present and future- Science answers questions about the past.eg why could the dinosaurs have become extinct? It is involved with the present. e.g. search for remedies to diseases. It also dwells in the future.eg what fuels can be used in the future?

6. Scientific ideas are subject to change -It is never a finished product. There is a lot more to be discovered. The quest in science is unending. Scientific laws are tentative and may be changed with further research. Science is an eternal quest for truth.

The Process Skill- Basic and Integrated

Science Process Skill

The science process skills are the tools that students use to investigate the world around them and to construct science concepts, so it's essential to teachers to have a good understanding of these skills. However, identifying and defining the process skills is not always a simple task.

Definition:-

- Process skills are intellectual skills needed for scientific investigation attained by students as a result of learning of science.
- These skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of the scientists.
- Science process skills are the set of procedures which are employed by scientists during investigation and discoveries.

- SAPA (Science: A process Approach) describes that scientific process skills are defined as transferable skills that are applicable to many sciences that reflect the behaviour of scientists.
- Harlen (1992) stated that process skills include planning, following, directions, observing experimenting, measuring, predicting and inferring; these are concerned with processing evidence and ideas and so are often called process skills

By observing the above definitions it can be inferred that science process skills are the set of intellectual skills which are performed by our mind in association with sensory organs during the process of science.

Classification of Science Process Skills

The American Association for the Advancement of Science (AAAS), UNESCO (1992) identified thirteen process skills under two major classification namely Basic and integrated. Basic Science process Skills (BSPS) are observing, classifying, communicating, Measuring, Predicting and inferring. These basic process skills are the foundation for acquiring the integrated process skills. Integrated science process skills (ISPS) are identifying and defining variables, describing the relationship between variables, formulating and testing hypotheses, collection of data, designing investigation and experimentation, manipulating the variables, identifying the cause and effects, acquiring organising and displaying the data with charts, graphs, tables. All these process skills are integrated; there is no sequence or particular order of these skills. Any skills can begin first, all other skills follow later. But most of the time observation skill starts forts; rest of the skills follow later.

Basic Science Process Skills:-

1) **Observing**

This is the most fundamental of all the processes. Observation may be defined as the gathering of information through the use of any one, or combination of the five basic senses; sight, hearing, touch, taste and smell.

The term observation may also be used to express the result of observing. In other words one might observe and, as a result, gather observations. These observations can also be called data or facts.

Skilled observers seem to proceed from general perceptions of a system to more specific ones so the nature of skilled observing can be thought of as analytical. Systems are first observed as a whole then analysed for subsystem information. Subsequently, subsystems can be treated as a whole and subjected to further analysis in an ever tightening spiral. In summary, observation is an objective process of gathering data through the use of one’s senses applied in an analytical way.

2) Classifying

Classification is the process of sorting, grouping, ordering or arranging objects on the basis of similarities and differences, larger or smaller and other common characteristics. Most intuitive thinkers can select and group the objects by some common property such as colour shape and size. The classification can be qualitative as well as quantitative.

3) Communicating

Communication skill refers to conveying information from one person to another by verbal or non verbal means. Verbal communication conveys the information orally using scientific terminologies clearly, Non verbal forms of communication are though charts, graphs, maps, and drawings, symbols, pie charts, tables, chemical formulas of particular element or compound, symbols of electric component. Flow chart scientists use to communicate with another person about what they observed or discovered.

4) Measuring

Measurement is the act of using numbers to describe objects or events. Measurement is a process wherein measure the attributes that are measurable such as temperature, length, breadth, height, area, mass and volume. Measurement is a process which involves comparison of an entity with standard measurement. Measurement skill follows calculation after completion of every measurement. It should be written with a proper measurement unit for example ; units like centimetre or millimeter,kilograms length breadth temperature weight mass area volume etc.

5) Predicting

Predictions are statements about what might happen or could be expected to happen in the future. It is based on some relevant prior knowledge in a form which can be investigated, prediction is the act of predicting the forecasting events based on a previously developed model or experience. A model is a visual or cognitive representation that relates various aspects to one another; a well-developed model allows one to be more confident in making predictions related to a situation.

6) Inferring

Inference is the act of making statements based on observations. Inference is a process of making suggestions, conclusions, assumptions or explanations about a specific event based on observation. Interference is different from observations, there can be misconceptions. Observation is the use of one's senses to perceive objects and events and their properties. Inferences are making statements or conclusions after deep observation and understanding of a phenomenon, therefore observations are the base for any inference.

Integrated science process skills (ISPS)

1) Identifying and defining variables:-

Identification of variables: stating the factors or variables which affect the experiment.
Defining variable operationally: operationally describe the variables of an experiment

2) Manipulating the variables:-

It is important to manipulate the variables being tested and keep all other variables constant, The one being manipulated is the independent variable. The one being measured is the dependent variable.

3) Describing the relationship between variables,

Describe the relationship between variables in an experiment such as independent and dependent variables

4) **Formulating and testing hypothesis,**

Formulating the tentative statements or expected outcome for experiments. These statements must be testable.

5) **Collection of data:-**

Collection of data : collect qualitative and quantitative data during experiments through observations, measurements and any other means, employ sensory organs to collect information.
Recording the Data: record the quantitative and qualitative data for further use

6) **Designing investigation and experimentation,**

Designing investigation: Design an experiment in a systematic way to test a hypothesis.
Experimenting: carry out an experiment carefully by following correct procedure so that results can be verified by repeating the procedure several times.

7) **Identifying the cause and effects,**

Identifying the cause and effect relationship: Identify the factor or variable which affects the experiment.
Analysing investigations: interpreting data statistically, identifying human mistakes and experimental error, evaluating the hypothesis, deriving, inferences, and designing further investigation if necessary.
During the process of doing science, scientists and students employ both basic and integrated science process skills. By employing the process skills one can acquire the procedural of doing science and conceptual clarity.

Basic process skills	Description
Observing	Use of five senses to derive characteristics of living organisms
Inferring	Explanation of observations and data
Measuring	Using standard and non-standard measures to describe dimensions
Communicating	Using words or symbols to describe an action, object or event
Classifying	Sorting, grouping and arranging based similarities and differences
Predicting	Stating the outcome of a future event based on a pattern of evidence
Integrated Process skills	**Description**
Controlling variables	Identifying variables, keeping variables constant and manipulating
Defining operationally	Stating how to measure a variable in an experiment
Formulating hypotheses	Stating the expected outcome of an experiment
Interpreting data	Organizing , concluding from data and making sense of data
Experimenting	Testing by following procedures to produce verifiable results
Formulating models	Creating a mental or physical model of a process or event;

b) Aims and Objectives of teaching science at upper primary, secondary and higher secondary level (NCF 2005)

The **National Curriculum Framework** (NCF 2005) is one of four National Curriculum Frameworks published in 1975, 1988, 2000 and 2005 by the National Council of Educational Research and Training NCERT in India. The document provides the framework for making syllabi, textbooks and teaching practices within the school education programmes in India.

The NCF 2005 document draws its policy basis from earlier government reports on education as Learning Without Burden and National Policy of Education 1986-1992 and focus group discussion. After wide ranging deliberations 21 National Focus Group Position Papers have been developed under the agencies of NCF-2005. The state of art position papers provided inputs for formulation of NCF-2005.

The document and its offshoot textbooks have come under different forms of reviews in the press. Its draft document came under criticism from the Central Advisory Board of Education (CABE). In February 2008 the director Krishna Kumar in an interview also discussed the challenges that are faced by the document.

The approach and recommendations of NCF-2005 are for the entire educational system. A number of its recommendations, for example, focus on rural schools. The syllabus and textbooks based on it are being used by all the CBSE schools, but NCF-based material is also being used in many State schools.

NCF 2005 has been translated into 22 languages and has influenced the syllabi in 17 States. The NCERT gave a grant of Rs.10 lakh to each State to promote NCF in the language of the State and to compare its current syllabus with the syllabus proposed, so that a plan for future reforms could be made. Several States have taken up this challenge. This exercise is being carried out with the involvement of State Councils for Educational Research and Training [SCERT] and District Institutes of Education and Training [DIET].

Upper Primary Stage (Classes VI to VIII)

1. At the upper primary stage the children are getting their first exposure to ‘science’; this then is the time to bring home the right perspective of what it means to ‘do Science’.

2. To provide a gradual transition from environmental studies of the primary stage to elements of science and technology.
3. Scientific concepts to be taught at this stage should be chosen so as to make sense of everyday experiences. Though most concepts should be arrived at from activities/experiments, a rigidly inductive approach is not necessary.
4. It is important to ensure that a majority of activities and experiments are inexpensive and use readily available materials, so that this core component of science curriculum can be implemented in all schools including those with inadequate infrastructure.
5. Science content at the upper primary stage should not be governed by a disciplinary approach and is not to be regarded as a diluted version of secondary stage science curriculum.
6. Technology components of science curriculum could include design and fabrication of simple models, practical knowledge about common mechanical and electrical devices and local specific technologies.
7. It is necessary to recognize that there is a lot of diversity in the nature of technology that children from different areas of the country deal with. These differences in exposure and interest should be addressed through specific contextualized projects.
8. Organizing information and displaying it in the classroom, in the school or in the neighborhood, or through skits and plays are an important part of the pedagogy to ensure larger participation and sharing of learning outcomes.
9. Biographical narratives of scientists and inventors are a useful practice to inspire students at this stage. The emphasis on the process skills of science should continue through the upper primary stage to enable children learn how to learn for themselves so that they could carry on learning to even beyond school.
10. There should be continuous and periodic assessment (unit tests, term end tests), with much less weight age to the annual examination.

Secondary Stage (Classes IX and X)

1. At the secondary stage, the beginning made at the earlier stage to introduce science as a discipline is to be further strengthened without emphasis on formal rigour.

2. Concepts, principles and laws of science may now appear in the curriculum appropriately but stress should be on comprehension and not on mere formal definitions.
3. The organization of science content around different themes as being practiced seems appropriate at the secondary stage, but the curricular load needs to be substantially reduced to make room for the additional elements of design and technology, and other co-curricular and extra curricular activities.
4. At the secondary school stage, concepts that are beyond direct experience may come to occupy an important place in the science curriculum. Since not all phenomena are directly observable, science also relies on inference and interpretation. For example, we use inference to establish the existence and properties of atoms, or the mechanism of evolution.
5. Students should have developed the critical ability to evaluate the epistemological status of facts that they encounter in science.
6. The technological modules introduced at this stage should be more advanced than at the upper primary stage. The modules should involve design, implementation using the school workshop, if possible, and testing the efficacy of the modules by qualitative and quantitative parameters.
7. Experiments (and, as far as feasible, the technological modules) should be part of the content of the secondary stage textbook, to avoid their marginalization or neglect. However, this part of the textbook should be subject to internal assessment only.
8. The theoretical test at this stage including that for the Class X external Board examination should have some questions based on the experiments/technological modules included in the textbook.
9. Participation in co-curricular activities must be regarded as equally important at this stage.
10. These may involve taking up projects (in consultation with teachers) that bear on local issues and involve the problem-solving approach using science and technology.
11. The various components of the science curriculum indicated above should be integrated imaginatively. The entire upper primary and secondary school curriculum should have horizontal integration and vertical continuity.

Higher Secondary Stage (Class XI and XII)

1. At the higher secondary stage, the present policy of two streams, academic and vocational, being pursued as per the National Policy of Education 1986 may be reviewed, so that students have an option to choose the subjects of their interest freely, though all the different subjects may not be offered by every school/ junior college.
2. The curriculum at this stage should be disciplinary in its approach, with appropriate rig our and depth. Care should be taken not to make the syllabus heavy.
3. The curriculum load should be rationalized to avoid the steep gradient between secondary and higher secondary syllabus, but this should not amount to making higher secondary syllabus only a slightly upgraded variant of secondary stage science.
4. There should be strong emphasis on experiments, technology, and investigative projects. Defining the appropriate advanced content for the higher secondary level is a matter of technical detail. What is clear, however, is what it should not be.
5. The content should not be information laden, and not aim to widely cover all aspects of the subject. Considering the vast breadth of knowledge in any subject, the exigencies of time and the student's capacity, some delimitation, or rather, identification of core areas has to be done.
6. Effective science curricula have to coherently focus on important ideas within the discipline that are properly sequenced to optimize learning. The depth should ensure that the student has a basic, if not rigorous, understanding of the subject.
7. The theoretical component of higher secondary science should strongly emphasize problem solving, awareness of conceptual pitfalls, and critical interrogation of different topics.
8. Narratives giving insights on the historical development of key concepts of science should be integrated into the content judiciously.
9. The teaching of the theoretical aspects and the experiments based on them should be closely integrated and dealt together. Some of the experiments must be open-ended, where there are no standards with expected results and there is scope for making hypotheses and interpretation of results.

10. Students should be encouraged to participate in debates and discussions on issues at the interface of science, technology and society. Though these would form an important part of the learning process, they should not be included for formal assessment.
11. Since the curricular materials at this stage also cater to students who intend continuing in science as a career, and to sustain the enthusiasm of those who are prepared to handle more challenging materials, textbooks may carry some non-evaluative sections. In order to broaden the horizon of students for career choices available after the study of a science course, it seems useful if the career options are discussed, perhaps within the textbook itself. The greater the variety of pedagogical approaches employed, the broader will be the range of learners reached.
12. The experiments and technological modules should be subject to continuous assessment even for the final Class XII examination. The theoretical papers including those for the Class XII external examination should have some experiment/ technology based test items. An important reform to reduce examination related stress is to permit students to accumulate marks/credits in different subjects at their own pace and not insist on their appearing for examination in all subjects at one go.

c) Values of teaching science in socio-cultural context

Place in curriculum

Science education is essential as it is of immense value in the student's individual's life as also his life in society science education is important due to the following reason.

Values of teaching science:

a) Intellectual value:

Science along with being a content of knowledge is a method of acquiring knowledge.

Scientific knowledge helps to sharpen our intellectual honesty.

It helps us to report about things and events without any bias.

It makes us quite systematic in our reasoning.

It helps us in acquiring the strength to face failures because the pursuit of science requires diligence and patience.

Science education develops a positive attitude like open mildness, reasoning etc.

Such a positive attitude is quite helpful to an individual to understand, evaluate and solve many social problems. We face in life and helps him to lead a happy, successful and satisfying life.

b) Vocational Value:

In the present age we do not find any covation that does not need the knowledge of science more ever there are a large number of vocations for which shady by science is a primary requirement..

e.g. :- medicine, Engineering, Agriculture Para medicines, Computers etc.

It thus becomes quite clear that to enter into any such vocational course an individual must have knowledge of science. At the school level science hobbies help the student for productive work in the later year of their life.

c) Aesthetic Value:

Knowledge of science develops in man a passion for truth and thus he has a passion for beauty. The English poet Keats has said, "Truth is Beauty."

Science is basically unfolding the mysteries of nature and nature is a storehouse of all the beautiful things. Thus we find that teaching of science is essential for developing an aesthetic sense in an individual.

E.g. By enjoying the aesthetic aspect of his discoveries and inventions the scientist fuels an intrinsic charm.

d) Practical Value:

Scientific principles and laws find a large number of applications in our everyday life.

For proper utility of such application some knowledge of science is necessary. At present we depend on scientific discoveries to a very large extent. Even a cursory and casual look around ourselves shows a lot of applications of science.

e.g. Electricity, electronics, communication, transport etc.

Science has provided us with a large number of devices such as television radio, cinema etc which entertain all of us.

The most important practical value of science is felt in the world of medicines and health.

Science has discovered a large number of new medicines which are used to cure such diseases which were considered as incurable only a few decades ago.

e) Moral Value:

We have already learnt that knowledge of science develops in us truthfulness and reasoning. Though such qualities may not make you a successful businessman or successful politician according to present standards, yet these are the very qualities which are desirable in all human beings. These qualities make life worth living though they have lost their value in today's materialistic world.

f) Psychological Value:

Science develops three basic facts: Truth, beauty, Goodness.

Teaching of science is essential for developing scientific attitude and scientific temper.

Science helps us to develop positive attitudes such as open mildness, reasoning etc.

The learning of science is based on the fundamental principles of psychology i.e. “Learning by doing; learning by observing concrete and living specimens.” Being an activity oriented subject. Science helps to satisfy basic human desire of knowing about wonders of nature and so it satisfies common instincts such as creativity, self assertion, curiosity etc.

g) Cultural Value:

Science has its own literature. A study of past scientists and their discoveries gives us an insight into the mode of their living, their spirit of sacrifice and their adventures. All such studies form a part of our cultural heritage and study of this cultural part has a romance of its own. Knowledge of science develops in us a capacity to critically examine facts and arrive at logical conclusions. It also develops in us imagination power that is essential for finding out proper solutions for various problems we face in our life.

h) Adjustment in Modern life:

Science develops in us a ‘scientific attitude.’ It also develops in individuals a specific procedure for attacking any problem. Such a specific procedure is called a ‘scientific method’ . Such a method prepares an individual to face the problems of life boldly and to solve them successfully.

A person having a scientific attitude has an open mind, a desire for accurate knowledge and confidence to solve a problem using his sense of reasoning. A person having a scientific attitude lives a peaceful and successful life.

i) Utilitarian Value:

It is the age of science and technologies from the time we get up in the morning till we go to bed. All activities are governed by science. Science has changed the way of life, the society and the traditions of the countrymen.

As a result the individual needs and preference of men have changed. The house is fitted with coolers, air-conditioners and heaters for comfort and relief from the weather the year round.

Radio, television and other entertainment devices are commonly used. Such changes may be observed even in rural regions also.

It is necessary to have some elementary knowledge of science for becoming a useful member of the community and to apply it to daily life.

j) Development of scientific attitudes:

It involves open mildness, suspended judgment, critical observation free from superstitions and false beliefs etc.

This type of attitude once developed in the pupil proves to be useful in the later stage of life. Inclusion of science as a school subject was supported by canon

Unit 3: Organisation of Science Curriculum

a) Maxims of teaching science (Known to Unknown, Whole to Parts, Simple to Complex, Particular to General, Empirical to Rational, Concrete to Abstract)

b) Correlation of Science in the Curriculum: Internal & External

c) i. Infusing Global Perspective in Science Curriculum (Need and Importance),

ii. Curriculum Organization- Concentric and Topical approach

a) Maxims of teaching science (Known to Unknown, Whole to Parts, Simple to Complex, Particular to General, Empirical to Rational, Concrete to Abstract)

The maxims of teaching are very helpful in obtaining the active involvement and participation of the learning in the teaching learning process

Maxims: General principles drawn from the observations and experience called maxims.

Maxims are based on psychological aspects and mental ability of students.

Maxims makes lessons meaningful, interesting, motivating, understandable and easier for students.

“Maxims are the support for teachers to make understand the subject to the students in a deep sea of knowledge”. Thus a maxim helps in directing the correct lines of lesson.

(1)From simple to complex:

The simple task or topic must be taught first and the complex one can follow later on. The words simple and complex are to be seen from the point of view of the child and not that of an adult.

We could be curbing the interest and initiative of the children by presenting them complex problem before the simpler ones are presented. Thus keeping students ability, attitude , potential and interest simple task should be fixed. Simplicity and complexity should be determined from a child's point of view.

Example: 1. to teach types of forces, 1st teacher should explain about force and its applications and then teacher should explain their types.

2. To teach classification of substances, teachers should give simple examples of day to day life and put substance into groups based on their properties. The teacher should explain the chapter.

3. To teach reproduction: teachers should give examples of living things and explain about natural methods of reproduction in plants.

(2)From whole to parts:

Whole is always not only greater than the parts but also more understandable , motivating and effective .Therefore beginning should always be made with the whole and then step by step its various parts or constituents should be presented before the student.

Example: 1. In teaching the topic “parts of flower” the beginning should be made with the actual presentation of the whole flowering plant and then gradually the knowledge of the elements and functioning of different parts should be presented.

2. Similarly the topic of “beekeeping or agriculture” the beginning should be made with the actual presentation of honey comb and then gradually the knowledge of the uses of honey and different kinds of bees , functions of bees that live in a honeycomb should be explained.

3. In teaching the topic “parts of the human body” the beginning should be made with the actual presentation of the whole human body and then gradually the knowledge of the parts and explain the function of each part.

(3) From empirical to rational:

Observation and experience are the basis of empirical knowledge, rational knowledge implies a bit of obstruction and argumentative approach. The general feeling is that the child first of all experience knowledge in his day to day life and after that he feels the rational based

Example: 1. Whenever we touch the hot body we immediately take our hand back. This is generally experienced by pupils using this common example. We can teach them about the reflex action which comes under life processes in the nervous system.

2. to teach the student about the characteristic of acid , the student has experienced the taste of lemon from which we can make them understand the characteristic of acids , e.g. acid are sour also lemon contain citric acid.

3. As the people know about the colour of the sky is blue he / she is observing every day , but due to air particles scattering the component of visible light which is having the shortest

wavelength is blue light . Hence whenever the colour of the sky is asked, the pupil gives the answer blue due to his observation in his / her day to day life.

(4) From concrete to abstract:

A child's imagination is greatly aided by a concrete material “Thins first and words after “is the common saying: children in the beginning cannot think in abstraction small children learn from things which they can see and handle, very young pupil learn counting with the help of pebbles etc .A child understand an aero plane with the help of model.

Examples: 1. To teach students about ‘human skeleton’ can be taught worth the help of the model.

2. To teach the functioning of the kidney requires a model of the kidney for better understanding of the students.

3. To teach the students about the chemical bond, can be explained with the help of a ball and stick.

(5) From known to unknown:

The most natural way of teaching a lesson is to proceed from something that the pupils already know to those facts which they do not know. The purpose of using what is known is to show them its resemblance with and difference from the things which they are going to learn. Those ideas which are most familiar must be used and do well upon in order to aid the children in grasping what is unfamiliar. Even in very difficult lessons the teacher can anticipate some of the points which the children already know, these can help them in understanding the new lesson.

1. Digestive system -The pupil knows that we eat food that goes in the stomach , but they don't know about the digestive process , so to teach this pathway the teacher should start with common or known things related to digestion .

2. The pupil knows about the various types of plants but they don't know about the classification of plants due to their similarities and differences.

So this maxims help to teach them classification of plants.

3. The pupil knows about the different types of soil found in nature but don`t know about the formation of soil , soil – a natural resource , other uses of soil , causes of soil erosion , different ways in which soil gets polluted .

(6)From particular to general:

The statement implies that particular faces and examples must be presented to the children before giving them general rules or principles

Infecting the study of particular facts should lead the children themselves to frame general rules.

The criterion of good teaching is that the children should be able to frame correct generalization for them by a close and correct process of observation.

Maxims are the methods and tools for the teacher. In teaching – learning process I shows active participation and interest of the student and also shows that teacher is also aware of all these techniques

“CONCLUSION”

Teaching is an art and to acquire efficiency is this art teacher needs to things

(1) Complete knowledge of subject matter.
(2) Scientific knowledge of teaching styles for describing the knowledge to the pupil

By studying the above maxims it is clear that they are the tools to make lessons easier , keeping in mind ,interest ,attitude , capacity and various levels of development of pupils. Therefore every teacher should be equipped with knowledge of maxims as well as their proper application.

b) Correlation of Science in the Curriculum: Internal & External

Correlation is one of the essential aspects, devices and techniques of the modern pedagogical system that makes study of the subject more purposeful, interesting, permanent and effective by seeking more coordination and integration within the different pieces of knowledge along with their application. It is based on the essential notion that knowledge neither exists nor works in isolation. Knowledge is one and is application as a whole in all practical situations faced by one in his life. Therefore, it is not wise to learn it through an artificial way that is total compartmentalization involving the following aspects.

1. Treating one piece of knowledge or subject as complete.
2. Isolation of its study from other subjects.
3. Divorcing it from the need of a once physical and social environment.

So, the correlations of different subjects are very essential for checking artificiality of treatment and for achieving unity of knowledge. It makes study easier, more interesting and natural. It develops knowledge by dovetailing with each other the bites of similarity existing in the diversity of the subjects and compounds them in such a complex whole which the mind of the child is willing to accept.

Definition:-

1. According to the dictionary, the meaning of correlation is mutual relation.
2. ‘Correlation 'is a technique which tries to establish relationships between various subjects of curriculum.
3. ‘Facts and ideas have a real and useful influence over the mind systematizes and co-ordinates those with other facts and ideas they provide.’

Importance /Advantages of correlation

1. The correlation of science with other subjects works as a stimulus to the learner of science.
2. Correlation makes the teaching learning process economical in view of time, energy and money.
3. Correlation gives a sort of unity to a curriculum.
4. It makes the study easier, more interesting and natural.
5. It encourages all rounder development and growth of a child.
6. It assists in bringing closer the school and society.
7. It establishes a close relationship with knowledge and experience.
8. Learning by doing fostered while organising projects to correlate different subjects.
9. It makes the lesson interesting by bringing the other subjects and experience.
10. It motivates the pupils for learning science

Types of correlation

1. Correlation of different branches of science/Internal correlation
2. Correlation of science with other subject/External correlation

3. Correlation with science with daily life.

Correlation of different branches of science/Internal correlation

As has been said, science cannot be taught in isolation. All the branches of science are interdependent on each other and there are a number of facts and principles which are common to various science subjects

1. A teacher while teaching the sense organs says I should make a paralysed with a camera, which the students have learned in physics.
2. Similarly, a biological teacher teaching digestive systems, should have an adequate knowledge of chemistry without the help of which he cannot justify the treatment of the topic

Correlation of science with other subject/External correlation

Science is quite a complex and vast kind of subject, because of which the task of correlating it with other subjects of the curriculum seems to be quite an easy task. Deliberate efforts should be done by the science teacher to bring about correlation between science and other subjects of the curriculum which are being imparted to the students.

Through this students will find the opportunities to relate the knowledge which they have already gained. With this knowledge which they are gaining. This kind of relations activity leads to development of interest among the students.

Science with language

All through science is a practical subject but it is very important for its learner to be able to express their views and ideas in clear and attractive form. For these purposes it is necessary that they should have knowledge of the language which they use. Students who do not have good control over the language cannot express their views and various scientific laws and principles in front of others and especially in front of teachers.

To correlate science with language subjects, students can be asked to write essays on some scientific topic. If a student makes any kind of grammatical mistakes then the teacher can ask him to make a correlation in his language. Likewise, a language teacher can give the task of writing about some scientific happenings in the assignment designed for them. In this manner he can correlate science with the knowledge. Similarly, the historical events and the biographies of scientists provide an excellent material for reading.

Science with Mathematics

Science is probably incomplete with mathematics. It is mathematics that has given a sound footing to the scientific laws. For the real understanding of science the knowledge of mathematics is important. There are many topics which are constantly used in science for e.g. decimals, proportion, equations, graph etc. Physics is such a subject which cannot precede even a step without mathematics. It is necessary to have some mathematical background before starting a particular topic in science for e.g. the quantitative work in gas laws and calculation of chemical equations should come after proportion has been studied in mathematics, simple ides of statistics is essential before dealing with genetics and other statistical calculations, the knowledge of trigonometrically ratio is very useful in mechanism and light and so on. It is therefore important that the teacher of science and of mathematics work in cooperation to bring about correlation and coordination of two subjects.

Science with History

It sounds quite amazing that some kind of correlation can exist in between science and history as the earlier subject is practical in nature while the nature of the later subject is purely theoretical . While mentioning the various scientific discoveries taken in the earlier periods, teachers can relate with the major events of world history. Students should be told about what was the situation of science at the time of reigns of various famous kings or rulers. Teacher should narrate the incidents which inspired various scientists to find out the medical remedies of various diseases. Not only this, the function of co relating science with history can be done by mentioning the kind of living standard people used to experience at different parts of human history, with such knowledge, they will become aware of the scientific concepts like sanitation and healthful living.

Science with Geography

Geography is so much related with science that it has now been regarded as a branch of science. The study about the soil, climate, distribution of plants and animals etc. Brings the two subjects very close to each other. The topics like pressure, temperature, humidity, description and properties of metallic ores and common minerals, the effect of climate and other factors on the plants and animals etc. Are common to both science and geography. So, it is essential that the science teacher and the geography teacher should put in cooperative efforts to bring about a close integration of both subjects.

Science with Civics

The main objective of imparting information of both the subjects is to create good and useful citizens for the nation, thus it is possible to correlate both of these subjects with each other. Through science, students become able to understand the utility of scientific inventions in their life, by which they become more responsible. They begin to realize a sense of responsibility, which helps them in playing an important role in the development of the nation, through information of scientific facts, students get to know about various kinds of diseases and the role which they can play in creating a healthy and clean atmosphere around them. Through this kind of information, they become more responsible citizens and play an important role in creating an ideal civic life in the society and nation as a whole.

Science with Crafts

The correlation between science and craft is possible to a greater extent. Agriculture, as a craft, is nothing but applied science and its relation with science need not be emphasised, /other crafts like wood work, metal work, car board modelling, clay work etc. Can be successfully made use of in the improvisation and construction of science apparatus. The students can prepare a model of scientific interest. On the other hand. The knowledge of science is also important so far as the chemistry and microscopic structure of the materials used in different crafts, are concerned so, crafts correctly organised and properly correlated with science, can help in producing just those qualities of thought, application and skill which are required of the future workers in the field of science, technology and agriculture.

Science with Fine Arts

The knowledge of different notes, typical vibrating systems in strings and air columns, musical scales etc. Is essential for the learning of music. And on the other hand, gramophones, tape recorders, films etc, which involve music, can make science lessons interesting and real by appealing to the emotions. Drawing is of immense importance in the study of all the branches of science especially Biology/ the preparation of charts and pictures requires some skill in painting. It is very important that the students of science should be given training in drawing and painting.

Science with Music

In our nation, music has its own importance as different kinds of songs are found in different parts of the nation. There are songs and theories of music in different languages. Various musical stars got born in our nation, but the number of persons engaged in musical area has diminished to considerable extent as nor do people consider it as wastage of time and efforts. To encourage people and especially students to get involve themselves in professions having their roots in music, this has been accepted as an independent subject in various schools and institutions and it forms an integral part of school curriculum. For the students of music, knowledge of resonance. A vibration system in the strings and air columns is very necessary and important. To make improvements in their voice and manner of singing various scientific equipment are being used today, which could not come into being without scientific developments? Thus, it is only through the utilisation of scientific developments in the real life that led to development of various apparatuses used in the musical field. Science teacher the students that what led to development of various equipments used by the musician and on which principles do they operate or function

Thus, it can be said that if a science teacher will relate science with other subjects of the curriculum, then he will get more justifiable and satisfactory results.

c) i. Infusing Global Perspective in Science Curriculum (Need and Importance),
ii. Curriculum Organization- Concentric and Topical approach

i. Infusing Global Perspective in Science Curriculum (Need and Importance),

Developmental education is an approach to the curriculum, which promotes equity and social justice, both locally and globally and enables pupils to develop skills and attitudes and values needed for a sustainable future.

It is a process of challenging negative assumptions about other countries and people and promoting positive attitude to diversity and differences.

Meaning

A **global perspective** is when someone can think about a situation as it relates to the rest of the world. It may seem silly to some that every business should be concerned with what goes on in another country, but today we're all connected in a lot of ways.

An attitude that develops a sense of shared humanity towards the overall goal of world harmony.

Awareness that we live in an interdependent world and that we cannot ignore the problems faced by mankind.

It involves taking a broader and more critical view of experiences, learning and knowledge and includes seeking to understand the links between our own lives and those of people throughout the world.

Through issues like pollution, global warming, depletion of natural resources, energy crisis, extinction of some species Science can highlight the aspect of global perspective in a more natural way to learners.

Infusing Global Perspective in the Science Curriculum

- This is an approach to teaching and learning which promotes a critical awareness of issues of development, both locally and globally and enables students to acquire the knowledge, skills and attitudes which are essential for global citizenship and social justices.
- This can be done effectively and easily more through Science than any other school subject.
- Science like issues like pollution, global warming, depletion of natural resources, energy crisis, extinction some species can highlight the aspect of global perspective in a more natural way to learners.

Global Perspectives aim at:

- Encouraging empathy and mutual understanding by exposing students to different worldviews.
- Developing skills and attitudes among students to bring about effective change leading to a more just and peaceful world.
- Preparing students to live in the world of increasing interdependence.
- Developing students' ability to think critically and have independence of mind in order to undertake whatever constructive action is appropriate.

Infusing GP in the science curriculum

I. Incorporating a range of key concepts as appropriate

- Citizenship
- Social justice
- Interdependence
- Sustainable development
- Human rights
- Values and perceptions
- Diversity
- Conflict resolution

II. Incorporating a range of perspectives from different countries/communities:

- Feel for 'real world problems'
- Increasing students' sensitivity to local needs and problems and putting them in the global concerns, constraints and opportunities. Examples of solutions arrived at in different contexts.
- Eg. The Nile Purification Project successfully carried out in Egypt can be related to the Ganga Purification Project.

III. Including action for change

- Small actions to bring about change.
- Personal → local →→ global
- Strategies used for sensitization: games, role-play, stories, scientific inquiries or simple activities.

IV. Developing sustainable practices

- encourage those practices that are enduring
- incorporate into the curriculum
- focus on exposing the students to socio-cultural realities of life, bringing in a new dimension of social relevance.

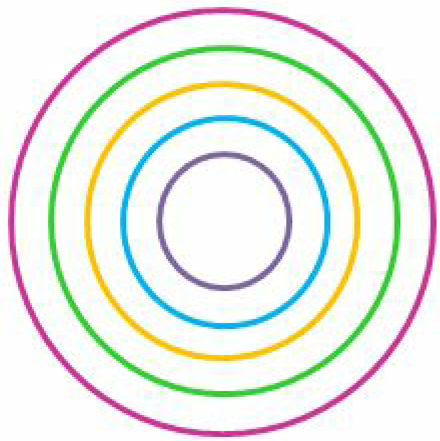
STEPS TO INTRODUCE GP THROUGH THE SCIENCE CURRICULUM: (with example)

- Identify two to three key concepts
- Locate plug points in the science curriculum
- Collect data/ information (both local and global)
- Design participatory methods/approaches
- Use appropriate strategies to further sensitize students to the issue
- Decide on small action- student initiative.

ii. Curriculum Organization- Concentric and Topical approach

Concentric Approach

In this approach the topics will find a place in different classes of different years of a course in a progressive manner. The content will be included from simple to complex as the pupils understand the content according to capabilities that present in chronological and mental ages. The concentric approach is a way of organizing a curriculum by laying out basic concepts, covering other related material, and then circling back around to the basic concept and filling in more complexity and depth. Instead of life science, earth science, physics, biology and chemistry being separated and studied in sequence, each year's curriculum revisits the sciences studied earlier. It's believed that starting with fundamentals that are then regularly revisited, built on, deepened and broadened each time leads to a better understanding of a subject's interconnections. The organization of curriculum using concentric approach is useful in primary and secondary school levels.



Concentric circles have a common centre but radius goes on changing

Merits

1. It proceeds from 'simple to complex 'and 'whole to part'.
2. Greater opportunity for revision of topic.
3. It takes into consideration mental growth of the pupil.
4. Continuity can be maintained.

Limitations

1. Repetition is sometimes cumbersome. Some facts are repeated again and again.
2. The presentation lacks novelty and freshness.
3. Less appealing and fails to arouse interest.
4. Pupil develops a sense of familiarity without the fullness of knowledge.

Topical Approach:

Topical arrangement means that a topic should be finished entirely at one stage. It takes the topic as a unit. Topical arrangement requires that easy and difficult portions of a topic should be dealt with at one stage only which is psychological. In topical approach all relevant material is covered in linear fashion and concepts are not revisited. In this system the topic which is dealt with earlier receives no attention later and so there is every likelihood of its being forgotten; they are introduced with a view to make the teaching of the topic complete and thorough. Hence topical method demands that a topic once taken should be finished entirely. This is not much useful for lower classes.

Air
Proerties of Air

Air and Weather

Air pollution

Atmosphere

Merits
1. Integrated knowledge is imparted to the pupils.
2. In-depth, thorough knowledge of the topic.
3. Pupil's interest and motivation is sustained.
4. Correlation of subjects.
5. This approach can be adopted according to the age, ability of the students.

Limitations
1. It destroys the continuity of subject matter
2. Since May aspects involved in a topic may be beyond the cognitive competencies of pupils in lower classes a complete study of the topic will not be possible because of the above reason.

Generally speaking, when a topic is complex and very large and involves units posing varied levels of difficulty it will be advisable to have the unit approach. The only thing is that care should be taken to effectively link all the units of the same topics as and when opportunities arise.

Conclusion

There are several approaches to curriculum development. They vary in their major focus. Concentric and spiral curriculum is concerned with the mental development of pupils. After topics have been selected according to the relevant fundamental principles described above, they have to be systematically arranged so as to facilitate meaningful and effective transactions. The content should be arranged in a systematic manner.

Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2

TRANSACTING SCIENCE CURRICULUM

UNIT 4
Science Teaching : Methods, Approaches and Tools

a) Methods of teaching- Lecture-cum-demonstration Method, Project Method, Problem Solving.

Lecture-cum-demonstration Method

Introduction

Lecture-cum-demonstration includes the merits of the lecture as well as demonstration method. It attempts to filter out the disadvantages of both. Demonstration means ‘to show’. In Lecture method teacher just tells but in demonstration method teacher shows and illustrates certain fundamental phenomena.

Characteristics of good demonstration

1. Visibility
2. One major idea at a time
3. Clear cut
4. Convincing
5. Rehearsal
6. Supplemented with other teaching aids
7. Asking relevant questions
8. Neat, clean and tidiness
9. Simple and speedy
10. To write observation
11. Teacher to act as performer
12. Sufficient time

Steps in Lecture-cum-demonstration

1) Planning and Presentation: While planning a demonstration the following points should be kept in mind.

§ Subject matter

§ Lesson planning

§ Rehearsal of experiment

§ Collection and arrangement of apparatus

2) Introduction of lesson: The lesson may be introduced on the following basis

§ Student's personal experience

§ Student's environment

§ Telling story

§ A simple and interesting experiment

3) Presentation of the subject matter

§ The teacher must study the subject matter on broad basis taking into consideration the interest and experience of students

§ While demonstration is going on, question should also be asked which help the students to understand the principles

§ The teacher should try to illustrate the facts and principles

§ Language used by teachers should be simple and clear.

4) Experimentation

§ Demonstration should be properly spaced and striking, clear and convincing

§ The demonstration table should have only apparatus

§ The experiment should be simple and speedy

§ All the apparatus should not be displayed at once

5) Blackboard work

A big blackboard behind the demonstration table is necessary in order to summarize the principles and other matters of demonstration and also to draw necessary diagrams and sketches.

Advantages of Lecture-cum-Demonstration Method

- Economical: This method is economical as it helps in economizing resources

- Psychological Method: Demonstration method psychological as the students are shown concrete things.

- This method is especially useful where

  The apparatus is expensive

  The experiment involves some danger

  The apparatus is sensitive to break

  The experiment involves some difficult and complex operation

- Student participation

- Save time and effort

- Helpful to promote useful discussion

- More efficient method

- Activity method

- Useful for all types of students

- Helpful for teacher

Disadvantages of Lecture-cum-demonstration Method

- Ignore maxim of education: The maxim of education, 'Learning by Doing' and the principles of psychology of learning has no place in this method.

- Visibility: Visibility is main problem for a teacher because all the students may not be able to see the details and results of a demonstration

- Speed of experiment: Either too fast or too slow speed of demonstration sometimes may create trouble

- Ignore individual difference: This method totally ignores the main principle of psychology.

- Hinder progress: This method somehow hinder the development of laboratory skills among the students

- Not useful for developing scientific attitudes.

Conclusion

This method can prove to be one of the best methods for teaching science to Secondary and Higher Secondary classes. The teacher should encourage the students to demonstrate the experiments to the class.

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Project Method

Introduction

Project method of teaching has evolved from the philosophy of pragmatism. It is an experience-centered strategy related to life-situation. This teaching strategy focus on

To socialize a child
To achieve cognitive, affective and psychomotor objectives

It is based on the philosophy of Pragmatism. Founded by John Dewey.
As a method of teaching, the founder is Dr. J.A. Stevenson. Emphasis is on a practical, experimental, instrumental and utilitarian basis.
Philosophies behind this method are:
1. Children learn better through association, co-operation and activity.
2. Learning by doing
3. Learning by living, because life is actually full of projects and we try to carry out these projects every day.

Definitions:

Stevenson : “A project is a problematic act carried to completion in its natural setting”.

Kilpatrick : “A project is a whole - hearted purposeful activity proceeding in a social environment”.

Ballard : “A project is a bit of real life that has been imported into the school”.

Parker : “A project is a unit of activity in which pupils are made responsible for planning and proposing”.

Thomas & Long : “A voluntary undertaking which involves constructive effort or thought and eventuate into subjective results ”.

Basic Principles of the Project Method:
This teaching strategy is based on the following principles

1. The Principle of Purpose

The activity performed by the pupils must be significant and of interest to them. It must be purposeful and combine life with learning.

2. The principle of activity

The pupils are naturally active. Opportunities should be provided for them to be active and do things for themselves. They must be kept active mentally as well as physically and must bear the maximum responsibility.

3. The Principle of Reality

This method aims at reproducing real life situations into the school. Pupils are given opportunities to exercise their powers in real life situations.

4. The Principle of Freedom

The desire for any activity should be spontaneous and not forced by the teacher. It should grow out of the pupil's own purpose and need. They should be free to do and express themselves.

5. The Principle of Utility

Knowledge should be useful and practical.
Choose those projects which are closer to social life.

6. Principle of readiness.

Involve the learners in finding the solution of the problem with their active participation.

7. Learning by Doing.

Learners perform certain tasks and experience new things. This adds to his knowledge and results in learning.

8. Socialization.

It develops the feeling of cooperation and group work.

9. Interdisciplinary Approach.

To involve the knowledge of different subjects in solving the social problems

Major steps of the Project Method.

1. Creating the situation

(providing a situation)

Provide for such a situation where the pupils feel a spontaneous urge to carry out a particular project according to their needs and interests. The teacher has to discover the interests, needs, tastes and aptitudes of children. He may draw the pupil's attention to the projects in mind through informal conversation or discussion as taking out children outside the school. Thus pupils are brought face to face with the situation.

2. Choosing the project

(Selection of the Project)

The pupils should themselves choose the subject. Self choice leads to better results and entails self satisfaction. Pupils select any one, discuss the various projects, reject some, explain others and thus come to a decision. The teacher should see that the project chosen is of great utility and satisfies the real need of the pupils and is within their capacity to be successfully carried out.

3. Planning

Pupils should themselves do the planning and the teacher is to guide them. Discussions may be held and each student should be encouraged to express his views and suggestions. The teacher may point out the difficulties involved in the carrying out of the project. Resources and limitations should be discussed. After such oral discussion, the detailed plan may be written up by the students in their project book.

4. Carrying out the project (Executing)

When the plan is ready, pupils are to put it to practice. Students themselves should distribute the various items of duties among themselves according to individual interest and capacities. Every student must contribute something towards the successful completion of the project.

A chain of activities are performed by the students. They are busy collecting information, visiting various places and pupils, looking up maps, writing letters, referring to library books, observing specimens, studying history, keeping accounts, calculating prices, inquiring rates, measuring lengths of areas.

The teacher should guide the students to provide necessary information and help them on the right lines.

5. Evaluating

No project is complete unless the work done in it is evaluated. Students should assess their activities; whether they have been carried out in accordance with the plan or not, mistakes committed are noted.

6. Recording
(Project Report)

The teacher should keep a complete record of work, how they planned, what discussions were held, how duties were assigned and finally criticism of their own work and some important points for future reference.

Role of the Teacher

1. The teacher is a friend, philosopher and guide. He moves about with the students and does not hesitate to guide and give help wherever need arises.

2. He develops intimate, close and healthy relations with the students. He understands and appreciates their problems and helps them to solve problems as an elder brother or father.

3. He should learn with the students and should not claim to know everything.

4. He should help the students in developing the character and the personality by allowing them to accept responsibilities and discharge them efficiently.

5. He should provide democratic atmosphere in the class so that the pupils can express themselves fully without any fear of the teacher.

6. He should be alert and active all the time to see that the project is running in its right lines.

7. He should have a thorough knowledge of individual children so as to allot them work accordingly.

8. He should have initiative, enthusiasm for learning and should be well-experienced.

Criteria of a Good Project

1. It should be purposeful, useful and practicable to the daily life of pupils.

2. The experience gained should be fruitful. Activities undertaken must be completed, knowledge must be gained and lead to further acquisition of knowledge.

3. The project should cater for the activities of the pupils.

4. There should be full freedom for the students to work of their own accord.

5. It should be selected by the active participation of both pupils and the teacher and a greater part of work will be done by pupils under the guidance of the teacher.

6. It should be economical and the purpose of the project should be achieved without any waste of money or time.

7. It should be timely and drawn in relationship with seasons of the year and the interest and need of the community.

8. It should be challenging.

9. It should be feasible.

Types / Kinds of Projects

According to Kilpatric, “A project is a whole-hearted purposeful activity proceeding in a social environment."
Kilpatric has classified the project method in four types.

Constructive.
When learners have to construct some things related to social life. e.g. charts, models, maps, parcels etc.

Artistic.
These projects are generally allotted in the aesthetic fields of life. e.g. in music, drawing, painting art and culture.

Problem-Solving.
These projects are given to solve the problems related to any life-situation or related to any subject e.g. how to operate bank accounts? Or how to send an email or letter. These general problems, if solved, will make a child efficient for social-life.

Group-Work.
A team of students is assigned a work to be performed. e.g. to develop a garden in the school.
There are four basic elements of this teaching strategy which make it purposeful
1. Spontaneity,
2. Purpose,
3. Significance, and
4. Interest or Motivation.

Projects are also of following types-

1. Producers type-
Students construct materials-models of gardens, collect specimens, and seeds.

2. Consumers type-
Students get experience and enjoy by conducting excursions.

3. Problem type-
Solution to problems to be found out like the cause of the epidemic, purify water etc.

4. Drill type-
Efficiency in some activities like swimming and manual work.

Merits

1. The method is in accordance with the psychological laws of learning.
    a) Law of readiness i.e., pupils are ready to learn creating interest, purpose and life like situations.
    b) Law of exercise ie., by practice we learn things, self activity on the part of students create experiences in later life.
    c) Law of effect i.e., a child should be satisfied and feel happy in what he is learning.

2. It promotes cooperative activity and group interaction.

3. It gives training in a democratic way of learning and living.

4. It gives teachers the dignity of labour and pupils develop respect and taste for all types of work.

5. Correlation of subjects is achieved effectively.

6. It develops innovativeness and self - activity.

7. It affords the opportunity to develop keenness and accuracy of observation.

8. It makes learning natural, spontaneous and interesting.

9. It sets up a ‘challenge’ to solve and thus stimulates constructive and creative thinking.

10. It helps in developing social norms and social values among the learners.

11. It provides invaluable opportunities for correlation of various elements of the subject matter and for transfer of training or learning.

12. It helps in growing knowledge very effectively as a result of their close cooperation on social participation in the spirit of democracy.

Demerits

1. Projects absorb large amounts of time and can be used as a part of science work only.

2. It gives the children superficial knowledge of so many things but leaves an insufficient basis of sound fundamental principles.

3. Planning and carrying out projects involves much more work on the part of the teacher than with their usual methods.

4. Larger projects in the hands of inexperienced and unskilled teachers lead to boredom.

5. It presupposes that the teacher is a master of all subjects and has an all-round knowledge of everything to impart correlation. But it is practically impossible.

6. Text books written on these lines are not easily available.

7. It is expensive, for the students will have to bear the expenses of excursions, outdoor activities, purchase or material.

8. In this method, teaching is not well organised, regularised and continuous, the whole time table is almost upset.

9. It is difficult to teach all topics in this way.

10. The project cannot be planned for all subjects and the whole subject matter cannot be taught by this strategy.

11. It is not economical from the point of view of time and cost.

12. It is very difficult for a teacher to plan or to execute the projects to the learners and supervise them.

Suggestions to overcome demerits

This teaching strategy should not be used as an independent teaching strategy but as a supplementary teaching technique.
Teachers should try to utilize the inexperience and waste projects to prepare models etc.
To avoid the problem of supervision, teachers may appoint a leader to each group of students.
Teachers should fix a time limit for each project.

Conclusion

Project is a system, which meets the requirements of the credit system and modern objectives. This method aims at reproducing real life situations into the school. Pupils are given opportunities to exercise their powers in real life situations. The desire for any activity should be spontaneous and not forced by the teacher. It should grow out of the pupil's own purpose and need.
The main idea of the project method is an opportunity for the students to self-study, to show their knowledge, and their scientific practical abilities.

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Problem solving

Introduction

The ability to solve problems is a basic life skill and is essential to our day-to-day lives, at home, at school, and at work. We solve problems every day without really thinking about how we solve them. For example: it's raining and you need to go to the store. What do you do? There are lots of possible solutions. Take your umbrella and walk. If you don't want to get wet, you can drive, or take the bus. You might decide to call a friend for a ride, or you might decide to go to the store another day. There is no right way to solve this problem and different people will solve it differently.

Meaning

Problem solving is the process of identifying a problem, developing possible solution paths, and taking the appropriate course of action.

Why is problem solving important? Good problem solving skills empower you not only in your personal life but are critical in your professional life. In the current fast-changing global economy, employers often identify everyday problem solving as crucial to the success of their organizations. For employees, problem solving can be used to develop practical and creative solutions, and to show independence and initiative to employers.

Many instructors in engineering, math and science have students solve "problems". But are their students solving real problems or mere exercises? The former stresses critical thinking and decision- making skills whereas the latter requires only the application of previously learned procedures. True problem solving is the process of applying a method – not known in advance – to a problem that is subject to a specific set of conditions and that the problem solver has not seen before, in order to obtain a satisfactory solution.

Below you will find some basic principles for teaching problem solving and one model to implement in your classroom teaching.

Principles for teaching problem solving

Model a useful problem-solving method. Problem solving can be difficult and sometimes tedious.

Show students by your example how to be patient and persistent and how to follow a structured method.

Articulate your method as you use it so students see the connections.

Teach within a specific context. Teach problem-solving skills in the context in which they will be used (e.g., mole fraction calculations in a chemistry course).

Use real-life problems in explanations, examples, and exams. Do not teach problem solving as an independent, abstract skill.

Help students understand the problem. In order to solve problems, students need to define the end goal. This step is crucial to successful learning of problem-solving skills. If you succeed at helping students answer the questions “what?” and “why?”, finding the answer to “how?” will be easier.

Take enough time. When planning a lecture/tutorial, budget enough time for: understanding the problem and defining the goal, both individually and as a class; dealing with questions from you and your students; making, finding, and fixing mistakes; and solving entire problems in a single session.

Ask questions and make suggestions. Ask students to predict “what would happen if …” or explain why something happened. This will help them to develop analytical and deductive thinking skills. Also, ask questions and make suggestions about strategies to encourage students to reflect on the problem-solving strategies that they use.

Link errors to misconceptions. Use errors as evidence of misconceptions, not carelessness or random guessing. Make an effort to isolate the misconception and correct it, then teach students to do this by themselves. We can all learn from mistakes.

Problem-solving process

A mental process or a phenomenon dedicated towards solving problems by discovering and analyzing the problem is referred to as problem-solving. It is a process dedicated to finding not just any solution, but the best solution to resolve any problems. There is no such thing as one best way to solve every kind of problem, since there are unique problems depending upon the situation there are unique solutions too.

Steps involved in problem solving

The process simply refers to solving every kind of problem in life in a proper manner. The idea of including the subject in psychology is because psychology deals with the overall mental process. And, tactfully using our thought process is what leads to the solution of any problems.

There are a number of rigid psychological steps involved in problem solving, which is also referred to as problem-solving cycle. The steps are in sequential order, and solving any problem requires following them one after another. But, we tend to avoid following this rigid set of steps, which is why it often requires us to go through the same steps over and over again until a satisfactory solution is reached.

Here are the steps involved in problem solving, approved by expert psychologists.

1. Identifying the Problem
Identifying the problem seems like the obvious first stem, but it’s not exactly as simple as it sounds. People might identify the wrong source of a problem, which will render the steps thus carried on useless.

For instance, let’s say you’re having trouble with your studies. identifying the root of your failure is your first priority. The problem here could be that you haven’t been allocating enough time for your studies, or you haven’t tried the right techniques. But, if you make an assumption that the problem here is the subject being too hard, you won’t be able to solve the problem.

2. Defining/Understanding the Problem
Defining the problem

It’s vital to properly define the problem once it’s been identified. Only by defining the problem, further steps can be taken to solve it. While at it, you also need to take into consideration different perspectives to understand any problem; this will also help you look for solutions with different perspectives.

Now, following up with the previous example. Let’s say you have identified the problem as not being able to allocate enough time for your studies. You need to sort out the reason behind it. Have you just been procrastinating? Have you been too busy with work? You need to understand the whole problem and reasons behind it, which is the second step in problem solving.

3. Forming a Strategy
Developing a strategy is the next step to finding a solution. Each different situation will require formulating different strategies, also depending on the individual's unique preferences.

Now, you have identified and studied your problem. You can’t just simply jump into trying to solve it. You can’t just quit work and start studying. You need to draw up a strategy to manage your time properly. Allocate less time for not-so-important works, and add them to your study time. Your strategy should be well thought, so that in theory at least, you are able to manage enough time to study properly and not fail in the exams.

4. Organizing Information
Organizing information when solving a problem

Organizing the available information is another crucial step to the process. You need to consider

What do you know about the problem?
What do you not know about the problem?
Accuracy of the solution for your problem will depend on the amount of information available.

The hypothetical strategy you formulate isn't all of it either. You need to now contemplate on the information available on the subject matter. Use the aforementioned questions to find out more about the problem. Proper organization of the information will force you to revise your strategy and refine it for best results.

5. Allocating Resources
Time, money and other resources aren’t unlimited. Deciding how high the priority is to solve your problem will help you determine the resources you’ll be using in your course to find the solution. If the problem is important, you can allocate more resources to solving it. However, if the problem isn’t as important, it’s not worth the time and money you might spend on it if not for proper planning.

For instance, let’s consider a different scenario where your business deal is stuck, but it's a few thousand miles away. Now, you need to analyze the problem and the resources you can afford to expend to solve the particular problem. If the deal isn’t really in your favor, you could just try solving it over the phone, however, more important deals might require you to fly to the location in order to solve the issue.

6. Monitoring Progress
Monitoring progress of solution of a problem

You need to document your progress as you are finding a solution. Don’t rely on your memory, no matter how good your memory is. Effective problem-solvers have been known to monitor their progress regularly. And, if they’re not making as much progress as they’re supposed to, they will reevaluate their approach or look for new strategies.

Problem solving isn’t an overnight feat. You can’t just have a body like that of Brad Pitt after a single session in the gym. It takes time and patience. Likewise, you need to work towards solving any problem every day until you finally achieve the results. Looking back at the previous example, if everything’s according to plan, you will be allocating more and more time for your studies until finally you are confident that you’re improving. One way to make sure that you’re on the right path to solving a problem is by keeping track of the progress. To solve the problem illustrated in the first example, you can take self-tests every week or two and track your progress.

7. Evaluating the Results
Your job still isn't done even if you've reached a solution. You need to evaluate the solution to find out if it's the best possible solution to the problem. The evaluation might be immediate or might take a while. For instance, answers to a math problem can be checked then and there, however a solution to your yearly tax issue might not be possible to be evaluated right there.

Promoting Problem solving

Take time to identify the possible sources of the problem. It's better to spend a substantial amount of time on something right, than on something completely opposite.

Ask yourself questions like What, Why, How to figure out the causes of the problem. Only then can you move forward on solving it.

Carefully outline the methods to tackle the problem. There might be different solutions to a problem, record them all.
Gather all information about the problem and the approaches. More, the merrier.
From the outlined methods, choose the ones that are viable to approach. Try discarding the ones that have unseen consequences.

Conclusion

Problem-solving is, and should be, a very real part of the curriculum. It presupposes that students can take on some of the responsibility for their own learning and can take personal action to solve problems, resolve conflicts, discuss alternatives, and focus on thinking as a vital element of the curriculum. It provides students with opportunities to use their newly acquired knowledge in meaningful, real-life activities and assists them in working at higher levels of thinking.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 4
Science Teaching : Methods, Approaches and Tools

b) Approach: Inducto Deductive Approach

Introduction

Science in the making is experimental and inductive. Induction is that form of reasoning in which a general law is derived from a study of particular objects or specific processes. The child can use measurement. inallipulator or constructive activities, patterns etc. to discover a relationship which he shall himself, later, formulate in symbolic form as a law or rule. Thc law. tile rule or definition manipulated by the child is the summation of all thc particular or individual instances. In all inductions. the generalization that is evolved is regarded as a tentative conclusion.

In deduction the law is accepted and then applied to a number of specific examples. The child does not discover the law but develops skills in applying the same, proceeds from general to particular or abstract to concrete. In actual practice, the combination of Induction and Deduction is practised. The laws discovered by pupils inductively are further verified deductively through applications to new situations.

Sr. No.	Inductive Method	Deductive Method
1.	Proceeds from the particular to the general; concrete to the abstract.	Proceeds from the general to particular, the abstract to the concrete.
2.	It takes care of the needs and interests of children.It is a developmental process.	Facts are thrust upon the child. The principle of growth is not considered.
3.	It encourages 'discovery' and stimulates thinking.	The authority decides or gives the formula and encourages memorization.
4.	The generalization or rule is formulated by the child, therefore he remembers it with ease.	The rule is given to the child. He does not appreciate its nature and is likely to forget it easily.
5.	The how and why of the process is made clear through reasoning.	The process is taken for granted and accepted without reasoning.
6.	It starts from observation and	Does not encourage learning by

	direct experience and ends in developing; a rule in abstract form.	doing. It starts with a rule and provides for practice and applications.
7.	It encourages child participation and group work.	It demands individual learning and treats the child as a passive recipient.

Science education is challenging. To some, science seems like a mere collection of facts waiting to be memorized. Not surprisingly, skills scientists exhibit are often emphasized in teaching science in primary and secondary schools. Since science does deal with a large amount of information about the world we live in, generalizations are greatly sought. Explanations that apply to a multitude of cases are theories worthwhile to both teach and learn. In high school, it is the deductive reasoning that is most often used to teach science. General rules are first taught and are applied to specific cases until a conclusion is reached. This is often called "top-down" logic. Drawing a hypothesis, performing experiments and making observations, and explaining the results is a common description of the scientific method. But scientists do not always work in this direction. There is likewise inductive reasoning or "bottom-up" logic.

What is deductive instruction?

A deductive approach to instruction is a more teacher-centered approach. This means that the teacher gives the students a new concept, explains it, and then has the students practice using the concept.

What is inductive instruction?

In contrast with the deductive method, inductive instruction makes use of student “noticing”. Instead of explaining a given concept and following this explanation with examples, the teacher presents students with many examples showing how the concept is used. The intent is for students to “notice”, by way of the examples, how the concept works.

Teaching methods can either be inductive or deductive or some combination of the two.

The inductive teaching method or process goes from the specific to the general and may be based on specific experiments or experiential learning exercises. Deductive teaching methods progress from general concepts to specific use or application.

- These methods are used particularly in reasoning i.e. logic and problem solving.
- To reason is to draw inferences appropriate to the situation.

- Inferences are classified as either deductive or inductive.

For example, "Ram must be in either the museum or in the cafeteria." He is not in the cafeteria; therefore he must be in the museum. This is deductive reasoning.

As an example of inductive reasoning, we have, "Previous accidents of this sort were caused by instrument failure, and therefore, this accident was caused by instrument failure.

The most significant difference between these forms of reasoning is that in the deductive case the truth of the premises (conditions) guarantees the truth of the conclusion, whereas in the inductive case, the truth of the premises lends support to the conclusion without giving absolute assurance. Inductive arguments intend to support their conclusions only to some degree; the premises do not necessitate the conclusion.

Inductive reasoning is common in science, where data is collected and tentative models are developed to describe and predict future behaviour, until the appearance of the anomalous data forces the model to be revised.

EXAMPLES OF INDUCTIVE REASONING

CHEMISTRY:

Elements in the periodic table are divided into several groups which have similar properties and electronic configurations etc. Thus if the properties of individual elements in a group like chemical reactivity, melting point, boiling point, ionization energy etc. are known the properties of the elements of the entire group can be predicted with very few exceptions. Thus it proceeds from specific to general and so is an example of inductive method.

PHYSICS:

By noting the amount of work done in lifting a body from the ground to a height h, we can derive the relation between the potential energy of the body (P.E.) with the height attained by it from the ground, which is P.E. = m g h, where, g = 9.8 m/sec2, the acceleration due to gravity acting vertically downwards. The height being specific, it proceeds from specific to general and so is an example of inductive method.

BIOLOGY:

a) Morphological and anatomical characteristics can be studied in particular plants with prominent characteristics, such as Lemna (Duckweed), Eichhornia (water hyacinth) hydrilla, Opuntia, Acacia, Calotropis (AK); for understanding the ecological adaptations of plants into three groups on the basis of plant water relationships as Aquatic (Hydrophytes), Terrestrial (Xerophytes, Mesophytes) and Halophytes. As it proceeds from particular to general, therefore it is an example of inductive method.

b) The children are explained the consequences of depletion of resources like coal, petroleum and then let them reason the need for conservation of resources and methods for it. As it proceeds from particular to general, therefore it is an example of inductive method.

Deductive reasoning is common in mathematics and logic, where elaborate structures of irrefutable theorems are built up from a small set of basic axioms and rules. However examples exist where teaching by inductive method bears fruit.

EXAMPLES OF DEDUCTIVE METHOD

CHEMISTRY:

The experiment of salt analysis is an example of deductive method because here, we firstly perform the preliminary test also known as dry test (general) to ascertain as to which group it may probably belong. The group being ascertained, we proceed to perform a specific confirmatory test to identify the particular salt. Thus it proceeds from general to specific.

4) PHYSICS:

By using the properties of semiconductors (general), we make several instruments like diodes and transistors which have (specific) uses like the light emitting diode (LED) is used in remote control instruments; the photodiode is used for counting the exact number of people present in a stadium at a particular interval of time. As it proceeds from general to specific thus this is an example of deductive method.

5) BIOLOGY:

a) This method can best be made use of in the study and understanding of diseases where the symptoms and precautionary measures of various diseases caused by bacteria, virus and other organisms can be explained and children are asked to identify the same on the basis of their understanding.

b) Classification of animals into chordate and Non-Chordate on the basis of their differences. Since, the differences are general in nature, and the classification as mentioned above is particular in nature, it proceeds from general to particular. Thus this is an example of a deductive method.

The examples cited above are not exhaustive. Many more examples can be given from a variety of subjects as well.

Conclusion

Inductive reasoning is the reasoning in which premises are viewed as a way of providing strong evidence for the truthfulness of a conclusion.

While the conclusion of an inductive argument is certain, the truth of that conclusion in an inductive argument is likely, based on the evidence provided.

Many sources may define the inductive method as one in which general principles are derived from specific observations.

In this method, broad generalizations are made from specific observations, so it can be said that it goes from the specific to the general. Many observations are made, a pattern is perceived, a generalization is made, and an explanation or a theory is inferred.

In a deduction, one begins with a general argument or hypothesis and examines the possibilities to arrive at a specific and logical conclusion. His scientific method Uses deduction to test hypotheses and theories.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 4
Science Teaching : Methods, Approaches and Tools

c) Concept mapping: meaning, steps and significance, PEOR (i. e. Predict, Explain, Observe and React)

CONCEPT MAPPING

Introduction

Used as a learning and teaching technique, concept mapping visually illustrates the relationships between concepts and ideas. Often represented in circles or boxes, concepts are linked by words and phrases that explain the connection between the ideas, helping students organize and structure their thoughts to further understand information and discover new relationships. Most concept maps represent a hierarchical structure, with the overall, broad concept first with connected sub-topics, more specific concepts, following.

Meaning

Concept maps were first used by Joseph D. Novak of Cornell University in the 1960s (Lanzing). Concept maps have their origin in the learning movement called constructivism. Concept maps identify the way we think, the way we see relationships between knowledge. The teacher who constructs concept maps for classes is interested in students understanding relationships between facts, not just "knowing" the facts.
Concept mapping is a great way to build upon previous knowledge by connecting new information back to it.

The components that make a concept map are boxes or circles (nodes), lines, labels and arrows (arcs). In the boxes are represented the concepts, with the lines indicating the relationships between the concepts, the labels explain the nature of the relationships and the arrows describe the directions of all relationships.

More specifically, the linking words which are usually used are: composed of, includes, causes, is influenced by, etc.

The technique for visualizing the relationships among different concepts is called concept mapping.

Similar to an outline or a flowchart, a concept map is a way of representing or organizing knowledge. However, a concept map goes beyond the typical outline in that concept maps show relationships between concepts, including bi-directional relationships. Usually, a concept map is divided into nodes and links. Nodes (often circles) represent various concepts; and links (lines) represent the relationships (propositions) between concepts (Lanzing, 1997). Words are used to label the links in order to explicitly depict relationships (Anderson-Inman & Zeitz, 1994).

Once completed, the concept map is a visual graphic that represents how the creator(s) thinks about a subject, topic, etc. It illustrates how knowledge is organized for the individual.

Definition of a Concept Map

Concept maps are visual display ideas, images, words, phrases and sentences that connect one another and present complex concepts based on the knowledge of the mapper.

They are created as two-dimensional diagrams composed of a central general topic that breaks down into more specific subtopics which are interconnected with linking words as an explanation of the connections.

A concept map is a type of graphic organizer used to help students organize and represent knowledge of a subject. Concept maps begin with a main idea (or concept) and then branch out to show how that main idea can be broken down into specific topics.

A concept map or conceptual diagram is a diagram that depicts suggested relationships between concepts.It is a graphical tool that instructional designers, engineers, technical writers, and others use to organize and structure knowledge.

A concept map typically represents ideas and information as boxes or circles, which it connects with labeled arrows in a downward-branching hierarchical structure. The relationship between concepts can be articulated in linking phrases such as "causes", "requires", or "contributes to".

When new knowledge is integrated with and connected to existing knowledge, that new knowledge is easier to understand and to remember. A professor's job is to build scaffolding from existing knowledge on which to hang incoming new knowledge. Using a concept map is one way to build that scaffolding.

"concept maps are two-dimensional representations of cognitive structures showing the hierarchies and the interconnections of concepts involved in a discipline or a subdiscipline" (Martin).

A concept map is a visual organization and representation of knowledge. It shows concepts and ideas and the relationships among them. You create a concept map by writing key words (sometimes enclosed in shapes such as circles, boxes, triangles, etc.) and then drawing arrows between the ideas that are related. Then you add a short explanation by the arrow to explain how the concepts are related.

Steps in Developing a Concept Map

A concept map is a visual representation of what you know about a topic. It helps you to organize, analyze, and communicate your studies and research.

Concept maps are typically hierarchical, with the subordinate concepts stemming from the main concept or idea. This type of graphic organizer however, always allows change and new concepts to be added. The Rubber Sheet Analogy states that concept positions on a map can continuously change, while always maintaining the same relationship with the other ideas on the map.

Start with a main idea, topic, or issue to focus on.
A helpful way to determine the context of your concept map is to choose a focus question—something that needs to be solved or a conclusion that needs to be reached. Once a topic or question is decided on, that will help with the hierarchical structure of the concept map.

Then determine the key concepts
Find the key concepts that connect and relate to your main idea and rank them; most general, inclusive concepts come first, then link to smaller, more specific concepts.

Finish by connecting concepts--creating linking phrases and words
Once the basic links between the concepts are created, add cross-links, which connect concepts in different areas of the map, to further illustrate the relationships and strengthen student's understanding and knowledge on the topic.

The process of concept mapping involves five major steps:

Step 1. Select a drawing medium
Step 2. Establish a main concept
Step 3. Identify related concepts
Step 4. Organize shapes and lines
Step 5. Fine-tune the map

Concept mapping is brainstorming with a purpose. You start with an overarching concept that you break down into its smaller parts, using arrows and linking words to show how ideas are connected. Common in education, concept maps are helpful in any field by driving creative and visual thinking.

If you want more information on when to use concept maps, check out our handy concept mapping guide.

A concept map helps you gain a better understanding of complex topics, see the big picture, and discover new connections through a collaborative and visual approach.

5 easy steps for drawing a concept map

1. Select a drawing medium

Many people just use pen and paper or a whiteboard because they're readily available, but it's not easy to save your whiteboard scribbles or make your handwritten diagram look professional once you're done.

2. Create a main concept

Whatever medium you choose, the next step is to determine the central idea that you want to detail. If you're not sure where to begin, try identifying a portion of text, a classroom activity, or a tough problem that needs solving.

List all the concepts related to the topic which you consider essential to understanding the topic. For example, for the topic "cooperative learning," Jose determined the key concepts to be:

Team Responsibilities
Individual Responsibilities
Characteristics
Roles
Basic Elements
Expected Behaviors

It might be useful to come up with a single question, called a focus question, that clearly specifies the problem or issue the concept map will help resolve. Your concept map will consistently lead back to that question and its answer.

3. Identify key concepts

Now that you've selected a main concept, the next step is to write down subordinate concepts. Make a list of related ideas, and rank them from the general to the specific. This list, also known as a parking lot because you're waiting to move these ideas to your map, should consist of around 15-25 key concepts.

Build up concepts to elaborate key concepts
After defining the key concepts, you then expand on those concepts. Ask yourself the question:

"What are the important concepts, facts, ideas, terms, etc. that explain the key concept?"

Describe each concept as briefly as possible; usually one or two words per idea will suffice. Keeping your descriptions concise will prevent your map from becoming bloated and text-heavy.

4. Organize shapes and lines
Order each of your concepts in a hierarchical format, with the most general ideas at the top of the map under your main concept and the most specific ones at the bottom.

Your concept map will take form as you connect shapes with lines and pinpoint the correct location for each idea.

Identify links between concepts
It is important to show how or why certain concepts relate to one another. This is called linking – explaining the connection between two separate parts of your concept map.

Concept maps typically have text, or linking words, written on each line to make sense of the relationship between a general concept and more specific ones. The text might include a specific verb like “provides” or “encompasses.”

Once you've created this preliminary concept map containing the basic links, add cross-links to illustrate relationships between concepts that are on the same level of specificity.

5. Fine-tune the map
As you add links to every concept, be sure to carefully examine the relationships you're illustrating. Ask yourself questions like:

Does every element fit well in its respective place?
Is there a better position for this idea or group of ideas?

Significance of Concept Maps in Education

A concept map is a visual organizer that can enrich students' understanding of a new concept. Using a graphic organizer, students think about the concept in several ways. Most concept map organizers engage students in answering questions such as, "What is it? What is it like? What are some examples?" Concept maps deepen understanding and comprehension.

1. When created correctly and thoroughly, concept mapping is a powerful way for students to reach high levels of cognitive performance. A concept map is also not just a learning tool, but an ideal evaluation tool for educators measuring the growth of and assessing student learning. As students create concept maps, they reiterate ideas using their own words and help identify incorrect ideas and concepts; educators are able to see what students do not understand, providing an accurate, objective way to evaluate areas in which students do not yet grasp concepts fully.

Since students might not know how to create a concept map, it is beneficial to model the process in class.
Once students understand the process, you can use concept maps in the following ways:

Use as an in-class pre-assessment.

Prior to discussing a topic, ask students to create a concept map. Then, as you discuss the information, they can add to or modify their map to reflect their understanding about the topic.

Do as a small group activity.

Give your students a problem, case study, or question about a key concept. Divide them into small groups of 4-5 students. Have each group create a concept map as they analyze and synthesize previously learned information into this new scenario. Have the groups present their conclusions.

Do as a whole class activity.

As a class, create a concept map and use it as a springboard to discuss relationships among the concepts and ideas listed in the map.

Fill in the blanks.

Before class, create a concept map of the material you want to cover in class. Then, remove some of the concepts and labels. Show the partially completed map to the class and have them fill in the blank spots and label the relationships.

Organize your research.

Use a concept map to build and organize your ideas, layer details, and find connections and relationships that might never have occurred to you before.

2. Benefits of Concept Mapping to learners

Concept mapping serves several purposes for learners:

Helping students brainstorm and generate new ideas
Encouraging students to discover new concepts and the propositions that connect them
Allowing students to more clearly communicate ideas, thoughts and information
Helping students integrate new concepts with older concepts
Enabling students to gain enhanced knowledge of any topic and evaluate the information.

3. It helps children organize new information.

4. It helps students to make meaningful connections between the main idea and other information.

5. They're easy to construct and can be used within any content area.

6. Concept mapping forces students to identify connections, and apprehend them more deeply, than traditional approaches such as reading or writing about a concept.

7. Additionally, concept mapping makes use of dual coding; that is, the students learn the material both from the text labels found on the concept map as well as the visual structure of the map.

8. For some students, concept mapping can ease their cognitive load by allowing them to focus on essential relationships, rather than on decoding a written text.

9. Concept maps are a form of visual thinking. Most people are better able to remember a visual representation -- such as a chart or graph -- than a chart full of numbers.

Conclusion

Concept maps are visual representations of information. They can take the form of charts, graphic organizers, tables, flowcharts, Venn Diagrams, timelines, or T-charts. Concept maps are especially useful for students who learn better visually, although they can benefit any type of learner. They are a powerful study strategy because they help you see the big picture—because they start with higher-level concepts, they help you chunk information based on meaningful connections. In other words, knowing the big picture makes details more significant and easier to remember.

Concept maps work very well for classes or content that have visual elements or in times when it is important to see and understand relationships between different things. They can also be used to analyze information and compare and contrast.Concept mapping tools allow you or your students to visually depict a system of relationships by creating a map in which nodes represent ideas or facts, and lines or connectors between nodes represent relationships (for example, cause-and-effect relationships, category and subcategory relationships, and so on).

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PEOR

Demonstrations are a core part of science teaching. In 1980 a three-
a part assessment method using demonstrating was proposed. Known
as DOE this consisted of demonstration, observation and explanation.
DOE quickly evolved into POE: predict, observe, explain. In the light
of experiences with POE and insights from constructivist theory a learning-focused refinement
of POE came forward , namely
PEOR: predict, explain, observe, react.

PEOR can be used with any age
of students.

PEOR enables
the teacher to clarify students' conceptions about the topic. These surface naturally and serve as an important
start in the process of clarifying ideas about the broader course content.
When using PEORs with student teachers,
students' affective and cognitive engagement in the activity become
considerably greater than that shown during a traditional
demonstration.
The POE strategy was developed by White and Gunstone (1992) to uncover individual students' predictions, and their reasons for making these, about a specific event.

PEOR

PEOR is an attempt to build on the experience of POE in the light of
developing ideas from constructivism about learning. In this section we look
at arguments for each of the four parts of PEOR.

Predict
Prediction tends to evoke engagement and a sense of a
stake in what happens. In addition constructivism has taught us that learners'
initial ideas are the platforms from which they construct new knowledge.
In our view the teacher's task is to guide and nudge learners from where

they are now towards understandings that fit better with the science community. It is therefore useful for the teacher to learn where the students are starting from, so as to be able to target her/his teaching interventions where they are needed. Students' predictions provide the teacher with this 'diagnostic' information – provided the students express their views about the demonstration rather than trying to guess the right answer to please the

teacher. 'Right answerism' (Holt, 1964) is a major hurdle to be overcome, as Dreyfuss and Jungwirth (1989) found: students whom they observed readily used the word 'photosynthesis' in response to teachers' questions - despite having little or no coherent understanding of plant nutrition. If the emphasis in class is on expressing and considering ideas, students' sense of self worth is likely to grow and their energy may shift away from closing in on the right answer or switching off their thinking. The teacher may be able to connect directly with some of the students' predictions by testing them in the demonstration, thereby providing further affirmation that the predictions are taken seriously.
In summary,
used in this way P engages learners and informs the teacher.

Explain
We don't want students to guess or opt out of taking part. Our experience is that learners of all ages have personal theories about why things happen and about what they expect to happen. Expecting them to explain their thinking behind their predictions encourages them to engage with the demonstration, especially if they know not only that this will be expected but that they may be called to account. We want to encourage tentative, imaginative thinking, rather than right answerism, so the premium in the E phase is on the process of thinking, not on the conclusions. A student who says, 'I think after you burn iron wool it will turn into a powder and be really light,' is not right but at this stage that isn't the issue.
What matters is
that
(i) the student is engaged and
(ii) the teacher has an insight into the
student's thinking.

To illustrate the importance of the second point consider
a student's prediction that ammeters connected on either side of a bulb in a circuit will show similar readings. This is correct. The teacher knows that any slight difference will arise from the calibration of the meters. But now let's ask the student to explain her/his reasoning: 'It's because the meters aren't sensitive enough to show the current used up by the bulb.' This Changes matter! The Explain phase has revealed to the teacher that the

student holds the common non-scientific conception that current gets used up by bulbs. Inclusion of the Explain phase in PEOR provides the teacher with diagnostic information about the students' ideas and takes seriously Piaget's recommendation that if one wants to find out about people's thinking one should not be content with eliciting their judgments but should seek their justifications for their judgments. Informed by diagnostic information from the E-phase, the teacher is in a position to make decisions about what questions to ask and what guidance to give during the following parts of the activity.

The safest classroom context, psychologically speaking, for trying out ideas is discussion with one or two peers, rather than answering to the teacher in front of the class. Because of this, E is initially carried out in small groups, after which the views of one or two groups may be elicited by the teacher for the class to hear. By circulating during the group discussion, the teacher may be able to select groups with divergent views for reporting back to the class.

In summary,

E encourages thinking about the science and informs the teacher about the students' pre-teaching conceptions.

Observe

The trap for the teacher in the observation phase is that what is obvious to the teacher may not be so to students. One of us recalls using digital ammeters in a demonstration leading towards the idea of conservation of current in a series circuit. The meter readings were 453mA and 452mA, which from The teacher's viewpoint was consistent with Kirchhoff's current law. It later emerged, however, that for some students this was confirmation that current does indeed get 'used up' in circuits! A teacher in the New Zealand based Learning in Science Project commented, 'They focus on things I would never dream of looking at, even'

We could amend this in the context of demonstrations to 'They see things.....'. To help avoid this trap in PEOR the teacher can ask lots of attention-orienting, or Socratic questions. We usually specify that these are for discussion by students with their immediate neighbours, which is both safe and non-disruptive to the flow of the demonstration. As earlier, the questions target thinking, in this case about concrete observations and their implications.

Observation offers the opportunity for concrete perceptual experiences as opposed to abstractions. Why is this significant in learning? Here we can draw on the constructivist insight that plausibility from the learner's perspective is highly significant. Teachers are all too well aware that they can provide what seem to be cast iron arguments in support of a scientific position yet some learners just don't 'get it', because it doesn't make sense to them. For instance, to many people, adults as well as children, plants must take in food through their roots and electricity must get used up in circuits. Science demonstrations can have a high impact in terms of plausibility because of a common human propensity: we tend to believe what we see first hand. For example, if a teacher only tells students that when iron wool is burnt to a powder the powder is heavier than the iron wool, many will be unpersuaded. If they see the scales tipping for themselves, some will pause for thought.

In summary, O provides concrete, plausible perceptual experiences.

React and Revisit:
Rethink or Reinforce

By the end of the observing some students will have found that their predictions fitted with what they observed and others will have experienced a misfit. The R part of PEOR asks students to react to the observation by revisiting their predictions and explanations and discussing in small groups how they feel about them now: would they like to stick with them or update them? This process is intended to help students to rethink their ideas about science or, if their ideas fitted, to reinforce them and to use them to peer teach others. The R part makes use of the insight that languaging is a process of creative commitment to a belief position and that a peer group is a testing ground for the belief.

In summary,
R gives learners the opportunity to test, change or reinforce new ideas.

In the account above we have stressed issues related to learning; for instance: small group discussion for safe languaging of tentative ideas and for addressing differences, prediction for learner engagement, explanation to promote high-level thinking as opposed to guessing, peer teaching to reinforce some ideas and challenge others. For us this practical and theoretical focus on learning is what makes PEOR a pedagogic step forward from POE.

When making use of PEOR there is a strong argument for using slightly novel or unusual demonstrations so that the students' experience is 'authentic'. The use of novelty brings with it the elements of surprise and curiosity and at the same time it challenges students to apply their ideas to new situations. If the PEOR presented is a traditional classroom demonstration or one commonly found in books the exercise may prove to be an anticlimax and one that will not motivate students to participate. In comparing POE with PEOR, one can argue that a PEOR sequence has a learning focus that is nourished by curiosity. This curiosity stimulates engagement throughout the whole sequence and hence students are active

When to use

POE is a strategy often used in science. It works best with demonstrations that allow immediate observations, and suits Physical and Material World contexts. A similar strategy also works well in mathematics, particularly in statistics.

It can be used for:
finding out students' initial ideas;
providing teachers with information about students' thinking;
generating discussion;
motivating students to want to explore the concept;
generating investigations.

The theory

Constructivist theories of learning consider that students' existing understandings should be considered when developing teaching and learning programmes. Events that surprise create conditions where students may be ready to start re-examining their personal theories.

How the strategy works

Unless students are asked to predict first what will happen, they may not observe carefully. Writing down their prediction motivates them to want to know the answer.
Asking students to explain the reasons for their predictions gives the teacher indications of their theories. This can be useful for uncovering misconceptions or developing understandings they have. It can provide information for making decisions about the subsequent learning.
Explaining and evaluating their predictions and listening to others' predictions helps students to begin evaluating their own learning and constructing new meanings.

What to do

Set up a demonstration of an event, related to the focus topic, that may surprise students, and which can be observed.
Tell the students what you are going to be doing.
Step 1: Predict

Ask the students to independently write their prediction of what will happen.
Ask them what they think they will see and why they think this.

Step 2: Observe
Carry out the demonstration.
Allow time to focus on observation.
Ask students to write down what they do observe.

Step 3: Explain

Ask students to amend or add to their explanation to take account of the observation.

Step 4: React
After students have committed their explanations to paper, discuss their ideas together to generate your own POERs

Books that contain science “experiments” are often a good source of appropriate activities for adapting to POER, including old teaching resources that promote transmission teaching. They often include an explanation.

A template is provided for teachers to give to students to write on. To adapt the template, save in your own files, and make appropriate changes.

Limitations

For primary school students, writing the answer can be a barrier to useful communication of ideas.

Oral responses need to be managed so other group members do not initially influence students. (Use Think-Pair-Share, for example, before sharing with the whole group).

Younger primary students may have difficulty explaining their reasoning.
It is not suitable for all topics, for example, topics that are not "hands-on" or in which it is difficult to get immediate results (for example, Living World).

If the POER strategy is used often, some demonstrations should be chosen to not give surprising results, otherwise students start looking for the trick. This may affect the explanations they give.

Some researchers say that students are more likely to learn from observations that confirm their predictions. This cautions us to be careful that predictions are not wild guesses.
A joint conversation about what we might expect to see, and why, based on the underlying science idea, could help avoid this trap.

Conclusion

For learning to active, students must do regular reading—for information and pleasure; they can clearly express themselves in written form and verbal form; they constantly upgrade their vocabulary; can accurately listen and take notes and are continuously challenged using their skills of thinking via problem solving, motivation, creativity and retaining playfulness and humor.

Teachers need to introduce a new teaching strategy like the Predict-Explain -Observe - React (PEOR) that could be used in association with demonstrations, hands-on activities and laboratory experiments. This can help improve classroom practice by recognizing the learner's conception and account the meaning of a specific laboratory phenomena.

PEOR is a teaching strategy that probes understanding by requiring students to carry out four tasks.

First the students must predict the outcome of some event and must justify their prediction; then they describe what they see happen;

Then they must reconcile any conflict between prediction and observation.

and finally students react to

explore, giving knowledge a new meaning and purpose.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 5
LEARNING RESOURCES AND ACTIVITY

a) **Science Textbook: Characteristics of a good science text-book.**

Introduction

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.

Textbooks are an important tool in the hand of a teacher. It helps students to know 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

Characteristics of a good science text-book

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

Content
Organization
Literary style vocabulary
Illustrations
Teaching aids
Mechanical make up and appearance
Authorship

I. Content

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

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

II. Organization

The subject matter should cover the whole syllabus
Subject matter should be developed in psychological sequence
The text book has to be organized into units which are based on student interests and probability of use
Inductive approach is to be used whenever possible in introducing new topic
At the end of each units there should be assignments informing to the following
Application to life situations
Self assessment test
Suggestions for further reading
Numerical questions if necessary
Assessment for practicing skills
The textbook should be written in simple unambiguous scientific language. Prefer simple and compound sentence to complex sentences
It should contain a glossary of technical terms used in the books
It should suggest some good methods of learning’s
Historical development of science should be attempted
Adequate provision should be made to correlate science with other subjects and crafts.
It is better if the text book contains examples from the local environment
There should be a detailed table of contents and index text books

Controversial topics should be treated impartially
The social significance of science should be stressed
Headings and sub- headings should be in bold type
Important principles should be set in italics
Each text books should be accompanied by a laboratory manual and pupil's workbook
It must be supplemented by a teacher's hand book
Education is the most powerful weapon which you can use to change the world. -Nelson Mandela

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.

Length of sentences
Directness of sentences
Number of ideas per seconds
Use of lead sentence or paragraphs
Presence or absence of irrelevant thoughts\continuity of thought
While evaluating a text book the teacher must decide whether or not the vocabulary is excessive or inappropriate text book should be easy to read

IV Illustrations

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

Photographs should be clearly reproduced
Diagrams should be carefully made attractive
Color in the illustrations add to eye appeal and when properly used has considerable teaching value
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
Photograph should have relation with content in the text
Teaching aids
The table of content and index should be comprehensive
Glossary should be included
Activities should be given the end of a chapter
Activities should be closely related to content

Mechanical make- up and appearance
Artistic cover
Durability for binding

Size of the book
Good quality of paper
Length of line and size- legible
Attractive over all experience
Cover design and colour should be appealing
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 textbooks. 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
Some principles of writing text-books in 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.

General characteristics of a good textbook

1 . The author: A good text-book is judged, at face, by the author, his qualification and experience.

2. Mechanical features of the text-book:

(a) The print and paper used and the binding of the text-book should be attractive. It should be hard and durable.

(b) The printing should be clear, legible and appropriately spaced.

(c) The book should be well-illustrated with diagrams, sketches and pictures.

(d) The size of the print, the language and experiments discussed should suit the age of the child and standard of the child.

3. The subject matter-its nature and organisation:

(a) The subject-matter should be developed as far as possible in psychological sequence. Care must be taken of the mental growth and interest of pupils.

(b) There should be consistency of the subject-matter and the text-book should satisfy the objectives of science teaching.

(c) Each chapter should begin with a brief introduction and end with a summary. ^

(d) Subject-matter should lead to the inculcation of scientific attitudes, disciplinary and cultural values.

(e) Each chapter should contain assignments at the end.

(f) During treatment of subject-matter, numerical examples should find a place where necessary.

(g) Headings and subheadings are given in bold letters.

(h) Each text-book should contain a detailed Table of Contents and an index.

(i) The language of the book should be simple, clear, lucid, scientific and precise. The English equivalents of the terms should be always given in brackets.

(J) The text-book should give suggestions for improving scientific apparatus.

(k) Examples in the text-book should be given from the local environment and from life experience.

(l) During the treatment of science subjects in the text-book, care should be taken to see that it is correlated with other subjects like craft, social environment and physical environment.

(m) Each text-book should be accompanied by a laboratory manual.

Conclusion

Textbooks 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 textbook should really design for the pupils rather than the teacher. Textbooks 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.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 5
LEARNING RESOURCES AND ACTIVITY

b) Science Club and Science Field Visit- Concept, Organisation and Significance.

The Science Club

Introduction

Non-formal mode of education is an organized activity which can be modified in a number of forms and methods depending on the requirements of the learner. Our classroom teaching does not provide opportunity for self expression, constructive activities and independent enquiry. No time is assigned for practical work. All these lead to the need for an organization providing an outlet for the pent up emotions of children and for pooling their energies. An organization which caters for the calculation of scientific attitude and genuine interest in science and also can supplement the work of the classroom and give the syllabus a practical dimension may be called a science club.

Concept of Science Club

It is a fact that we can learn and remember things better if we do it and practice rather than just read them. This basic principle is involved in the formation of an organization called "Science Clubs" meant for 'learning by doing'.

Children have the tendency to make things, break things and handle things on their own but the conventional system of education does not allow them to do so. Self-expression, independent research, constructive activities, etc., are some of the opportunities provided by the science clubs. In the classrooms, the students work formally and restrict themselves to the school curriculum. Whereas in science clubs, there are no restrictions and the students can work on their own ideas with full freedom

Science clubs channelize the energies of students and make use of their skills and talents, which satisfy their instincts and urges and help in their overall personality development. Science clubs work in association with classroom instruction of science subjects. Therefore we can define the science club as “an organization, which helps in the development of scientific attitude, and develop genuine interest in science and scientific activities, supplements the work of the classroom and the laboratory and parts the syllabus on a practical basis.

Definitions:
According to Devis: The future of India belongs to youth and science. Therefore there should be a vast place for science clubs in the school curriculum.

According to Maclean: the club offers the pupil an opportunity for facilities which we do not have in the curriculum. The curriculum work is formal whereas the club activities are informal.

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

Some concepts can not be taught either in the classroom or in the laboratory, for such concepts science club provides better opportunities. In the science teaching process laboratory is considered as the heart of science, curriculum whereas the science club is considered as the blood of it.

Organization of Science Club

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

To begin with, the science teacher can explain the importance and benefits of organizing a science club and can arouse enthusiasm among students. This discussion may be followed by a business meeting in which office bearers are chosen. Every science club should have its own constitution. They should be a general body and an executive body.

The suggested office bearer should be:

The senior science teacher may be the Sponsor.
The principal/Headmaster of the school may be Patron
The resources of the school should be made available to the club.
An elective executive committee formed from the club members/students.
Executive committee: Chairmen, Secretory, Joint Secretary, Treasurer, Librarian, Store keeper, Publicity in charge, Class representative.
A nominal membership fee should be charged from every member.
Other resources should be tapped by the club.
The members of the club should be encouraged to extend the activities of the club in their locality.
The duties of office bearers should be

Patron : To extend all the facilities to the club for its effective working.
Sponsor: To look after, Guide, Lead.
Chairperson: To prescribe over the function of the club and over the meetings of the executive committee.
Secretory: To maintain the minutes of the meetings of the club.
Join Secretory: To assist the secretory.
Treasurer: To collect subscriptions and maintain the accounts.
Librarian: To issue and receive books, maintain catalogue.
Store Keeper: To keep record and equipment of the club
Publicity in charge: To publish the activities of the club in and outside the school.

There should be regular meetings, discussions, planning, feedback etc. The responsibility of the taking initiative in the establishment of a science club in the school and then for its effective organization essentially lists.

Preliminary Considerations:

1- After performing the above mentioned tasks the teacher should call a formal meeting of the science teacher and a formal meeting of the science students. In this meeting the proposal and scheme concerning the organization of the Science club in the school should be discussed. The aims and objectives of this club are to be placed before the students and constitution of the club is chalked out and the membership drive is launched.

2. With the active cooperation of the head of the institution, he should make efforts to arrange for the finances to establish the science club. While some amount may be taken from the finances of the institution and collected from the students in the form of membership fee etc.

3. The department of NCERT, State Government or any voluntary agency may also be approached for providing assistance in the project.

Suggested functioning of Science club:

Every office bearer and member of the club should work wholeheartedly in a team spirit for the smooth and effective running of the programs and activities of the club . Usually the following activities may be undertaken in a science club:

v Arranging lectures of the subject experts on the subject of the scientific interest

v Arranging cleanliness and health weeks in the institution

v Arranging excursions and short trios for the members to places of scientific interest.

v Creating in the school healthy environment for carrying out scientific studies and activities.

v Decorating the walls of the classroom, library and laboratory with scientific and activities.

v Organizing school services in the field of health and sanitation

v Preparing certain things of common use like soaps, writing ink, phenyl, etc

v Publishing science magazine and news bulletin of scientific events.

Suggested duties of office bearers

Duties of the Secretary-

To take responsibility for conducting the programmes and activities of the club.
To take charges of all correspondence related with the club activities.
To frame the programmes of the meeting and keep proper record or the proceeding of the meetings of the club.
To invite the outside expert and guest speaker etc., in the club and attend them properly.

Duties of the Publicity Officer-

To publicize the activities of the club in the school and outside the school through posters and writing in the magazines, newspapers and scientific journals.
To keep a record of all important scientific activities, achievements and programmes of the club.

Duties of the Treasure-

To prepare the budget of the club and present the statement of the account .
To keep the proper account of the income and expenditure of the club.
To collect subscriptions from the members.

Suggested Science Club Activities

Through activities of a science club, learning of science becomes joyful. The science club caters to freedom for expression, whereas the classroom atmosphere leads to conformity and repression. While participating in a science club students organize thought and translate these into action and thereby develop a zealous enthusiasm to strive for the cause of scientific enterprise.

The club should be in contact with scientists and other nearby scientific institutions who could visit the schools to speak to learners about exciting topics and show them some “science in action”. This could also be an opportunity for learners to ask about careers in science.

The club could organise for its members (and other interested learners) to meet for talk sessions where current scientific topics could be discussed. This session could be used to talk about ideas that might help solve some of the world’s many problems. With a little more initiative, real scientists and university students could be invited to sit in at these sessions.

The most exciting part of such a club is the opportunity to meet people from other schools. If neighbouring schools were encouraged to form similar clubs, then these clubs could communicate with each other and form some joint organisation with representatives from each school. This larger group could then organise much bigger projects such as regional science expo’s and other interesting inter-school events.

This is an easy-to-organise event that would be fun as well as intellectually challenging. The club could find interesting mathematics or science problems that lie within the capability of the targeted learners and offer small prizes to those who can solve them. Depending on the level of difficulty, there could also be prizes for group entries.

Many learners may exhibit great interest in a certain aspect of science but lack the motivation to pursue it. By providing some incentive for them (e.g. obtaining partners from industry who may also be interested in a certain topic) the club will facilitate and encourage these learners to research topics that they find interesting.

Activities organized by Science Club

Conducting visual programmes of scientific interest . Improvising and preparing hand-made apparatus. Collecting. Preparation of soaps, ink ,candle matches, toys, bleaching powder, nail polish, chalk etc. Mounting and preserving the specimens.
Rendering school services in health and sanitation through managing a first aid squad. Helping the community by way of demonstration on health and hygiene, improvement of agriculture, eradication of superstitious belief etc.
Publishing school science magazine.Preparing science albums, Preparing still/Working models on science topics .Maintaining a bulletin board for displaying science news .Conducting essay competition on scientific problems.
Arranging science discussions, debate, essay writing,
Conducting workshops

Conducting science quiz competitions,   Arranging the science excursions and visits.
Arranging science exhibitions , Film shows and science fairs.
Organizing lectures, debates, seminars, symposia etc.
Participation in Science Fairs
Fundraisers for trips and charity
Participation in the mobile laboratory
Middle School teaching visits
Trying cool science experiments for discovery.

Celebrating the science days . Celebrating birthdays of eminent scientist

Significance of Science Club

Science club is the place where the pupil works with many pupils. So he is able to work in cooperation, able to know others' attitudes and points of view on a problem. He can discuss with the co members of the club about the problem. So the science club plays an important role in encouraging problem solving skills in pupils

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

To begin with, the science teacher can explain the importance and benefits of organizing a science club and can arouse enthusiasm among students. This discussion may be followed by a business meeting in which office bearers are chosen. Every science club should have its own constitution. They should be a general body and an executive body. The Principal or Headmaster be the patron and the science teachers should be the sponsors. Executive members such as president, Vice President, Secretary, Treasures, Librarian, Publicity officer, etc are chosen from among the student members. The executive committee has to ….out programmers. These activities of the club should be taken up by the students themselves, There should be regular meetings, discussions, planning, feedback etc.

The responsibility of the taking initiative in the establishment of a science club in the school and then for its effective organization essentially lists. With the science teacher therefore, every science teacher must acquire the necessary ability for performing such responsibility by taking care of the things mentioned below.

Significance of a science club may be outlined below.

To provide proper incentive and inspiration for the pursuit of scientific knowledge in a rigorous way by broadening their scientific outlook.

To make the students understand the values of time and to help them in the proper utilization of their hours.

To provide opportunities for bringing school close to the society and to acquaint the people with the services and contribution of science in their life.

To develop among the students the spirit and attitude of healthy competition for the individual and social cause.

To help the students in imbibing The habit of self-reliance, self-dependence and love for manual work.

To inculcate scientific attitude.

To provide opportunity for the development of the constructive, explorative & inventive faculties of the students.

To develop training in scientific method of problem solving.

To develop students, interest and participation in the practical application of the knowledge related to different branches of science.

To grate interest in scientific facts and events related to one's surroundings.

To develop interest in scientific hobbies.

To encourage individual and group activities.

To stimulate active participation and initiative among students in the learning process.

To develop creativity and encourage the habit of exploration.

To widen the outlook of students, apply the knowledge in life situations.

To provide opportunity for the development of the constructive, explorative and inventive faculties of the students.

To create interest in the latest inventions and discoveries of science in various fields and to get acquainted with the life history and contributions of great scientists.

To develop students, interest and participation in the practical application of the knowledge related to different branches of sciences.

To develop creativity and encourage the habit of exploration.

To widen the outlook of students, apply the knowledge in life situations.

To develop interest in scientific hobbies.

To keep the students in touch with the latest developments in science.

To develop the observation power, co-operative working among the students.

Conclusion

The Science Club is the place for students who are interested in science to learn about all scopes of science from medicine to chemistry to physics to the environment. We discuss how to use this conceptual basis for applications in the real world. Trips are taken to museums, aquariums, and state parks.
Learning by doing and learning by living are two essentials of learning science. Children are interested in making things, breaking things and handling things. But the curriculum does not satisfy this natural urge. In the classroom everything is done in a formal, artificial and controlled atmosphere. This will never give the child an opportunity for his free fights in the world of science. Our classroom teaching does not provide opportunity for self expression, constructive activities and independent enquiry. No time is assigned for practical work. All these lead to the need for an organization providing an outlet for the pent up emotions of children and for pooling their energies. An organization which caters for the calculation of scientific attitude and genuine interest in science and also can supplement the work of the classroom and give the syllabus a practical dimension may be called a science club.

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Science Field Visit

Introduction

A field visit or excursion is a journey by a group of people to a place away from their normal environment.

The purpose of the visit is usually observation for education, non-experimental research or to provide students with experiences outside their everyday activities, such as going camping with teachers and their classmates.

Field trips are most often done in 3 steps: preparation, activities and follow-up activity. Preparation applies to both the student and the teacher. Teachers often take the time to learn about the destination and the subject before the trip.

Activities that happen on the field trips often include: lectures, tours, worksheets, videos and demonstrations. Follow-up activities are generally discussions that occur in the classroom once the field visit is completed.

Popular field visit sites include zoos, nature centers, community agencies such as fire stations and hospitals, government agencies, local businesses, amusement parks, science museums, and factories.

Concept of Science Field Visit

The concept of Science field visit was introduced in 1827 by George Shillibeer for a Quaker school at Abney Park in Stoke Newington, London, United Kingdom.

A field visit is a visit to a place outside the regular classroom which is designed to achieve certain objectives, which cannot be achieved as well by using other means. For example if the lesson is on "making cheese", and if there is no hand on experience it is very difficult to achieve the objectives. In such a lesson this is required. Field visits give students the opportunity to get out of the classroom and experience something new. The location for field visits can be zoos, colleges, museums, theater and schools.

Features of field visit

1. Facilitate the learning of abstract concepts. Taking students on a field visit makes learning more effective as they will be able to gain vast ideas on the topic.

2. Motivate students through increased interest and curiosity. Field visits can add variety to the regular classroom instructional program and they tend to be special and enjoyable learning experiences. As a result, students will develop positive attitudes in students toward related classroom activities.

3. Increases student-student and student-teacher social interaction. Field visits provide an opportunity to involve students, parents, and the teachers in the instructional program. Students can select the place to be visited, developing questions to ask, writing reports or thank you letters after the visit , or evaluating the experiences. Since parents must give their permission, a letter sent home with the permission form explaining the purpose of the visit is a good way to arouse their curiosity and encourage them to ask the student or teacher about the visit . The parent guides their child in order to make sure that they do not come to any harm. This role allows the parent and teacher to establish a much closer relationship. The interaction between students within themselves will also be increased when they work in groups. Moreover, the interaction between the students and teacher will enhance as the students will have to discuss the teachers when they have doubts.

4. Develops social awareness.

Field visits make students aware of learning activities in everyday life. For instance, visits to supermarkets or shopping malls are typical field experiences, which teachers may fail to notice. A well-organized visit to a "normal" place is an excellent method of teaching students to observe, ask questions, and learn in the large classroom.

Types of field visits.

1. Instructional visits

An instructional visit is a visit by a class or group of classes to a location outside the regular classroom, which is designed to allow the students to achieve specific course objectives, which cannot be achieved as efficiently by other means. An example of an instructional field visit is a visit to a botanical garden to study about different kinds of flowers.

2. School contests or festivals

A school contest is an extra campus activity, which provides an opportunity for students to demonstrate knowledge and skills developed through subject area instruction. Contests, competitions, festivals, or evaluations may involve teams of students from more than one class or subject. An example of a school contest, festival, or evaluation is the school level essay competition.

3. Motivational visits

A motivational visit is an extra-campus activity, which is not a part of a scheduled class. It provides a motivational incentive for the school, club, group, or class and is related to improving the school climate. The procedures in this guide are for instructional field visits. If you are planning a motivational visit , please note that this requires approval from the General Area Director.
An example of a motivational visit is an end of year visit to Buddha point by a student body. First a teacher must choose the kind of visit to take and then decide on a general location for the visit .

Organization of Science Field Visit

Good organisation and planning must precede field visits. Careful attention should be given to visit selection, pre visit preparation, the visit itself, appropriate follow up, and evaluation. When considering a field visit , teachers are advised to first consult with their administrator regarding existing school policies and follow those recommended procedures in planning a field visit .

Steps involved in conducting science field visits .

1. Visit Selection.

a. Identify the rationale, objectives and plan of evaluation for the field visit .
b. Select the site to be visited.
c. Contact the educational coordinator for the site and arrange the date and time.
d. Obtain the pre-visit information package if one is available.
e. Record addresses, directions, contact persons, phone numbers, email addresses, etc.
f. Conduct a pre-visit to familiarize yourself with the major features of the field visit .
g. Purchase postcards and posters.
h. Take photographs to share with students prior to the visit.
i. Explore the exhibition(s) you plan to visit to get ideas for pre field visit activities.

2. Logistics Planning

a. Apply for administrative approval from the head of the school.
b. File requisition for bus transportation if the school has any or seek administrative support for arranging transportation if the school does not have the facility
c. Make arrangements for meal or sack (pack) lunch if needed
d. Develop schedule for the day
e. Arrange for special equipment -supplies, film, video camera, digital camera if needed
f. Collect money for admission fees if the visit site demands
g. Inform the parents (in case of day school) about the following things:
· Date and location of field visit and transportation arrangements
· Educational purpose of field visit
· Provision for special needs students
· Cost
· Clothing for the visit
· Lunch arrangements
· Money needed
· visit schedule
· Whether a child will need prescribed medication administered
h. Provide alternative arrangements for pupils who will not be going on the visit .
i. Submit a list of students who will be attending the field visit to other teachers if their schedules will be affected.
j. Create a list of all student names and home phone numbers for use in an emergency.

3. Preparing Students before the visit / Field visit Preparation/Pre-visit discussion

a. Discuss the purpose of the field visit and how it relates to the current unit of study.
b. Introduce vocabulary words that will be used by field people during the tour.
c. Show photographs or posters of the field visit site or related to exhibits that will be viewed.
d. Assign students "specialists" roles in one aspect of the topic that they will be studying during the field visit .

e. Students could be grouped in different subject areas related to the field visit topic.(e.g., history, art, technology , science, environment, etc).
f. As a class brainstorm a set of standards of conduct for the visit and discuss suggested spending money, lunch plans, appropriate clothing to wear for the visit including gear for weather.
g. Discuss with students how to ask good questions and brainstorm a list of open-ended observation questions to gather information during the visit.
h. Record questions on chart paper or in student field visit journals.
i. Overview the field visit schedule.

4. Final Planning / the field visit

a. Check all permission slips the day before the field visit.
b. Plan activities that allow students to work alone, in pairs or small groups.

Activities might include:
Sketch pages with partial drawings of objects found in the exhibits for students to complete the drawings based on their observations
Peepholes in construction paper - cut different sized round holes in construction paper and have students view a part of the exhibition through the peepholes. Ask them to describe what they see, what they notice now that they missed before, and how their perspective changes with each new view
Field notebooks for recording answers to prepared questions based on clues
Hand drawn postcards to write near the end of the tour that will summarize the field visit visit
Provide time for students to observe, ask questions, and record key words, ideas and phrases as journal entries in their Field book after viewing each exhibit
Ask follow-up questions as students make observations and listen to presentations.
How are these two objects different from one another?
What clues does this artifact provide about the topic?
In what ways do these two objects relate to one another?
If you could change one thing in this exhibit, what would it be?
Pretend you are an archaeologist in the future who is observing this object. What would you be able to conclude about the culture of the past?
Describe the setting in which you might have found this object.
Which object will be of greatest value in a hundred years? Why?
Which object took the most time and effort to produce?
Pretend you are a character in this exhibit. Tell us as much as you can about your life.
What does this object tell us about the person's attitude toward...?
Schedule a particular segment of the field visit for a scavenger hunt where students look for particular objects and record them in their Field book or on an observation sheet.
Provide time for students to work in their Field Book writing questions, describing favorite displays or making sketches of artifacts, structures, scenery, etc. If they cannot complete their sketches, encourage them to label them for future completion as to color, detail, etc.

5. Post-Field visit Activities

Just as quality pre-planning is essential to the success of a field visit , planning for appropriate follow-up activities will facilitate student learning and multiply the value of hands-on experiences outside the classroom.
The following activities provide a general guide when planning for post-field visit classroom experiences.

a. Provide time for students to share general observations and reactions to field visit experiences.
b. Share specific assignments students completed while on the field visit.
c. Create a classroom bulletin board displaying materials developed or collected while on the field visit.
d. Develop a classroom museum that replicates and extends displays students observed on the field visit. For example, if the field visit involved a museum, develop a classroom museum containing student work.
e. Link field visit activities to multiple curricular areas. For example, students can develop vocabulary lists based on field visit observations; record field visit observations in a classroom journal; complete math problems related to actual field visit budget planning; etc.
f. Share and evaluate student assignments/activities from the Field Book.
g. Have the class compose and send thank-you letters to the field visit site host, school administrators and other persons that supported the field visit .
h. Include favorite objects or special information learned during the field visit.
i. Create a short news report about what happened on the field visit.
j. Publicize the visit via an article in your local newspaper, school bulletin board, visit presentation for parent's night, or school web page.

6. Evaluating the visit

Complete a "Teacher Journal" regarding the field visit . This will provide a good reference for future field visits.
What was of unique educational value in this field visit ?
Did the students meet the objectives/expectations?
Was there adequate time?
Was there adequate staff and adult supervision?
What might be done differently to make this an even better experience in the future?
What special points should be emphasized next time?
What special problems should be addressed in the future?
What would improve a visit to this site in the future?
Share the evaluation with the students, volunteers, hosts from the field visit site, and school administrators.

Significance of Science Field Visit

Every student comes to the classroom with a different world experience. We know that students who have been exposed to many different things do better in school. In order to be successful readers, students need to relate what they read to what they've experienced. To think broadly students need to have a variety of experiences.

As teachers, we know that field visits are important, but why specifically? There are a number of significant benefits.

1. Curriculum Enhancement

It enhances the curriculum. Field visits are rich in educational possibilities as students learn from actual hands-on experiences, rather than by simply reading or hearing about something. Involvement in a real world experience makes learning more meaningful and memorable compared to regular classroom instructional programs.

2. Experiential learning experiences

Give students experiential learning experiences. Involvement in a real world experience makes learning more meaningful and memorable. As a result the students will have more concept of the topic as they have learnt through their hand-on experiences.

3. Skills development

Concrete skills such as note taking. Students have to develop questions to be asked, write reports or thank you letters after the visit , or evaluate their experiences. By doing such activities, students will develop various skills such as note taking skills, speaking skills, and writing skills will enhance.

4. Memorable learning

Involvement in a real world experience makes learning more meaningful and memorable.

5. Enjoyable learning experiences

Field visits can add variety to the regular instructional program; they tend to be special and enjoyable learning experiences, ones which develop positive attitudes in students toward related classroom activities. Field visits are rich in educational possibilities because students learn from actual firsthand experiences, rather than by simply reading or hearing about something.

6. Relevance of learning

Field visits help the students appreciate the relevance and importance of what they learn in the classroom. For e.g. determining blood type is a skill, which can be learned in a school laboratory setting, but students may not learn the importance of this skill until they observe what goes on in a real hospital where life and death of real patients may depend on this skill.

7. Real World Learning

As teachers, a field visit is one of the best tools that we can use to provide every student with real-world experiences. Whether that's a visit to the local grocery store, waterfront park, a library, a museum, a theater, a community garden or a restaurant, each experience that a student participates in contributes to their understanding of the world.

8. Dissolve walls of the classroom

When students leave the classroom, they see the connections between what is happening at school and in the ‘real-world’. They begin to see that what they learn within the walls of the classroom can help them solve the problems they see in the world around them and can have a direct impact on who they become as people.

9. Access to tools and environment

Students are able to access tools and environments that are not available at school. Our communities are rich learning laboratories. Field visits make it possible to take students to see an underwater ecosystem at an aquarium, participate in citizen science in a river, use high powered microscopes, see and touch historical artifacts in person and present on a public stage among hundreds of other things. Each experience solidifies learning and supports important academic concepts.

10. Socio-emotional Growth

Students who go on field visits become more empathetic and tolerant. A study conducted by the University of Arkansas found that students that participate in a field visit to an art museum show increased empathy, tolerance and critical thinking skills. Studying art gives students a chance to think about a topic or theme from a different perspective.

11. Academic Impact

Field based learning increases test scores. A recent study by Emilyn Ruble Whitesell showed that middle school students who participate in science field visits through the Urban Advantage program score better on the state science test. Field visits and hands on learning make concepts more memorable. Just think back to what you learned in school, the field visits you took, and what you learned on them are still some of the clearest concepts.

12. Concept clearance through various media

Additionally, field visits are important because students are able to engage with content in a variety of ways. Concepts are presented through all different media and different modalities, so students who struggle with traditional learning can feel smart and confident. They are able to access the content better when they can learn holistically. When they return to school, the visit that they took can serve as a touchpoint for an entire unit.

13. Multisensory learning experience

Some of our students' worlds are so small, but the community that each child lives in is an incredible resource for broadening it. Within each student's city or region, there are people and places that students can access that cannot be replicated by the Internet or in the classroom. This multisensory learning experience can bring one dimensional lessons to life and create enthusiasm for a subject that is hard to replicate through other media. As teachers, it's our duty to make that possible.

14. Interesting

Field visits expose students to new experiences and can increase interest and engagement in science regardless of prior interest in a topic.

15. Affective gains

Field visits result in affective gains such as more positive feelings toward a topic.

16. Useful in long term

Field visits are experiences that can be recalled and useful long after a visit.

17. Real-world experience.
It allows students to have a real-world experience. For example, a textbook lesson on domestic animals can be enhanced by a visit to a local farm where the students can clearly see the domestic animals.

18. Increase in the quality of education.

For example, a biology field visit could take kids on a hunt for bugs or certain types of flowers. In this case students can learn more. Hence it improves the quality of education.

19. Improvement of social relations.

It is a way to bring the students closer together. Many field visits combine educational content with team-building activities, such as working together to clean a stream that has been polluted.

In fact, it is often a good idea to go on a field visit to help create a bond between the students.

Disadvantages of field visit

Time considerations.
Difficulty in preparation (getting approval from various heads of administration) and fitting the visit as per the school timetable which takes more time.

Lack of support from school

administrations for field visits. It means schools can't afford the materials and sometimes can't provide financial support where students have to search their own ways.

Poor student behavior and attitudes.

Means loss over students like sometimes some students don't listen to the teacher showing their ego attitudes and doing the things in their own ways which cause visits to be unsuccessful where it affects the other students and the relation between teacher and students because of the bad attitude.

Shortage of resources and choice of venue.

Sometimes schools can't provide the materials and teachers also can't have the correct materials for the visit which causes shortage of resources. And sometimes students can't have the choice to pick their own place and they have to agree with the teacher's choice which shows students don't have the choice to select the venue.

Medical risk.

For example, while travelling via vehicle some children get motion sickness.

Conclusion

Field visits are recognized as important moments in learning; a shared social experience that provides the opportunity for students to encounter and explore novel things in an authentic setting.

Field trips provide alternative educational opportunities for children and can benefit the community if they include some type of community service. Field trips also provide students the opportunity to take a break from their normal routine and experience more hands on learning. Places like zoos and nature centers often have interactive displays that allow children to touch plants or animals.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 5
LEARNING RESOURCES AND ACTIVITY

c) Improvised Apparatus and E -resources (Virtual Laboratory and Simulation)

Improvised Apparatus

Introduction

An improvised apparatus in science is an apparatus which is used as an alternative for the original equipment.

The use of improvised apparatus is an effective step taken towards reducing the cost in Integrated Science teaching. The teacher involved makes use of available materials as a substitution for lab equipment.

The importance of improvised equipment is that it helps the student to comprehend an idea behind the experiment better, also helps to overcome the issue of lack of apparatus and helps the student community to grow a constructive attitude toward science.

Meaning of improvised apparatus

The concept of improvisation has become increasingly popular in the discourse of scientific experiments.
The reason why several aspects of improvisation, in the context of sciences and everyday activities are dealt with in the study in order to address some of the philosophical and practical issues relevant to this emerging interest. It provides a forum for practicalising the theoretical knowledge gained in the classroom and for demonstrating the psychomotor skills of the teacher and learner who performed the experimentation.
Ironically however, the activity remains not appreciated by the students as many of them see Science as abstract and irrelevant to their lives due to lack of engaging classroom laboratory equipment. It cannot be overemphasized that laboratory and field work aid in the understanding of difficult concepts in the subject, creating opportunity for the testing of facts and theories in science.
Indeed, educationalists believe that
learners can achieve more if given the opportunity to improvise materials needed especially for experimentation. Obviously, it gives room for the attainment of lesson objectives, since it depends on the
availability of Science equipment for proper understanding, development and application.
As a moral responsibility, every mentor should ensure that learners learn how to choose from the myriad of readily available materials and tools through improvising laboratory apparatuses.
To be able to do this, teachers should be flexible, creative, and innovative in the classroom to turn learners into critical and creative thinkers.

Improvisation is the art of using alternative materials and resources to facilitate instruction whenever there is a lack or shortage of some specific first hand teaching aids.
It is the art of designing a replica of something to make it function or play the role of real thing using available materials.

Improvisation is the art of using alternative materials and resources due to lack or insufficiency of some specific first hand teaching aids.
According to **Ada**, improvisation is provision of materials locally made by teachers, students or even an education agency as a substitute and supplement to standard equipment.

From **Gaberial's** point of view, improvisation is the act of using materials and or equipment obtained from local personnel to enhance instruction.

Bilikisu describes it as having composed and proving instructional tools or material at hand to meet a basic need.

Eriba
Improvisation is an art of identifying,
developing and using suitable materials in the absence of the real one for effective teaching and learning of process, morphology and anatomy of
various organs.

Improvisation could mean making of instructional material or teaching aid by science teachers where the original materials are not available or
where they are available but not functional.
(Biologist from cross river state). Improvisation is the local provision of an object or material to meet a particular need (biologist from Kogi).

Improvisation is an art of sourcing for and
providing substitute materials for the original ones using what is locally available in the absence of standard materials usually aimed at meeting the specific instructional objectives.

Examples of innovative improvised apparatus-

The use of fine graduated stick as a **meter scale** ,

Use of glass cup as a **beaker**,

The moulding shapes using clay to make three dimensional **models** of plant and animal cells,

Drawing of plants and animals cells using cardboard papers,

The use of watch in place of **stop watch**, The use of stove in place of **bunsen burner,**

The use of transparent glass containers in place of **aquariums**.

Electroscopes made from plastic pet bottles, metal strings, aluminum sheets, and plastic straws can equally illustrate the same phenomenon as industrial made one.

<u>Need For Improvisation of Science Resources.</u>

Absence of those well- equipped laboratories
In an Ideal world, all science students
would be taught in small classes held in well- equipped laboratories. In absence of those well-equipped laboratories, the place of practical activities cannot be over emphasized. Improvisation helps overcome this obstacle to a certain extent.

Short supply of learning resources
The materials required for the teaching and learning of science are very much in short supply as these are a total or partial absence or inadequacy of the science teaching resources.

Inadequate finances
Gross inadequate finances most especially for the purchase of science equipment, galloping inflation using enrollment of students generally downward trend in the nation's economy, poor maintenance culture and at times attitude of some school heads towards science and science equipment for effort at making science teaching and learning.

Population explosion
The school system today is experiencing a boost in population explosion, giving size to greater demand for classroom and laboratory facilities and equipment with limited government resources, the teacher ingenuity to improvise becomes tasking for learning to be more effective and productive.

With all these heinous problems, it seem
that the best option is the improvisation of
Science teaching materials in the classroom by teachers and even students. Thus, improvisation becomes imperative in a situation where there are scarce resources and facilities .

Factors Affecting Improvisation of Science Resource Materials

It has been noted that several factors
affect the improvisation of learning resources.
Balogun identify two main constraints

militating against the successful improvisation of science equipment which he mentioned as follows:

1. **Technical Factor**

This relates to the question of degree of accuracy and precision that is possible with improvised equipment.

2. **Human Factor**

This relate to the teachers skills in
developing the resources while providing the appropriate learning experiences to the learners.

Lack of adequate professional training as a major problem militating against the effective use of local resources for science teaching.

There is need for a definite well planned training programme of improvisation for
teachers. He suggested regular meaningful workshops on improvisation techniques for science teachers to improve and update their competence.

Most at times teachers do not have
access to the resources needed to conduct science experiments.

Improvisation is the act of creating something or using something in the absence of the ideal tools, science teachers often try to teach students about scientific principles through the use of laboratory experiments, though they do not always have access to the resources needed to optimally perform experiments.

Innovative teachers can use cheaper products to stimulate experiments;
teachers can also help students to learn
improvisation as an important life skill .If the technical and the human factors are taken into consideration the process of improvisation becomes very successful.

Guide on the utilisation of Improvised apparatus as Science Resource Materials

On embarking on any improvisation in the
teaching and learning of science, certain
pedagogical consideration is necessary. Some of this consideration includes:

1. What is to be taught?

Improvised apparatus should have relevance to the lesson they are meant for. It should be prepared by considering the needs of the learners.

2. Objectives of the lesson.

The degree of sophistication of the

improvised materials will be determined by what is to be taught and the objective of the lesson.

3. The background knowledge of the
learner.

Knowledge of the learners student
academic background would provide the teacher with insight to whether the improvised materials would be appropriate to learn the task at hand or
not.

4. The durability of the improvised
materials.

It is also necessary to give consideration to the durability of the improvised materials. A durable material on a long term basis reduces cost as well as saves time and labour.

5 . The cost advantage of improvisation
materials.

In the cost advantage, it may be more beneficial to acquire an already existing cheaper factory made material than to spend time and labour to embark on the improvisation of such materials.

6. Individual Differences.

Before giving the task of preparation of improvised apparatus, teachers should take into consideration the individual difference between students.

7. Learning Environment.

Improvisation becomes imperative in situations where there are scarce resources and facilities. It should provide enriched learning experiences and create an appropriate learning environment.

8. Appropriateness of improvised apparatus to the
age of the learners.

9. Clarity of improvised apparatus in illustrations and simplification of concepts.

10. Adequacy of improvised apparatus in size.

Improvised apparatus must be appropriate in size. It should fulfil all the purposes of the original apparatus.

11. It should be-
- interesting to the learners,
- durable and
- improvisable among others.

When the desirable is not available then the available becomes the alternative if it can perform the same or similar functions as the desirable.
It should be borne in mind that resource materials do not achieve any of the attributed values on their own.
The usefulness depends on what the
the teacher makes out of them i.e. the influence made on the students by the teacher with the materials.

SIGNIFICANCE /
EDUCATIONAL IMPLICATIONS

1. **Better understanding** of concepts taught by the teacher since the students are able to see what the teacher is talking
about.

2. It will enable the teacher to have **mastery** of the subject or concept he or she wants to teach.

3. It enable the Government, and other Education stakeholders to access the level of teachers **performance** and his or her knowledge on improvisation and utilization of resources in the teaching
and learning of Science.

4. Improvised materials provide a **cognitive bridge** between abstraction and reality to students.

5. Improvisation saves **cost** and in addition the teacher and the students makes positive effort towards effective
instruction.

6. Improvisation undertaken by teacher
enable him to think and research for
- cheaper,
- better and
- faster methods

of making the teaching and learning
process easier for students.

7. Improvisation process of instructional materials makes students exposed to -
- **creativity,**

- **innovation,**
- **imagination and**
- **curiosity,**

which are essential to science teaching and learning.
Hence, improvisation should not be the prerogative of teachers only. Rather, students should also be engaged as integral parts of the process of creating improvised apparatus.

8. Learning science starts with **hands-on experiments** that the pupils are familiar with and not with abstract definitions of scientific concepts.

9. Learning by doing
Low cost apparatus from locally available materials assume to enrich the capacity to -

- **observe,**
- **explain and**
- **do real science.**

10. As students apply various facets of their intelligence for the purpose of understanding in their natural environment, they are also held accountable for their

- **observations,**
- **inferences, and**
- **conclusions.**

11. Well-designed simple or improvised apparatus of good quality will help the pupils to understand the idea behind the experiment more easily.

12. Overcome the problem of lack of apparatus.

13. Save money by using **local materials**.

14. Help pupils develop **positive attitudes** towards science.

15. Benefits if pupils construct apparatus

- acquire manual skill
- learn to apply principles of science
- supply the school laboratory with equipment.

16. The improvised apparatus provide chance of hands-on experiment and practical activities in science to -

- improve students' learning,
- help practical skills development,
- enhance problem-solving ability,
- assist analytical skills development, and
- develop a positive attitude towards science.

17. Learners achieve more when they are
allowed to **manipulate apparatus** rather than merely listening or observing teachers' ideas.

CONCLUSION

Improvisation is the act of construction of
instructional materials from locally available materials that can adequately replace or function in place of the original material which otherwise may be very expensive or in short supply or unavailable.

Improvisation therefore is not just an un pre-conceived on the spot activity, improvisation is a state of mind and it is a
skill that lies at the heart of good science
teaching.

The utilization and production of science
material resources would help to enhance the teaching and learning of Science. Teachers who are the implementers of the curriculum should engage themselves in proper utilization and improvisation of material resources used in the teaching and learning of Science.

Students are motivated and excited in creativity and use of improvised materials. Hence, in view of the shortage
of science labs in schools and the imperatives related to the implementation of the Competence Based Curriculum, teachers should use improvised apparatus in their daily teaching activities so as to improve the students' learning and achievements.

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<u>The Virtual Laboratory</u>

<u>Introduction</u>

The field of science, in its broadest contemporary sense, makes some of the most valuable contributions to the general welfare of humanity. It is not an overstatement to say that the level of
Scientific activity in a country or region can be directly correlated to the level of development and quality of life in that region or country. Indeed the widely used descriptors "first world countries" and "third world countries" are direct references to the levels of development and quality of life in these places.
Level of productive scientific activity is one of the distinguishing factors between the developed and developing countries. One of the various reasons advanced by third world countries for this difference is a lack of resources to effectively teach and train scientists in the various

disciplines. This boils down to the lack of adequate laboratory facilities. This challenge has to be addressed against a background of a proud history of incorporating the physical laboratory experience as an indispensable and integral part of teaching and training scientists. However, the capital requirements of setting up a fully equipped physical laboratory have been and continue to be a deterrent for effective science teaching and training in the developing countries. Consequently, India and many of the third world countries have, to date, continued to lag behind their first world counterparts in terms of scientific activity and quality of life. Advancements in information and communication technology have opened up real opportunities for developing nations to narrow the gap between them and the developed nations.

Meaning of Virtual Laboratory

The Virtual Laboratory is an interactive environment for creating and conducting simulated experiments: a playground for experimentation. It consists of domain-dependent simulation programs, experimental units called objects that encompass data files, tools that operate on these objects.

Definitions abound about what a virtual laboratory really is.
Captured here are some of the definitions in existence:

1. “Virtual laboratories use computers to provide highly interactive virtual reality simulations of laboratory exercises.”

2. “A virtual laboratory is one where the student interacts with an experiment or activity which is intrinsically remote from the student or which has no immediate physical reality.”

3. **Harry and Edward**
“ A laboratory experiment without a real laboratory with its walls and doors”.

4.**Scheckler**
“Virtual labs use the power of computerized models and simulations and a variety of other instructional technologies to replace face-to-face lab activities.”

5. **Babateen**
“Virtual studying and learning environment that simulates the real laboratory.”

6. “A virtual laboratory is a computer -based activity where students interact with an experimental apparatus or other activity via a computer interface.”

A distilled definition of the virtual laboratory that is consistent with the ideas advanced in all above definitions is given below:
“A virtual laboratory is a set-up consisting of computer hardware and software designed to simulate, as closely as possible, traditional physical laboratory activities for the purpose of imparting comparable knowledge and skills to learners.”

Virtual Labs will provide to the students the result of an experiment by one of the following methods (or possibly a combination). Modeling the physical phenomenon by a set of equations and carrying out simulations to yield the result of the particular experiment. This can, at-the-best, provide an approximate version of the ‘real-world’ experiment. Providing measured data for virtual lab experiments corresponding to the data previously obtained by measurements on an actual system. Remotely triggering an experiment in an actual lab and providing the student the result of the experiment through the computer interface. This would entail carrying out the actual lab experiment remotely.

Salient Features

1. Virtual Labs will be made more effective and realistic by providing additional inputs to the students like accompanying audio and video streaming of an actual lab experiment and equipment. For the ‘touch and feel’ part, the students can possibly visit an actual laboratory for a short duration.

2. Virtual laboratories are a great way for learners to practice science and engineering experiments in a safe online environment.

3. Educational Technology researchers have developed many virtual lab games and interfaces that enable learners to interact with elements and compounds to execute “reactions”.

4. A virtual laboratory is an on-screen simulator or calculator that learners use to test ideas and observe results. They allow the learner to “tinker” with laboratory equipment that behaves in almost the same way as it would in a real environment. Learners perform a series of experiments that yield authentic results. Towards the end, learners are able to generalize these results and deduce a learning objective.

5. It’s not just about science
Virtual laboratories are not limited to science and chemical reactions. Programming courses can easily employ these kinds of tools to help learners learn code. Such screens have compilers and code editors embedded in HTML pages, which enable learners to write, edit and run code easily, all within the eLearning course. Virtual laboratories in such scenarios provide more control over the learning than if the learning occurred independently.

6. Graphs and plotting papers have been used and wasted over the past decades. Learners can now plot and replot right from their web browsers to create the correct results without wasting paper! Learners simply drag and drop the dots to plot the graph on the virtual paper. This allows learners to observe the relationship between the different variables. The hints provided on the screen create an even friendlier and scaffolding learning environment.

7. Virtual laboratories in eLearning
Here nothing ever gets broken – so experiment away!

In a virtual laboratory, learners can try all kinds of experiments without the risk of damaging equipment or injuring themselves.
8. Learners can conduct experiments that are almost impossible even in the most generously funded laboratories.

Significance / Educational implications
The Benefits of the Virtual Laboratory

The benefits of using virtual laboratories vary from author to author but some of the more prominent ones are outlined below.

1. Increased accessibility of laboratory activities for students prevented by some reason from being able to access a physical laboratory. Such a limit may emanate from a student's reduced dexterity, physical disability, or geographic distance.

2. Improved safety in the case of hazardous experiments.

3. Provision of training and practice for new or high risk experiments.

4. Virtual laboratories do not suffer from the constraints of space requirements as do physical laboratories.

5. Low set-up and maintenance costs.

6. Reduced complexity in carrying out experiments using a virtual laboratory.

7. The technology-rich environment of the virtual laboratory greatly enhances the modern students' motivation.

8. Physical distances and the lack of resources make us unable to perform experiments, especially when they involve sophisticated instruments.

9. Good teachers are always a scarce resource. Web-based and video-based courses address the issue of teaching to some extent.

10. Conducting joint experiments by two participating institutions and also sharing costly resources has always been a challenge.

11. In a country such as ours, costly instruments and equipment need to be shared with fellow researchers to the extent possible.

12. Web enabled experiments can be designed for remote operation and viewing so as to enthuse curiosity and innovation into students. This would help in learning basic and advanced concepts through remote experimentation.

13. Today most equipment has a computer interface for control and data storage. It is possible to design good experiments around some of this equipment which would enhance the learning of a student.

14. Internet-based experimentation further permits use of resources – knowledge, software, and data available on the web, apart from encouraging skillful experiments being simultaneously performed at points separated in space (and possibly, time).

15. Virtual laboratories provide remote -access to Labs in various disciplines of Science and Engineering. These Virtual Labs would cater to students at the undergraduate level, post graduate level as well as to research scholars.

16. Virtual laboratories enthuse students to conduct experiments by arousing their curiosity. This would help them in learning basic and advanced concepts through remote experimentation.

17. Virtual laboratories provide a complete Learning Management System around the Virtual Labs where the students can avail the various tools for learning, including

- additional web-resources,
- video-lectures,
- animated demonstrations and
- self evaluation.

18. Virtual laboratories share costly equipment and resources, which are otherwise available to a limited number of users due to constraints on time and geographical distances.

19. Use a virtual laboratory interface instead of real laboratories. The development costs of an interactive interface that looks like a simulator are high, but once built, they are never crowded, they never blow up and they are never closed!

20. Use virtual laboratory interfaces to prepare learners to use real laboratories. As learners master simple procedures, the interface can give way to complex processes to master.

21. Virtual laboratories can also be used for abstract learning environments. Learners can play with orbits of planets, tinker with the global economy or create a cross breed between two species. Use virtual labs to simulate any level of scale, complexity or abstraction.

22. If the teaching objective deals with using a real laboratory, create a virtual version and embed it in your eLearning course. This creates a richer eLearning experience and serves as good preparation.

23. Challenge your learners' assumptions by providing them with a safe environment for discovery. This gives them room to correct their misconceptions and compare their assumptions with reality.

24. Provide lab-style assignments that instruct learners on how to use the laboratory, step by step. Also encourage exploring and manipulating for variables in an independent way.

25. Try to create a simple laboratory that can be changed and used in multiple courses. Developing a rich and interactive user interface is a tough undertaking, but reusing it will improve the quality of the other remaining courses.

26. Creating interactive scenes is the best way to go. It enables you to create responsive interfaces that work on any device, and we all know that flexibility in using different devices are one of the most important factors that create a smooth eLearning experience.

27. Virtual laboratories are usually synonymous with inquiry-based learning. Learners are exposed to critical questions and they are left to their own devices to find the answer. An interactive interface will walk the learners through the problem scenario until a solution is determined.

Think about virtual laboratories as applications of eLearning objectives. Use these best practices to decide if a learning situation requires a virtual laboratory, and implement this exciting technique into your courses to provide rich interactivity in eLearning.

Disadvantages of Virtual Laboratories

The following are some of the criticisms against the use of virtual laboratories to train scientists:

1. Students need to possess prior knowledge of computers and the internet.

2. Special hardware and networking requirements such as multimedia capabilities and high-speed servers may limit the utilization of the virtual lab concept by those who most need it e.g remote users.

3. The possibility of virtual lab software becoming obsolete fast thereby causing high replacement costs.

Conclusion

Rather than continue to fight the concept of virtual laboratories in the teaching of natural sciences, regulatory bodies need to accept it as a viable alternative to traditional physical

laboratory laborites. The accreditation process should then focus on evaluating the different virtual
laboratories that will be developed against set criteria designed to assess the virtual laboratory's resemblance to reality, flexibility for different outcomes, functionality, user friendliness and other such important criteria.

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Simulation

Introduction

Simulation has come a long way in Western countries, however in the developing world, education sectors have not adequately addressed its significance and role in preparing and updating personnel. Standardization, paucity of trainers, validation, deficiency of a structured syllabus and costs of equipment need to be overcome in the next decade. Despite these problems, worldwide acceptance of the concept of simulation is growing. It is undoubtedly the wave of the future. Multidisciplinary, Inter-professional, multimodal simulation training is possible. Virtual worlds are increasing the vistas of training, making the actual health care dispensing more skilled and safe.

Meaning of Simulation

Simulation means "An imitation of some real thing, state of affairs or a process" For the purpose of solving a problem and making a judgment. Warfare Technology and the aviation industry have made rapid strides in simulation and are the true proponents of this virtual world. In the developing world, we find there is a need to establish dedicated simulation centers to support a cluster of schools where pupils can learn without compromising the safety.

A simulation lab enables the students to learn and acquire new skills in a relatively shorter time. Students can repeat a set of actions and exercises as many times as they want. Moreover the self training module can help them to perfect their skills at a pace convenient to them even in the absence of an instructor. In the absence of such a lab, specific educational experiences may take several weeks or months to accumulate. Once simulation has produced mastery of fundamental skills, it can expose the students to different levels of difficulties, abnormalities and other problems. The system can inject variations which compel the students to think, and modify their experimental plans.

Learning is evidence based and the simulation thus provides a learner centric and yet teacher enabled environment.

The repeat attempts of the performance by the learner are mapped and the student can see for himself the progressive improvement that he/she is making. This is a morale booster.

Debriefing is a very vital component of the course and this promotes the culture of trust and openness in learning. Adverse events reporting increases as there is no fear of a blame game.

Another significant advantage of simulation is its applicability across different professions. One can tailor the course contents and the syllabus. They then can be trained to work as a team. Telemedicine can be incorporated to facilitate distant learning and preceptor concepts in health care dispensing. Real time feedback enables the learner to understand where he went wrong and the simulator can also give valid useful suggestions. Quantification of the performance and time taken to achieve the desired result can be monitored and this works like a corrective tutorial improving the student's thought process and clinical skills.
The virtual labs use a teaching method called simulation. The simulation, as defined by Dr. Ali, is an educational method that the teacher usually uses to bring students closer to the real world. The simulation method is believed to be closer to what is happening in areas that do not accept the lowest percentage of error, such as nuclear industries and some military industries.

Simulation is one of the most important methods of education and training that trainers rely on to rationalize financial costs and also to rationalize time and effort. The simulation serves many educational objectives such as "goal of acquiring skills" in an environment similar to reality, and also serves the "cognitive goal" as it helps the learner to gain a lot of knowledge about the real work environment and its requirements.

Principles of simulation

Some simulations require one hour, while others may extend over weeks. Scope and content varies greatly. However, similar principles apply to all simulations.

1. Prepare in advance as much as possible

- Ensure that students understand the procedures before beginning. Frustration can arise when too many uncertainties exist.
- Develop a student guide and put the rules in writing.
- Try to anticipate questions before they are asked. Some simulations are fast-paced, and the sense of reality is best maintained with ready responses.

2. **Know what you want to accomplish.**

Many simulations have more than one instructional goal. Developing evaluation criteria, and ensure that students are aware of the specific outcomes expected of them in advance.

3. Monitor the process closely

Teachers must monitor the simulation process to ensure that students both understand the process and benefit from it.
Ask yourself:

- Does this simulation offer an appropriate measure of realism for my group of students?
- Are the desired instructional outcomes well defined?
- Is the level of ambiguity manageable for this group?

- Does the student demonstrate an understanding of his/her role?
- Are problem-solving techniques in evidence?
- Does the research being generated match the nature of the problem?
- Is cooperation between participants in evidence?
- Has the student been able to resolve the issue satisfactorily?
- Does the student provide meaningful answers to probing questions?
- Will follow-up activities be necessary?

4. Consider what to assess
You might find it best to use simulations as part of the process of learning rather than as a summative measure of it. Use follow-up activities to establish a measure of comprehension and as a de-briefing mechanism when students return to reality (e.g. use reflection on the process as the assessable component of the activity, rather than participation in the simulation itself).

Classification of simulation programs used in virtual labs
Simulation programs are classified into two types in learning:

1- **Decision making simulation:**
One program is “What if?” This program is constructed to allow the student to choose the variable. It explains what happens to these variables in different circumstances. The student experiments with the different variables to see their impact on the results without serious risk.

2- **Process simulation:**
This type shows how any process that requires a set of steps to operate a device is completed. This type of program is highly suited to teach practical skills, especially when it is difficult to perform these skills in the first stages directly, for fear that the operating errors might cause damage to the device.

Educational implications

Simulation has the ability to teach experiments. However, prior to the study, simulation was used in rare and very serious cases only.
After the spread of computers in the mid-nineties of the twentieth century, interest in simulation as appropriate and effective in the process of education has increased. Simulation has become more effective and exciting in teaching. Simulation languages have varied and the material losses reduced adding flavor of fun to the educational process. This made the process of laying the foundations for learning some of the difficult topics that can’t be dealt with in the real world more effective.

Digital Age and Educational Systems

The tremendous technological growth we witness in various fields, including the field of e-learning, is the most important feature of the information revolution, which created a rapid

information network that led to the calibration of educational systems and study systems. These systems should help students keep up with these developments by providing them with new knowledge and skills.
The best way to do this is not only to communicate knowledge to the students, but to teach them how to become creators and innovators, and how to use new technologies to activate their ideas effectively.

Use of computer in simulation
In physical labs, many experiments usually can't be performed in real labs due to

- time,
- complexity,
- difficulty or
- hazards.

In virtual labs, these experiments are simulated. Using the computer we can conduct, study and analyze these experiments under different conditions and variables to know the results of all the conditions of the experiment without fearing material or moral cost.

Use of 3D models
Simulations are also useful in training in various fields of experimental science with the use of 3D models to meet the needs of students and researchers in various fields of science. The simulation program represents the absolute safety of users where errors are detected and processed without the risk of electronic, mechanical, or toxic substances.

Hence, virtual labs that use simulation systems in the design of the ideal reality provide the maximum benefit to the student with minimal effort and less cost to the educational institution to which the student belongs and in a completely secure and high degree of flexibility.

Critical and Evaluative Thinking.
Simulations promote the use of critical and evaluative thinking. Because they are ambiguous or open-ended, they encourage students to contemplate the implications of a scenario. The situation feels real and thus leads to more engaging interaction by learners.

Concept attainment through experiential practice.
Simulations promote concept attainment through experiential practice. They help students understand the nuances of a concept. Students often find them more deeply engaging than other activities, as they experience the activity first-hand, rather than hearing about it or seeing it.

Social development
Simulations help students appreciate more deeply the management of the environment, politics, community and culture.
For example, by participating in a resource distribution activity, students might gain an understanding of inequity in society.

Skill reinforcement
Simulations can reinforce other skills indirectly, such as Debating, a method associated with some large-scale simulations, and research skills.

Problem solving skills
In a simulation, guided by a set of parameters, students-
- undertake to solve problems,
- adapt to issues arising from their scenario and
- gain an awareness of the unique circumstances that exist within the confines of the simulation.

Common issues using simulations

Resources and time are required to develop a quality learning experience with simulations. Assessment of student learning through simulation is often more complex than with other methods.

Simulated experiences are more realistic than some other techniques and they can be so engaging and absorbing that students forget the educational purpose of the exercise.

If your simulation has an element of competition, it is important to remind the students that the goal is not to win, but to acquire knowledge and understanding.

Conclusion

Simulations are instructional scenarios where the learner is placed in a "world" defined by the teacher. They represent a reality within which students interact. The teacher controls the parameters of this "world" and uses it to achieve the desired instructional results. Students experience the reality of the scenario and gather meaning from it.

A simulation is a form of experiential learning. It is a strategy that fits well with the principles of Student-Centred and constructivist learning and teaching.

Simulations take a number of forms. They may contain elements of:
- a game
- a role-play, or
- an activity that acts as a metaphor.

Simulations are characterised by their non-linear nature and by then controlled ambiguity within which students must make decisions. The inventiveness and commitment of the participants usually determines the success of a simulation.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 6
SCIENCE TEACHER

a) **Science teacher : Need and Avenues of Professional Growth**

Introduction

Professional development refers to many types of educational experiences related to an individual's work. Doctors, lawyers, educators, accountants, engineers, and people in a wide variety of professions and businesses participate in professional development to learn and apply new knowledge and skills that will improve their performance on the job.
Many fields require members to participate in ongoing learning approved by the profession, sometimes as a requirement for keeping their jobs. Professionals often also voluntarily seek new learning.
In education, research has shown that teaching quality and school leadership are the most important factors in raising student achievement. For teachers and school and district leaders to be as effective as possible, they continually expand their knowledge and skills to implement the best educational practices. Educators learn to help students learn at the highest levels.
Many people may not be aware of their local school system's methods for improving teaching and student learning. Professional development is the only strategy school systems have to strengthen educators' performance levels. Professional development is also the only way educators can learn so that they are able to better their performance and raise student achievement.
Many misunderstandings exist about professional development, its purpose, and how it functions. This publication is an effort to answer basic questions and to inform and engage more people in strengthening the quality and improving the results of professional development.

NEED OF PROFESSIONAL DEVELOPMENT

Education is a never-ending process. It doesn't stop after earning a degree and starting a career. Through continuing education, career-minded individuals can constantly improve their skills and become more proficient at their jobs. In the field of K-12 education administration, it is particularly important for school administrators to encourage teachers to pursue professional development, not only to ensure the best learning outcomes for their students but also to be more effective and satisfied in various other aspects of their work.

Students Have Better Learning Outcomes

Educational technology, school district guidelines and curriculum standards are constantly changing, making it challenging for teachers to keep up with trends and best practices in the field. Professional development transforms teachers into better and more apt educators by enabling them to create relevant and tailored course instructions for today's students. Student' achievement can improve by as much as 21 percentile points as a result of teachers' participation in well-designed professional development programs.

Certification is one path for teachers to pursue professional development and keep up with the latest educational standards to ensure optimal student learning.

Teachers Learn Better Ways to Teach

When educators discover new teaching strategies through professional development, they are able to go back to the classroom and make changes to their lecture styles and curricula to better suit the needs of their students. However, these changes are hard to evaluate because they are typically implemented gradually. Professional development for teachers makes them more efficient in their presentations and course evaluations by exposing educators to new delivery methods, evaluation styles and record-keeping strategies.

Teachers Develop Better Organization and Planning Skills

In addition to the hours spent presenting in the classroom, much of teachers' time is spent on student evaluations, curriculum development and other paperwork. Professional development training can help teachers to become better at planning their time and staying organized. This ultimately makes teachers more efficient and gives them extra time to focus on students rather than the paperwork.

Teachers Gain Knowledge and Industry Insight

Students expect teachers to be subject matter experts for the topics they teach. This means teachers should be able to answer any question a student throws their way. Professional development programs can enable teachers to expand their knowledge base in different subject areas. The more professional development a teacher undergoes, the more knowledge and industry insight he or she gains.

Teachers Want to Continue Their Education

It's easy for teachers to become burdened by the grind of teaching. Professional development gives them an opportunity to step out of their routine — they get to be the student instead of the teacher. This keeps educators engaged because they feel like they are receiving the professional help they need to be better teachers. After all, professional development nurtures the talents of teachers who aspire to take on educational leadership positions, and teachers must learn from other experienced leaders to become effective future leaders themselves.

Competent future school administrators

Implementing professional education development has benefits for both teachers and students, but most importantly, it helps teachers become better educators and develop into competent future school administrators.

Professional development for anyone is necessary, as new teaching information, techniques, and methods are continually being updated and changed. Your education and experience alone will not be enough to serve you throughout your whole career. To revitalize your teaching career you need to take passionate action steps.

Never Stop Learning

Professional development is about life-long learning and growing as an educator. You always have the potential to progress and refine your teaching skills. There is always more to learn and new skills to attain. Professional development is important to teaching success and can help you figure out why you make certain decisions, and can help you examine the way you think about and deal with certain situations.

There are courses and seminars you can take (sometimes free, sometimes at a cost) that you can incorporate into your resume or bring up during the conversation at an interview. Your willingness to take the initiative to learn new things will impress a prospective employer. Network with like-minded professionals, engage online and in-person and find out about learning events in your area. If you’re currently employed, many employers will be happy to send you to seminars such as these on the school district’s dime.

Set Professional Development Goals

Professional development and goal setting go hand-in-hand. It can seem hard to schedule the time to devote to courses and seminars, but the extra time is worth it to become the best teacher you can be. Setting teaching career goals that are both realistic and attainable can help you achieve what you want. Goals need to be measurable by setting a timetable. It’s important for you to see how far you’ve come.

Reflect, planning, prepare, and take action are the key to moving your career forward.

Setting goals on a schedule will give you focus and a timeline.

For example, make a goal to attend a professional development talk or seminar every quarter (3 months).

Even if it's something as small as a one-hour webinar, choose a topic that you'd like to learn more about or are unfamiliar with, and document it. Take notes, absorb the information, and put your newfound knowledge to good use. Repeat until you've hit a calendar year, and then evaluate your progress.

Have you expanded your professional network as a result of your efforts?

Have you learned new information?

Are you a more well-rounded professional (and individual) than you were a year ago?

If so, consider maintaining your calendar for another year. If you've fallen behind, it may be time to reevaluate your goal or the way you're going about achieving it.

When you achieve your goal, it will give you a sense of greater accomplishment.

Professional Development Can Help Overcome Failures

Think of failures as an opportunity for improvement. If you've had past failures in your classroom, for example with classroom management, these issues can be hard to overcome. Through professional development, it is possible to learn how to overcome these challenges. Embrace career transformation goals by taking the steps necessary.

Professional development for a teacher is about improving and moving forward.

Taking these courses is how you learn to overcome the challenges you are facing in the classroom. It is about acquiring new skills and becoming a better teacher. You will gain confidence by learning new methods and information about your field.

Enrich and update teachers' knowledge in their discipline, pedagogy and other areas of school curriculum continuously.

Develop a culture of **shared learning** and accountability such that teachers are not mere recipients of training conceptualised in a top down manner but are engaged with the task to develop their own and the group's knowledge.
3. Evolve a mechanism by which effective programmes of teacher professional development can be initiated for large number of teachers in

vastly different areas and to deal with a range of diverse learners for inclusive education.

Research and reflect on the gaps in students' learning and their progress

Understand and update their knowledge on **social issues**

Apply **Information Communication Technology (ICT) in their classrooms** for better student learning.

Motivate and regenerate enthusiasm of teachers to inculcate interest in innovations.

AVENUES OF PROFESSIONAL GROWTH

It takes a lot of hard work and dedication to be an effective science teacher. Like other careers, there are those who are more natural at it than others. Even those with the most natural teaching ability must put in the time necessary to cultivate their innate talent. Personal growth and development is a critical component that all the science teachers must embrace in order to maximize their potential.

There are several different ways that a teacher can enhance their personal growth and development. Most teachers will use a combination of these methods to solicit valuable feedback and information that will guide their teaching career. Some teachers may prefer one method over another, but each of the following has been proven to be valuable in their overall development as a teacher.

Advanced Degree

Earning an advanced degree in an area within education is a fantastic way to gain a fresh perspective. It is also an excellent way to learn about the newest educational trends. It provides tremendous networking opportunities, can lead to a pay increase, and allows you to specialize in an area where you may have more interest. Going this route is not for everyone. It can be time-consuming, costly, and sometimes overwhelming as you try to balance the other aspects of your life with those of earning a degree. You must be organized, self-motivated, and adept at multitasking to use this as a successful way to improve yourself as a teacher.

Advice/Evaluations from Administrators

Administrators by nature should be excellent resources of advice for teachers. Teachers should not be afraid to seek help from an administrator. It is essential that administrators are accessible for teachers when they need something. Administrators are typically experienced teachers themselves who should be able to provide a wealth of information. Administrators, through teacher evaluations, are able to observe a teacher, identify strengths and weaknesses, and offer suggestions that when followed will lead to improvement. The evaluation process provides natural collaboration where the teacher and administrator can ask questions, exchange ideas, and offer suggestions for improvement.

Experience

Experience is perhaps the greatest teacher. No amount of training can truly prepare you for the adversity that a teacher can face in the real world. First year teachers often wonder what they have gotten themselves into over the course of that first year. It can be frustrating and disheartening, but it does become easier. A classroom is a laboratory and teachers are chemists constantly tinkering, experimenting, and mixing things up until they find the right combination that works for them. Each day and year brings about new challenges, but experience allows us to adapt quickly and make changes ensuring that things continue to operate efficiently.

Journaling

Journaling can provide valuable learning opportunities through self-reflection. It allows you to capture moments in your teaching career that may be beneficial to reference at other points along the way. Journaling does not have to take a lot of your time. 10-15 minutes a day can provide you with a lot of valuable information. Learning opportunities arise almost daily, and journaling allows you to encapsulate these moments, reflect on them at a later time, and make adjustments that can help you become a better teacher.

Literature

There is an overabundance of books and periodicals dedicated to teachers. You can find a plethora of terrific books and periodicals to help improve in any area you may struggle with as a teacher. You can also find several books and periodicals that are inspirational and motivational in nature. There are excellent content driven books and periodicals that can challenge how you teach critical concepts. You will probably not agree with every facet of every book or periodical, but most offer sensational tidbits that we can apply to ourselves and to our classrooms. Asking other teachers, talking to administrators, or doing a quick online search can provide you with a good list of must-read literature.

Mentoring Program

Mentoring can be an invaluable tool for professional growth and development. Every young teacher should be paired with a veteran teacher. This relationship can prove to be beneficial for both teachers so long as both sides keep an open mind. Young teachers can lean on a veteran teacher’s experience and knowledge while veteran teachers can gain a fresh perspective and insight into the newest educational trends. A mentoring program provides teachers with a natural support system where they are able to seek feedback and guidance, exchange ideas, and vent at times.

Professional Development Workshops/Conferences

Professional development is a mandatory component of being a teacher. Every state requires teachers to earn a certain number of professional development hours each year. Great professional development can be critical to the overall development of a teacher. Teachers are presented with professional development opportunities covering varying topics throughout the course of each year. Great teachers recognize their weaknesses and attend professional development workshops/conferences to improve these areas.
Many teachers commit a portion of their summer to attending professional development workshops/conferences. Workshops/conferences also provide teachers with invaluable networking opportunities that can further enhance their overall growth and improvement.

Social Media

Technology is changing the face of education inside and outside of the classroom. Never before have teachers been able to make the global connections that they are able to make now. Social media such as Twitter, Facebook, Google +, and Pinterest have created a global exchange of ideas and best practices amongst teachers. Personal Learning Networks (PLN) are providing teachers with a new avenue for personal growth and development. These connections provide teachers with a vast array of knowledge and information from other professionals across the globe. Teachers struggling in a particular area are able to ask their PLN for advice. They quickly receive responses with valuable information they can use for improvement.

Teacher-Teacher Observations

Observations should be a two-way street. Doing the observing and being observed are equally valuable learning tools. Teachers should be open to allowing other teachers in their classroom on a regular basis. It is necessary to note that this will not work if either teacher is egotistical or easily offended. Every teacher is different. They all have their individual strengths and weaknesses. During observations, the observing teacher is able to take notes detailing the other teacher’s strengths and weaknesses.
Later they can sit down together and discuss the observation. This provides a collaborative opportunity for both teachers to grow and improve.

The Internet

The Internet provides unlimited resources to teachers with the click of a mouse. There are millions of lesson plans, activities, and information available online for teachers. Sometimes you have to filter everything to find the highest quality content, but search long enough and you will find what you are looking for. This instant access to resources and content makes teachers better. With the Internet, there is no excuse for failing to provide your students with the highest quality lessons. If you need a supplemental activity for a particular concept, you can likely find it quickly. Sites like YouTube, Teachers Pay Teachers, and Teaching Channel offer quality educational content that can improve teachers and their classrooms.

Conclusion

Teaching is a profession. It is seen as the noblest profession around the world. It is the career that receives highest respect in society. Teachers prefer to be identified by their profession. The points of reason for seeing teaching as a profession.

Dr. A P J Abdul Kalam, former president of India has quoted that, “We request that teachers do two things, first let them think about developing India in their own ways & enthuse the students, secondly they should update their own knowledge, because the student is only as good as the teacher. Let them constantly try to upgrade their skills so that they can enthuse the children to think big.”
Professionalism in teacher education is the key factor to improve the quality of education. Teaching is a noble profession which lays the foundation for preparing the individual for all other professions.

Professional development for a teacher is important for both new teachers and veteran teachers. Life-long learning will keep you motivated and thinking positively and will help you gain the confidence to overcome any obstacles you face in the classroom. Professional development is about becoming the best-equipped teacher you can be, and so it should be an important part of your career development.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 6
Science teacher

b) Science Laboratory - Planning and maintenance, Laboratory Method.

Science Laboratory - Planning

Introduction

There was a time when science laboratories were planned and built as stand alone facilities, with science encompassing a range of activities from general science to specialist physics and chemistry. Now there are new ways of thinking in which science is seen to link into the school's total curriculum, and sometimes to go beyond the school into the workplace. Science is now seen to link to technology, to the creative arts (art and graphic design) to health and personal development (including home economics and life skills) and to workplace training. Synergies between components of the curriculum and also between places for learning -- schools, higher education and workplace -- are changing the ways in which facilities are planned. An emphasis on student centred learning through discovery and experimentation, teamwork and cooperative learning as well as greater emphasis on environmental issues and on occupational health, safety and welfare is reshaping the internal environment and the management arrangements. Changes now being accommodated include linking studies in physics to work being done in technology,
e.g. using computer modelling to plan and trial a project before actually constructing it from materials.
Another change involves testing and analysing chemicals and substances, and then linking this to commercial applications in the workplace -- in paint production, in food production and in management of environmental waste.
Schools have the opportunity to respond to new demands from industry where there is a need to train people in laboratory procedures for basic testing, including management and oversight of technology used for routine testing and recording of results. Also as workplaces are required to comply with legislated
standards, higher order skills in occupational health, safety and welfare are required and training is essential.

Following aspects should be taken care of while planning a science laboratory.

Size of laboratory

If all the laboratories in a suite are the same size, there should be few constraints on timetabling them. You can enhance flexibility if all the laboratories can accommodate the likely maximum class size.
The size and shape of any existing laboratories will vary, but in general spaces of 85 m are suitable for a maximum group size of 30 learners. However, in some situations, for example where a school has small class sizes, it may be appropriate to provide some small specialist laboratories.
The size of a new laboratory will depend on the maximum group size expected rather than the calculated average. You will also need to think about the range of activities being undertaken and the amount of storage available in the laboratory.

Other teaching areas

Extra teaching areas can be valuable additions to the science suite where space allows, for example a small resources area. This space can provide a focus for the department, with displays of learners' work and a poster area illustrating new scientific developments. Common resources such as books and computers or laptops can also be kept here, avoiding duplication in each laboratory.

Preparation and storage areas

Preparation and storage areas of around 0.5 m per learner is needed to support the teaching. Where the laboratories are dispersed or on two floors, this figure may need to be increased to allow for some duplication of resources.
A shared staff office can be useful for meetings and preparation work, as well as the secure storage of paperwork such as learners' records and coursework.

Planning principles

There are two main types of arrangement:
1. linear
2. grouped around a central preparation room.
These arrangements are based on a number of principles that aim to make the best use of the space available:

• Laboratories are grouped together on one or two floors to allow common resources to be shared and safer transportation of equipment.

• There is only one preparation area for each floor of laboratories. This provides a more economical use of space, equipment and technicians' time. If a preparation room is centrally positioned, distances to the laboratories are minimised.

• Other teaching areas are located for ease of access. The resource area or 'staff base area' is located to provide a focus for the department and to be easily accessed by the whole suite.

• The planned arrangement must allow for an exit door from each laboratory to the outside, if on the ground floor.

1. Linear

Where the number of laboratories is small (fewer than about six), a linear plan is suitable; the laboratories and other areas are close enough to give the science department a distinct identity. Staff can also easily reach all the working areas. With more than about seven laboratories, the distance between the preparation room and some of the laboratories makes the transfer of apparatus much more difficult.
Linear plan layout may be modified with laboratories on more than one floor.

There may, however, be extra expenditure involved, for example you may need to install a lift or hoist for heavy items. Some resources may also have to be duplicated to avoid moving heavy or sensitive apparatus up and down stairs. Extra storage and resource areas may be needed.

2. Central preparation room

Locating the preparation room in the centre of the laboratory suite is suitable for schools with a larger number of laboratories. It is convenient for the technicians because the preparation room is central to the suite. Levels of natural light and views from the room, however, will be restricted.
This plan may be modified with the laboratories around a central courtyard. This requires a greater area than the plan shown above, and there will be greater distances from the preparation room to some of the laboratories.
The disadvantage of the above plan is reduced, and the courtyard may be suitable for some practical activities.

A well-designed laboratory should be able to accommodate a wide range of scientific activities. The size of the space, the method of distributing services (gas and water) and the choice of furniture systems will all affect the way in which it can be used.

Activities in the laboratory

Modern science courses place a much greater emphasis on practical work. The range of activities involved in these courses is diverse and will affect the way in which the laboratory is designed. Some of these activities are:
- teacher demonstration of experiments
- use of ICT and video
- learners' experimental work and investigations
- discussion and note-taking
- display.

Demonstration

Despite the increasing emphasis on learners' own practical activity, do not underestimate the use of the teacher demonstration of an experiment (real or simulated). Learners may need to group more closely around the teacher's bench or another area of the laboratory, such as the fume cupboard.

Use of ICT and video

You may have access to an interactive whiteboard, laptops, personal computers (PCs), tablet devices (for example, iPads) or videos/DVDs to illustrate particular aspects of the curriculum. Ethernet/wireless connection to the school network might also be preferable.

Make sure that the laboratory design allows learners to easily see screens without unwanted reflection.
Learners may also need to use PCs to access information from CD-ROMs or for use with data-logging equipment. A video-projector may be useful for class demonstrations.

Learners' experimental work and investigations

In many science courses, practical work can take a variety of forms, with learners working individually or in groups of different sizes.
It is essential that the laboratory provides sufficient space for learners to work safely, with access to the full range of appropriate resources. These may be fairly basic, such as Bunsen burners, tripods and mats, but will also include the necessary services. Investigations will often require practical work in more than one session. In this case, adequate space must be provided to store apparatus between sessions, while still allowing the laboratory to be used for other classes.

Discussion and note-taking

These activities can include writing up experiments, class discussion and learner presentations, perhaps using an interactive whiteboard, overhead projector (OHP), video/DVD or tablet devices (for example, iPads). For these activities you may need to reconfigure the furniture to allow for some group work.

Display

The science department and individual laboratories can be made much more interesting if well-mounted displays, perhaps of commercially produced posters or, better, learners' own work, fill the empty spaces on the walls. It is worth investing in a good pin board, painting it and screwing it to the wall.

The size and shape of the laboratory

A laboratory of 85 sq. m is a suitable size for a group of 30 secondary school learners undertaking both practical and theory work. This size of laboratory will allow for enough local storage of basic items,provided that there is adequate central storage.
You may need to allow for more storage if the central store is small or inconveniently located. Smaller spaces may restrict your choice of apparatus, and safety considerations may also become more significant.
A laboratory of less than 70 sq. m may only be useful for smaller groups of secondary school learners, or for sixth form groups. Space should also be allowed for the safe storage of learners' belongings, such as bags and coats.
The shape of the space is almost as important as its size. A simple rectangular shape allows for a flexible layout and good learner supervision.

Rooms that are too long and narrow are difficult to arrange. For example, if the teacher's bench and board are on the short side of the room the learners furthest away may have difficulty seeing the board and hearing the teacher.

Planning guidelines

• A work surface area of at least 0.3 sq. m is allowed for each learner.

• Each learner has good access to a full range of services, with a minimum of one gas tap (or portable Bunsen burners) and one socket outlet per two learners, and one sink per six learners.

• Learners face the teacher and the whiteboard whenever possible. Alternatively, learners should be seated around the teacher.

• For safety reasons, the fume cupboard should be positioned away from the fire exit or main circulation routes, but should have good access for groups of learners during demonstrations.

• Where possible, the main teaching wall is placed at 90° to the external wall, to allow good side lighting and to avoid direct glare from the window.

• A computer position is provided close to the teacher to enable supervision, and to maximise the potential of shared learner/teacher use.

• By placing the monitor screen at 90° to the window, problems of glare will be minimised.

• Storage of about 5 sq.m is provided for local resources and display, and is concentrated above and below the perimeter benching. There is a separate preparation area.

• There is adequate floor space at the perimeter for additional mobile storage units such as a general-purpose trolley.

• A clear area is provided to allow learners to gather for briefing sessions and the safe demonstration of fume cupboard experiments. It is important to consider each learner's ability to see and hear the teacher clearly.

• A clear floor length of around 3 m is allowed within the circulation route for runway experiments.

• An adjustable table for a wheelchair user positioned with a direct view of the whiteboard and near the door is preferable.

• A coat rack and bag storage area should be positioned away from the work areas.
It is important to allow adequate distances between furniture and equipment in laboratories. This will allow learners and staff to move around safely, especially during practical sessions.

Services distribution

There are three main options for the distribution of services within a laboratory:

1. Overhead
2. Underfloor
3. Perimeter.

Within each option there are variations, and sometimes two systems may be combined.

1. Overhead

In this option, services are distributed from a high level, for example through trunking attached to the ceiling or running above a false ceiling. Services are delivered to the benches by cables and pipes.
Drainage is provided by the usual gravity method.
This system has advantages in that benches or islands can be serviced in a flexible manner – this has consequences for the arrangement of furniture. Maintenance is relatively straightforward.
However, the connections from the ceiling to the benches may appear untidy and obstruct the line of sight for some learners. The connections themselves may not be robust.

2. Underfloor

In this option, services may either be run in ducts set into the floor with varying degrees of accessibility or they may be located in the ceiling void of the room below. Services reach bench-top level via rigid or flexible connections, usually encased within furniture.
The advantages of an underfloor system are that most arrangements of benches can be serviced easily and the pipes and cables are all concealed. On the negative side, care should be taken to make sure that water services and electricity supplies are separated. Also, it may prove difficult to rearrange the furniture in the future if the service outlets are fixed.
If this kind of system is used, it is essential that access to the service ducts is as easy as possible.
You should not need to dismantle a bench in order to gain access to a duct to add another electrical socket.

3. Perimeter

Perimeter service ducts are usually located at bench level (or just below it) with drainage at a low level. In this system, the service ducts are accessible yet discreet and the laboratory looks tidy. Modifications are reasonably easy to implement, but there are restrictions on the servicing of island workstations, which may require extra spurs.

Health, safety and environmental issues

It is important that all relevant health and safety procedures are followed. This requires employers to prevent or control exposure to hazardous substances at work to prevent ill health. Full consideration must be given to any national or local regulations.

Schools and colleges can receive guidance on storing and handling chemicals. This guidance is aimed at both meeting the legislative requirements and promoting good practice. It is also there to build on other guidance to improve the security and storage of hazardous chemicals.

Schools must keep an accurate inventory, and list approximate quantities of chemicals in stock and their location, as well as confirmation that they are stored appropriately. This will make sure that all chemicals can be accounted for at all times.

Teachers should perform a risk assessment for all practical activities. This normally involves noting any hazards and precautions in the lesson plan before starting the practical, highlighting any risks to learners and any special disposal requirements.

Some schools assign a risk assessment level to all practical experiments based on a three-level scale from level 1 (lowest hazard rating) to level 3 (highest hazard rating). Learners would normally perform level 1 and 2 practicals, while level 3 practicals will be teacher demonstrations, normally carried out in a fume cupboard.

Teachers also need training so that they are aware of the location of main electrical switches, gas and water stopcocks, first aid kits, chemical-spill kits etc.

Supply staff and teachers providing cover for absent teachers must also be briefed on the locations of these controls. We strongly advise that non-science specialists should not be allowed to teach in laboratories on a regular basis.

The following checklist may be useful when considering health, safety and environmental issues.

Ventilation

Science laboratories must be designed to provide adequate ventilation, both for occupants and to dilute fumes and water vapour generated.

In most laboratories and preparation rooms some form of mechanical ventilation, such as a fume cupboard, will be required some of the time. This will help deal with the pollution loads, heat gain and water vapour produced by Bunsen burners.

Some questions to ask are:

- Is adequate ventilation provided with the windows and ducts that are available?
- Is the extraction system for the fume cupboard adequate, and does it discharge at a legal height?
- Is there an adequate source of fresh incoming air when the fume cupboard is switched on?
- Particularly in chemistry laboratories, is there sufficient ventilation to cope with all the learners doing chemical experiments at the same time?

You may need to consult local health and safety advisors for assistance in answering such questions.

Lighting

This aspect of laboratory design needs careful attention. A good general level of luminance (e.g. 300 lux) is recommended for all teaching.
Laboratories will usually need window blinds to significantly reduce daylight in the room.

Some questions to ask are:
• Is the lighting system flexible enough for the full range of activities that take place in the laboratory?
• Is extra lighting available at each workstation?
• Is the lighting system designed to minimise the effects of glare and reflection of boards, screens and benches?
• Can light levels be reduced to allow optics experiments to be carried out with ease?
One laboratory may need black-out facilities for light experiments; a dimming facility is also useful, which can provide enough light to allow learners to read instructions and record readings, with the main lights off and the blinds drawn.

Heating and air conditioning

Another important consideration is that of the working temperature in the laboratory. Local regulations may prescribe a certain range of temperatures in the workplace.

Some questions to ask are:
• Can the laboratory be heated easily?
• Are radiators so enclosed that convection is restricted?
• Is the air conditioning system adequate to cool down the laboratory if the temperature rises during long experiments involving heating?

Water

Each laboratory should have a manual shut-off valve for its water supply. Easy access to sink waste traps should be included at each sink. Also consider the insulation of water pipes.

Electricity

All installations should comply with the latest local legislation.
Some questions to ask are:
• Is the system correctly wired and protected?
• Are all electrical items earthed properly?
• Is portable electrical equipment inspected and tested at intervals in line with current best practice and recommendations from the government or local authorities responsible for health and safety issues?
• Is a residual current device (RCD) used to protect the supply in each laboratory?
• Is this device easily accessible to the teacher, for example near the main entrance?

It may be appropriate to include extra electrical switching. For example, a single switch at the teacher's desk may control a ring supplying all the low-voltage power supplies to the laboratory, so assisting in the control of experimental work. As with the installation and safe use of fume cupboards, you may
decide to seek local advice.

Gas

Each laboratory with piped gas should have a manual shut-off valve at the pipe entry to the laboratory.
An automatic shut-off system can be used – this is activated in the event of a gas leak if the manual valve is not easily accessible.
Gas pipes should be installed in accordance with local legislation. If gas bottles/ cylinders are used, these should be fitted in a secure cage outside the building.
The use of portable Bunsen burners is acceptable as long as safe storage is provided.
The use of spirit burners as a replacement for Bunsen burners is not acceptable as the temperature generated is insufficient for many experiments.

Fire

Local building and fire regulations must be consulted so that extra exits are provided if necessary.
Suitable fire extinguishers and fire blankets should be provided in every laboratory and preparation room.
Two 2 kg carbon dioxide extinguishers should be provided in each laboratory in addition to a fire blanket in a suitable container.
Fire equipment inspections should be carried out in line with the local authority recommendations.

First aid

A first aid kit should be stored in the laboratory and it should be easily accessible. This should include a dedicated system for washing eyes. See Appendix A. Eye goggles should be provided for every student.

General

Accidents do occur but fortunately the majority are relatively minor. The most common injuries to pupils are minor burns (the picking up of a hot tripod for example) and skin contact with caustic chemicals.
These injuries can often be dealt with on the spot by irrigating the damaged area with cold water; a sympathetic approach is always beneficial in these cases. See below for simple first aid advice.

Procedure for accidents

• If there is an accident (injury, damage to equipment or spillage), assess the situation.

• If you feel that you can deal with it yourself then do so.

• Otherwise, stop the lesson and seek assistance from a colleague (you may need to contact the school first aid representative).

Emergencies

• **Fire**: In case of fire, follow the normal school procedures (display details in each lab). All staff must know how to deal with the situation when there is clothing on fire.

• **Serious injury**: If you suspect a serious injury you should stop the lesson immediately, initiate any simple first aid measures and contact the school first aid representative without delay.

Immediate remedial measures

This details the remedial measures that staff may carry out while waiting for first aid or professional remedial treatment. The following advice covers common laboratory accidents.

Chemical splashes in the eye

Immediately wash the eye under running water from a tap for at least 10 minutes. The flow should be slow and eyelids should be held back. Afterwards, take the casualty to the school first aid representative.

Chemical splashes on the skin

Wash the skin for 5 minutes or until all traces of the chemical have disappeared. Remove clothing as necessary. If the chemical adheres to the skin, wash gently with soap.

Chemicals in the mouth, perhaps swallowed

Do no more than wash out the casualty's mouth with water. After any treatment take the casualty to the school first aid representative. Do not make any attempt to apply an antidote.

Burns

Cool the burn under gently running water until first aid arrives. The casualty should then go to the school first aid representative.

Toxic gas

Sit the casualty down in the fresh air.

Hair on fire
Smother fire with a damp cloth.

Clothing on fire
Smother fire by pushing the casualty to the ground, flames underneath. Spread a thick cloth or garment on top if necessary. A fire blanket is ideal in labs but only used if very close by.

Electric shock

Take care for your own safety. Break contact by switching off or pulling out the plug. If you need to move the casualty clear while the supply is still on, use a broom handle or some such implement, or wear rubber gloves.

Bad cuts

There are gloves in all first aid kits; wear these. Apply pressure on or as close to the cut as possible, using fingers or a pad of cloth. Leave any embedded large bodies and press around them. Lower the casualty to a chair or the floor and raise the wound as high as possible.

Splinters

These are best removed by the school first aid representative.

Service ducts, cables and pipes

It is important that all the ducts are easily accessible and well ventilated, especially those carrying gas pipes. All cables and pipes need to be well supported or fixed to the walls, especially where the servicing system is flexible. You must follow electrical earthing regulations.

Flooring

Safety is the key consideration when choosing a floor surface. Old wooden floors must be sealed. Vinyl that is resistant to most chemicals and slip resistant is often a good choice. The number of joints in the flooring material should be kept to a minimum.

Benching

Badly stained benching can make a new laboratory look very unkempt very quickly, so it is worth choosing a material that will not mark easily.
Iroko wood, ideally from sustainable sources, is a good option, but it must be sealed and well maintained. Some synthetic materials, such as cast epoxy resin, are also suitable.

900 mm is generally considered a suitable height for a laboratory work surface. A working depth of 600 mm for benching and tables is recommended.
Stools should correspond to the height of the worktop. A measurement of 240–270 mm from the top of the stool to the underside of the worktop allows sufficient clearance for the learner to sit comfortably.

The preparation room

The traditional design of science laboratories often includes separate preparation rooms for physics, chemistry and biology. While this has advantages, it does not always provide for the best use of technician time and resources, or allow for the best use of apparatus. A central preparation room can provide a better solution in many cases.
The preparation room can serve two main purposes: as the main storage area and as a workroom for the technicians. There are generally five main zones of activity in a prep room:
1. main storage
2. cleaning, dispensing and preparation
3. trolley park
4. clean working area
5. chemical storage.

The preparation room may also need to accommodate an autoclave, a distillation unit, a fume cupboard and a secure store for any radioactive materials. A fridge can be useful for storing ice.
The preparation room should also be equipped to allow for simple construction work in wood or metal and also for electrical repairs and soldering.
Assuming that there is virtually no apparatus storage in the laboratories, a floor area of 0.5 sq. m per learner can be taken as a guide to the size of the preparation room required.
The preparation room in a school for 11 to 14 year olds only will be simpler than the room(s) described in this section. It will probably serve only one or two laboratories, but it may also be used to prepare trolleys of equipment for teaching younger learners in their normal classrooms. You must consider local needs when planning the preparation room.

The main storage area

The main storage area is best located in one place, preferably alongside the preparation and cleaning area. Equipment used frequently by all learners (such as tripods, Bunsen burners and goggles) is usually kept in the laboratory.
All other equipment is best kept centrally in the main storage area, where it can be checked regularly by a technician. Storage may be in the form of free- standing timber or metal racks providing flexible storage systems, which can be rearranged to suit the available space. An alternative method of bulk storage is the rolling unit system sometimes seen in libraries. This system is economical in its use of space, but is expensive.
Storage systems need careful thought so that new staff can find items easily. One way is to number each shelf and add this location to the inventory.

Small items, such as lenses, can easily go missing. The simplest way to prevent this is to construct boxes with exactly 16 slots, one for each of the 16 lenses, so that the teacher can easily check apparatus at the end of the lesson.
Technicians need to be warned never to put out incomplete sets of equipment. The same method can be used for the storage of compasses, screwdrivers, protractors, hand lenses and so on. Although this is time consuming to start with, the effort is worthwhile.

The working area

This is where glassware is washed and equipment sorted after being returned on trolleys from lessons.
In addition, practical experiments are prepared and small items of equipment are repaired in the working area.

Bench space needs to be provided to allow for:
• washing glassware
• drainage
• dispensing chemicals
• repairing apparatus
• constructing new apparatus.
The benching must be fully serviced with sinks, water, gas and electricity, paying due attention to health and safety, and to wiring regulations.
The preparation room should have shut-off valves/switches for electricity, gas and water services, in addition to a first aid kit and a variety of chemical-spill kits.

The trolley park

The easiest way to move apparatus between laboratories is to use trolleys. As a guide, there should be two trolleys for each laboratory: one in use in the laboratory and one in the preparation room. There must be enough space to park the maximum number of trolleys and to allow circulation alongside. The best location for the parking area is between the main storage area and the working area.

Clean working area

You will need shelving and desk space for books, CD-ROMs, DVDs, videos and other resources. You may also wish to provide a computer.

Chemicals storage

It is important that all local regulations are strictly adhered to in this critical area of safety. Heads of science need to undertake regular reviews to make sure that, for example, prohibited substances are not being stored and that excess stocks are not being held. The store should be secure to prevent unauthorised access.

Bulk supplies are usually stored in the school grounds away from the laboratory complex, and away from areas frequented by learners. Then, only smaller quantities need to be kept in the preparation room, accessible to teachers and technicians only.
The chemical store must be well ventilated to the outside air, either by natural means or by mechanical extraction; full air conditioning is not necessary. The store requires protection from frost, and the door should open outwards. The flooring material should be impervious to chemicals.
Pressurised gas cylinders should be stored vertically, unless specifically designed to be used otherwise. Any storage area should be a secure, dry, safe place on a flat surface in the open air. If this is not reasonably practicable, store in an adequately ventilated area. Storage should always be in accordance with local regulations.

Shelves are best made of wood in case of leaks, and corrosive chemicals should be kept on the lowest shelves, at, or close to, ground level. Deep shelves can allow materials to become hidden at the back.
High shelves (e.g. above shoulder level) should be avoided because there is a safety risk associated with lifting heavy bottles down from them.
In the preparation room, it is essential to have a locked cupboard for toxic chemicals and a fireproof cabinet for flammable liquids. The latter should be designed so that no chemicals will leak from the cabinet, even if all the contents are spilt.
It is important to keep an accurate inventory list and details of approximate quantities of chemicals in stock and their location. This will ensure that all chemicals can be accounted for at all times.

Fume cupboards

The use of a fume cupboard is required for schools offering a chemistry based subject. Fume cupboards may be either fixed or mobile.
The main advantages of a mobile fume cupboard are ease of access and visibility for demonstration purposes, and economy of use, because one unit can be shared between a number of laboratories.
Mobile fume cupboards may be either ducted or recirculatory in nature.

• The ducted type must be attached to a fixed extraction system, whereas the recirculatory type (a self-contained unit) can be used anywhere, which is particularly useful in conversion schemes.

• Recirculatory fume cupboards contain filters that need to be changed at regular intervals. There may be a legal requirement to test them for saturation. You may need to seek independent advice regarding this and other maintenance matters.
To ensure flexibility, the overall size of a mobile fume cupboard may need to be checked against door opening sizes. You can find information on the types of fume cupboard available by searching online.
It is important to adhere to local regulations regarding the use of fume cupboards.

Radioactive materials

The teaching of most combined science, co-ordinated science and physics courses is enhanced by demonstrations using radioactive sources. As with chemicals, it is essential to comply with all local regulations; in some areas it may not be possible to obtain such sources for school work. The sources need to be stored in a locked, labelled cupboard away from any area regularly used by the same people. It is not a good idea, for example, to place this cupboard in the preparation room above the technician's workbench. Control access to the cupboard and its keys, and keep a log of all movements of the radioactive sources. The sources need careful maintenance and all staff need careful training in their use.

Recommended first aid equipment

First aid boxes and travelling first aid kits should contain a sufficient quantity of suitable first aid materials and nothing else.
Replenish the contents of the boxes and kits as soon as possible after use so there is always an adequate supply of all materials. Items should not be used after the expiry date shown on packets.
You must therefore check first aid equipment frequently to make sure there are sufficient quantities of items and that all are usable.
Keep the first aid equipment in a labelled, dust-proof, damp-proof container, which is used exclusively and specifically for the purpose of first aid in the workplace.
The standard first aid box should contain only the following materials:

- a card giving general first aid guidance
- sterile (unmedicated) dressings of various sizes (e.g. six 12 cm x 12 cm and two 18 cm x 18 cm dressings)
- individually wrapped adhesive dressings (minimum of 20)
- two sterile eye pads, preferably with attachments
- a minimum of four individually wrapped triangular bandages
- six safety pins
- several pairs of disposable gloves.

The quantities of each type of first aid material will depend upon the workplace and number of students and staff.

Important advice
In places where mains water is not readily available for eye irrigation, sterile water or sterile normal saline (0.9 per cent) in sealed, disposable containers should be provided. Each container should contain at least 300 ml and should not be re-used once the seal is broken. At least 900 ml should be available.
Sterile first aid dressings should be packaged to allow the user to apply the dressing without touching

the part which is to come into direct contact with the wound. This part should be absorbent. There should be a bandage or other fixture attached to the dressings – there is therefore no reason to keep
scissors in the first aid box. Dressings, including adhesive ones, should be of a design and type appropriate for their use.

Supplementary equipment

Disposable gloves, aprons and suitable protective equipment should be provided near the first aid materials and should be properly stored and checked regularly to make sure that they remain in good condition.
Plastic disposable bags should be provided for soiled or used first aid dressings. Used dressings must be safely disposed of in sealed bags in accordance with any local regulations. Sharps bins are a good way of safely disposing of broken glassware, needles and scalpels, and may be a legal requirement in some countries.

Conclusion
When planning school science laboratories the planners and designers need to address long-term educational and structural implications. To do so, they must look carefully at the educational, environment and physical sustainability of their designs.
The team must work out whether the planning takes into account current ways of managing the school's science curriculum and whether the proposed plans will meet the needs of the curriculum and match ways in which students learn (team work, collaborative learning, self directed research). Planners and designers must ensure that the plans reflect current and future thinking rather than replicating past practices without questioning their current validity.

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Maintenance of science laboratory

Introduction

Whether you're looking to stay within your budgets or you're hoping to ensure that experiments run effectively and without a hitch, your first step should always be the laboratory and equipment maintenance.

Without a spotless laboratory in which to work, the risk of cross-contamination is likely making good housekeeping almost as important to your work as the study itself. And, the benefits of good laboratory maintenance don't end there. Equipment is often one of the biggest outlays in a lab so taking adequate care of what you have (therefore preventing unnecessary re-purchases) is an added bonus.

Laboratory Maintenance includes.

Developing standard operating procedures for all lab equipment.

Preparing documentation on each specific equipment, outlining the repairs and maintenance undertaken.
Outlining a preventive maintenance program for each equipment.
Training both technical and managerial staff on proper use and care of lab equipment.

Standard Operating Procedure for Maintenance of Lab Equipment

Standard operating procedures (SOPs) are a must for all complex lab equipment. This ensures that the correct use and maintenance of the equipment is integrated within routine work. Detailed instructions of equipment use should be sourced from the manufacturer’s operator manual. The SOP can be written by the lab manager, an equipment officer, or staff that frequently works with the specific equipment. The SOP should also be easily accessible at the workbench.

A proper SOP should contain the following;

The title and description of the content/scope of the SOP.
Definitions of all abbreviations used.
An outline of the personnel responsible for the equipment or involved in its use, including their qualifications and training requirements.
Detailed instructions for the use of equipment, containing the do’s and don’ts of operating them.
A description of quality control and maintenance.
Instructions on waste management, where applicable.
Reference documents, such as manuals used to prepare SOP and manufacturer’s websites, should be outlined for use when further information is required.

Equipment Maintenance Documentation

This is a centralized collection of all the information regarding a particular equipment. It is a reference archive for equipment maintenance that can be used to understand the history of the equipment. It is usually organized by the lab manager or the lab’s equipment officer. The maintenance log outlines equipment identification and descriptions like equipment name, model number, manufacturer, purchase date, warranty, model, etc as shown in Table 1. It also contains description of repair work, parts replacements, tests, measurements, adjustments, or deep cleaning done on the equipment.

Highlight trends like repair costs and equipment durability and efficiency. Therefore, helping lab managers to make decisions on equipment models and brands that are best suited for the lab. Point out the equipment that undergoes wear and tear frequently. If the cause of malfunction is operation related, it can highlight the need for re-training of laboratory staff.

Preventive Maintenance Program

A preventive maintenance program ensures that the equipment is functioning with minimal interruptions and within the manufacturer's specifications. It maximizes the equipment operational efficiency and reduces overall costs. It is mainly recommended for equipment with moving parts, gas or liquid flow, optical systems and filters.The maintenance and quality control is performed under an outlined schedule and results are documented.

A preventive maintenance file should detail;

Error alerts on the equipment and subsequent action to be taken.
Basic troubleshooting when the equipment malfunctions.
Logs for error reports and failure events.
The servicing and calibration done on the equipment and the dates for subsequent calibrations.
Stickers should be used for equipment labelling to summarize the preventive maintenance actions undertaken, the date, and the personnel involved.

Training Laboratory Staff on Equipment Maintenance

Training of both technical and managerial staff is not a one time activity. It should be regular with additional courses given when new equipment or improved models are bought. The initial induction training should be elaborate with an expert-guided discussion and demonstration, while follow-up training can be done in-house to refresh the staff technique. The lab manager or lab quality control officer are responsible for ensuring all staff are well trained.

For proper staff training on equipment care and maintenance;

Provide all necessary documentation including SOPs, maintenance logs, service manuals etc.
Ensure that the staff have, along with theoretical presentation, a practical on-the-job training on use and maintenance of lab equipment.
Train all staff on preventive maintenance, where they learn the general care of equipment like lubrication and checking for possible damage.
At the end of the training, a scoring system should be available to evaluate the effectiveness of the training.

General Care Tips for Lab Equipment

Cleaning

Regular cleaning of lab equipment ensures that it is ready for use when needed, that stubborn stains/substances do not get a firm hold, and that experiments are not contaminated by impurities carried over from previous experiments.

Make certain that;

The equipment is always cleaned before and after each use.
Cleaning reagents and cleaning aids used are specific for laboratory equipment care.
In addition to cleaning lab equipment before and after each use, a schedule is required for more in-depth cleaning. This might involve dissembling certain machines to clean hard-to-reach parts.
Always follow instructions from the manufacturer on cleaning policy. Certain parts of the equipment might require very specific solvents, cleaning materials, or drying procedures.

Lab cleanliness is one of the easiest, most affordable and most obvious ways to keep your lab in great shape but surprisingly is often overlooked.

It's advisable to:
Carry out a daily wipe down of all equipment exteriors
Carry out a weekly deep clean of all equipment
Carry out a regular deep clean of microscopes using a 70:30 mixture of ether and alcohol – this ensures that they are sufficiently clean to yield most accurate results
Consult the manual or lab manager on any specific processes for cleaning demanding equipment.
Consider outsourcing cleaning of challenging items to a qualified professional
Following these simple cleaning procedures will keep equipment in peak condition so that your lab runs without a hitch.

Calibration

Calibration involves comparing the measurements of an equipment against the standard unit of measure, for the purpose of verifying its accuracy and making necessary adjustments. Regular calibration of laboratory equipment should be done because over time, biases develop in relation to the standard unit of measure. This guards against invalid data and ensures safety during experimentation. An independent specialist, that can provide calibration certificates where necessary, should be engaged in the process.

Calibration should be done when;

The recommended time by the manufacturer elapses.
The equipment is hit by a force, dropped on the ground, or involved in any accident or an event of safety concern.
There are unusual patterns or sounds while the equipment is in use.
Measurements obtained are questionable.
Highly critical measurements, where data accuracy is of utmost importance, are to be carried out.

Failure to regularly calibrate equipment can lead to a lack of accuracy with your data which could end up disrupting entire experiments. There are various services available to ensure your equipment is regularly calibrated and done so to the right standard.

It's advisable to:

Carry out an inventory of your equipment and decide which is most suitable for each item – from basic preventative maintenance to more advanced accuracy verification.
Regularly calibrate equipment for ongoing preventative maintenance that will keep your lab sharp.

Repairs and Refurbishments

Lab equipment is generally costly and repairs and refurbishment prolong the lifespan of equipment, saving the lab the expense of new purchases.

The following are points to consider;

Repair and/or refurbish faulty or worn out lab equipment without any delay. Faulty machines may stop working suddenly in the middle of an experiment leading to losses and they can also be a source of safety concerns.
Minor repairs can be done by a dedicated staff, while major repairs should be directed to specialists with knowledge on the specific machine or equipment.
Refurbish old equipment to give them a new lease of life by cleaning thoroughly, polishing where necessary, lubricating movable parts, and replacing small worn out bits.

Repairs

From time to time, lab items will wear out and stop working. But, rather than immediately disposing of faulty equipment, take the time to see if parts could be replaced or items can be repaired instead.

It's likely that equipment can be updated and maintained rather than simply disposed of.

Particularly with larger items, repairing and replacing parts can be an effective way to increase lifespan and keep down costs. Due to the nature of the items, some parts will wear quicker than others but, when adequately managed, these can be replaced in time to prevent problems or burnout. Consider centrifuges, filtration systems and microscope lenses, each of these can be simply replaced without the need to dispose of the entire machine.

Don't immediately dispose of any faulty or outmoded equipment, first see if there's a way to repair or replace parts to increase the lifespan.

Refurbishment

For faulty equipment, repairing can be invaluable but if your items still work, just not as smoothly as before, refurbishment could hold the key. If you're looking to refurbish older items of equipment, then consider carrying out the following process:

Take the entire piece of equipment apart
Fully clean each component
Where necessary polish components
Re-lubricate any moving parts
If parts are showing signs of wear and tear, consider replacing them at this preventative stage
Put the equipment back together
Of course, you'll need to know a thing or two about the items you're working with to carry out the above procedure, but this can help items return to good as new.

Quality Replacement

Equipment that cannot be repaired or refurbished should be replaced. It is advisable to buy equipment from well known sources that can guarantee quality and offer technical support. High-quality lab equipment is easier to maintain and its durability translates to reduced costs in the long term. Non-faulty equipment that is too old should also be replaced, while some wear and tear might not be noticeable during its operation, outdated machines are not reliable and technical support in terms of servicing and acquisition of spare parts may be limited.

There will undoubtedly be times when no matter how well you've completed your daily cleans, or carried out regular calibration or even repaired and refurbished older items, you will need to purchase replacements.

It can be tempting to take what initially looks like the economical route and scrimp on equipment by choosing the less expensive model. Unfortunately, this offers a false economy. The parts in cheaper items of equipment are often more prone to wear and tear and therefore less likely to go the distance. Choosing high-quality lab equipment usually offers enhanced durability, particularly for items of equipment that are used regularly.

Consider the following:

High-quality lab equipment is often easier to find parts for.
It's usually a more straightforward process to clean and refurbish high-quality items
If you only intend to use the item for a short period of time or your budget is very tight, it could be worth looking into hiring good-quality equipment rather than purchasing the cheaper equivalents.

Conclusion

The care and maintenance of laboratory equipment is an integral part of quality assurance in the lab. Well-maintained lab equipment ensures that data is consistent and reliable, which in turn impacts the productivity and integrity of the work produced. Furthermore, since laboratory equipment generally takes up a big cut of the budget, good maintenance contributes to cost-cutting measures, by lowering the chances of premature repurchases and replacement. In addition, routine maintenance ensures that lab equipment is safe for use through highlighting and repair of faulty equipment and equipment parts.

The care and maintenance of laboratory equipment should be a routine and embedded within the standard operating procedure of the lab. This will ensure that the life span of the equipment is prolonged and data collected within the laboratory is reliable.

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Laboratory Method of Teaching Science

<u>Introduction</u>

The word ‘Laboratory’ was originally applied to the work-room of a chemist, a place devoted to experimental study in natural sciences. Hence the term
Laboratory Method was first widely used in the physical sciences to characterise a teaching procedure that makes use of experimentation with apparatus and materials in order to verify physical laws and other facts.

Science educators have believed that the laboratory is an important means of instruction in science since late in the 19th century. Laboratory method was
considered essential because it provided training in observation, supplied detailed information, and aroused pupils' interest.

In a laboratory, students work individually or in small groups on a question, problem or hypothesis. They use the processes and materials of science to construct their own explanation of scientific phenomena. The distinction between laboratory and traditional classroom learning is that activities are student-centered, with students actively engaged in hands-on, minds-on activities using laboratory techniques.

Laboratory method is a unique source of quality teaching and learning in science because science students are able to observe and manipulate materials to demonstrate certain aspects of the subject matter which has been learnt in class through lectures, discussions and textbooks. Hence, laboratory methods of teaching provide students with opportunities to engage in processes of investigation and inquiry which is believed to enhance quality education.

<u>The Method</u>

The Laboratory Method of teaching science has in recent years come to connote a learning situation somewhat in contrast and opposition to the demonstration method. Some experts believe that the Laboratory Method is the one in which there is maximum pupil activity.

This method is one of the important methods of teaching science and it forms an integral part of effective science teaching. Under this method, teachers encourage the students to derive various scientific laws and principles on their own by getting personally involved in the experiment work.

For this, provision of a well- equipped laboratory is made by the teacher. Along with such materials and facilities, proper instructions are being provided by the teacher to the students by which they can carry out their experiments self-independently. They carry on the experiments and record the observation properly, on -the basis of which they infer their results or draw conclusions.

The Laboratory Method is a planned learning activity dealing with original or raw data in the solution of a problem. It is a procedure involving first hand experiences with materials or facts derived from investigations or experimentation. Of it, the Laboratory Method is not one that may be used exclusively. Used in conjunction with some other techniques, it may be a very effective means of collecting evidence in the solution of problems.

The Laboratory Method is used in many different ways. It is, for the most part, planned on an individual basis. Of course, group laboratory work can be carried on, but it is less satisfactory. Previously laboratory work was done, separately from class work and there was hardly any correlation between the two. The trend at present is to merge the laboratory and class-room work, making each supplement the other.

If the Laboratory Method is to produce its maximum effectiveness, it must be planned, directed, and controlled by the teacher with just as much care as is used with a demonstration lesson. Under proper guidance and supervision the Laboratory Method can yield much in training for the development of skills and techniques.

Entire work of the students is being supervised and controlled by the teacher, as a result of which, the probability of meeting with any kind of accident reduces to considerable extent. Not only this, with this, students perform their work without conducting any kind of mistake.

Various categories of Laboratory Method

For science teaching, this method is used to maximum possible extent by the teachers, as a result of which, some experts have divided it into various categories, some of which are as follows:

Inductive Laboratory Method:

Through this method, students get the opportunity to form various scientific concepts and principles on their own as in this method they have to take part in various project functions.

Verification and Deduction Method:

Through this method, teachers illustrate various scientific concepts, principles and laws in front of students.

Technical Skill Oriented Method:

This method stresses acquiring various kinds of manipulative skills which involve the development of hand-eye coordination.

Science Process Oriented Method:

Through this method, teachers develop the science process skills of various kinds in the students.

Thus, any form of laboratory method can be used by the teacher. But, it is very necessary to plan and organise laboratory activities carefully. Pre-laboratory instructions should be provided by the science teacher well in advance of time as through it students will get prepared for taking active part in laboratory activities.

Through such kind of pre-laboratory instructions, students will become oriented to the objectives to be attained and the procedures or methods to be adopted.

Necessary directions for actual laboratory work should be provided by the teacher to the students, which should highlight the precautions which they are required to observe. Teachers can provide the instructions to the students either in' written form or orally. If these are provided in the written form, then there should be proper provision of black-board and instruction cards in the classroom, as without it, this function cannot be performed properly.

Steps of the Laboratory Method

The technique can be conveniently divided into three parts or steps namely,

(i) Introductory steps
(ii) Work Period
(iii) Culminating activities.

Let us discuss each one by one.

(i) Introductory step

In this step which provides for motivation and orientation, the following factors should be taken into account.

(a) Determination of Laboratory work to be done

If the teacher has planned this work in advance, then the first step is an explanation of the problem or other work to be done. This may be called a presentation. Here is the teacher's opportunity to motivate the students.

But if the work is to be planned cooperatively by the students and the teacher, the first step is to determine by means of class discussion, the nature of the problem or the work to be done.

(b) Determination of the Plan of Work.

The second step is to get clearly in mind what is to be done. This may be set forth by the teacher who gives the necessary directions for both individual and group work. Since this work is likely to take more time than one period as it consists of various activities, written directions in the form of guide sheets, manuals, work-books and so on should be used.

The introductory step thus considers the problem and the objectives of the work as well as of the plan of work to be carried out. After considering the first step, we now discuss the second one-work period.

(ii) Work-Period

The laboratory activity should take the form of a supervised work-period in which groups or individuals have their particular work to do. The students can work individually or collectively on a particular problem or on different problems. Directions must be very specific. The length of the work periods should be determined by the nature of the problems and the objectives. If the laboratory work occupies several days, it may be desirable to have the class meet as a group each day, preferably at the beginning of the period for a discussion of the problems, progress and to receive criticisms, suggestions or directions from the teacher.

(iii)Culminating Activities

When the members of a class have completed their laboratory work, the class should meet for discussion and organisation of findings or for presentation of the results of individual work. The following types of activities may be used:

1. Students re-state the problem that the group has been working on and explain its nature and importance.

2. Review of the plan for solving the problem and organisation of plan for recording the data gathered.

3. Presentation of illustrative material or special contributions by students working on special problems.

4. Where students are working on individual projects, special reports may be given before the group, together with an exhibition of their work.

5. Note-books and written reports may be completed for the final record of work.

6. Work of the class may be exhibited and rated by members of the class or by competent judges from outside.

7. Exhibits of various projects may be set up and explained by then- sponsors.

8. Tests or examinations may be used as a means of measuring achievement relative to certain outcomes.

Since it would be impracticable to have too great a variety of culminating activities, those chosen should be adapted to the particular needs of the class, as well as to the time available. Written reports and summaries may be required to assure adequate participation of all the class in the completion of the work.

Educational implications

Science educators have believed that the laboratory is an important means of instruction in science.

Purpose of laboratory method

Shulman and Tamir, listed five groups of objectives that may be achieved through the use of the laboratory method in science classes:

- **Skills -** manipulative, inquiry, investigative, organizational, communicative.

- **Concepts** - for example, hypothesis, theoretical model, taxonomic category.

- **Cognitive abilities** - critical thinking, problem solving, application, analysis, synthesis.

- **Understanding the nature of science -** scientific enterprise, scientists and how they work, existence of a multiplicity of scientific methods, interrelationships between science and technology and among the various disciplines of science.

- **Attitudes** - for example, curiosity, interest, risk taking, objectivity, precision,confidence, perseverance, satisfaction, responsibility, consensus, collaboration, and liking science.

First-hand experience

Laboratory method assumes that first-hand experience in observation and manipulation of the materials of science is superior to other methods of developing understanding and appreciation.

Skills development
Laboratory training is also frequently used to develop skills necessary for more advanced study or research.
The activity of the student, the sensorimotor nature of the experience, and the individualization of laboratory instruction contribute positively to learning.

Direct experience

Information cannot usually be obtained, however, by direct experience as rapidly as it can from abstractions presented orally or in print. Thus, one would expect laboratory method to have an advantage over other teaching methods

- in the amount of information retention,
- in ability to apply learning, or
- in actual skill in observation or manipulation of materials.

Abilities enhancement
The laboratory method plays significant role in enhancing-

- achievement,
- attitudes,
- critical thinking,
- cognitive style,
- understanding science,
- the development of science process skills,
- manipulative skills,
- interests,
- retention in science courses, and
- the ability to do independent work.

Laboratory methods appear to be helpful for students as laboratory instruction increases students' problem-solving ability in science and the laboratory could be a valuable instructional technique in science if experiments were genuine problems without explicit directions.

Scientific method
Laboratory method of teaching science effectively is scientific method as it motivates -

- Thinking students as inside the learning process both mentally and physically in an active way,
- Giving opportunities for the students to try,
- Hypothesize and test,
- Searching theoretical information instead of quoting them directly,
- Presenting learning facilities by means of interrogation based activities,
- Gaining understanding relating to technology, society and environment.

Meaningful learning.

The most important feature of science in which it differs from other sciences; is providing opportunity for

- experiment,
- investigation,
- asking of the student by minding the survey,
- establishing hypothesis,
- developing their researching skills and
- interpreting the results

Together with the science education, besides bringing information to the students, supporting the development of their scientific thinking skills and submitting solutions to the daily problems are planned. It eases the material usage in education, perception and learning.

Dynamism to the classroom
It inspires and brings dynamism to the classroom.

It shortens the time in learning, compacts knowledge and helps permanence.

It provides the students to participate in the subject, arouses reading and searching interest.

It carries the cases, actualities and facts which are impossible to bring them in the class with their real faces.

The students are active when they are making experiments and they live the experiment with everything. Therefore, during an experiment, dynamism is seen in the classroom.

Active participation of students

Laboratory method which provides the activeness of the student, carries great value in terms of education. The most valid learning methods are learning by living and performing, preparing experiments and investigating.

Today in which science and technology are developing with a rattling rate, science education is performed with different techniques and methods. Inside these methods, one of the most efficient ones is the laboratory method.

Although there are several discussions on it, laboratory and applied studies have an important and central role in science education.

Laboratory provides the students to participate in the activities related to science and to learn the scientific method. Laboratory for students is a place where new information is developed by sighting, developing ideas and interpreting the data.

PROBLEMS FACING THE EFFECTIVE USE OF LABORATORY IN TEACHING SCIENCE

The use of the laboratory method in teaching science has become a dogma among science educators and teachers. On one hand, they extolled the importance of the use of the laboratory method in science teaching while on the other hand, they only pay "lip service" to its use in practice. Science teachers do not usually find it convenient to make laboratory work the center of their instruction.

They usually complain of lack of materials and equipment to carry out practical work. At the same time, it is possible that some of these materials and equipment may be locked up in the school laboratory store without teachers being aware of their existence. The conditions under which many teachers function do not engender any enthusiasm to use the laboratory method of teaching science even where they know that these materials and equipment are available. Class size in urban schools is getting larger and this does not usually encourage teachers to use the laboratory method to teach science. In some states of the country, teachers go for months without salary owing to shortage of funds. Science teachers who fall in this category cannot reasonably be expected to give off their best to their students. Higher institutions in India charged with the responsibility of training science teachers at all levels, are increasingly turning out teachers without requisite laboratory experience. A common reason usually given is shortage of laboratory facilities. Such trained science teachers usually lack the necessary confidence to conduct practical classes with their students. It is only accreditation exercises that are improving this situation in Colleges of Education and Universities at present. Such governments seem to have given up on their capacity to equip all school laboratories.

In addition, most laboratory classrooms are not equipped with work tables that have sinks, a water supply, and natural gas and electrical outlets available in sufficient quantities to support a laboratory based science course. There is not enough allocation of funds to provide opportunities to learn in an inquiry-based curriculum. There are no approved guidelines for the safe use, maintenance storage and disposal of laboratory materials.

Conclusion

Laboratory Method is a practical procedure which the students have to adopt in order to achieve a planned learning activity dealing with original or raw data in the solution of problems. Even John Dewey in this book “In the School and Society” published in 1896 set forth his philosophy that we “learn to do by doing”, thereby giving impetus to the Laboratory Method not only in home economics and manual arts but in all other subjects.

Quality education is achieved when science laboratory and the laboratory in the context of teaching and learning science is made relevant regarding research issues as well as developmental and implementation issues. It is quite obvious that the laboratory space should be available to the teacher during the planning and preparation period and available to students for special projects, makeup laboratories, etc. outside their regular class hours. Each student should have his/her own laboratory work space. To that end, science teachers must be provided with an annual budget sufficient to purchase both expendable material and equipment necessary to conduct inquiry-based learning that is believed to enhance quality learning.

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Elective course 3 (EC 3)

PEDAGOGY OF SCHOOL SUBJECT: SCIENCE

MODULE : 2
TRANSACTING SCIENCE CURRICULUM

UNIT 6
Science teacher

c) Diagnostic testing and Remedial teaching in Science

Introduction

In teaching, a problem emerges when students are unable to learn all that teaches in the class. Students are of a different type in a class that is they have individual differences.
Some students of a class are intelligent while some students are of general grade or average and other students are backward. Backward students of a class can be traced through examinations, interviews, class work, question answer and inspection by the teacher.
Various types of diagnostic tests have been formed for this purpose. A diagnostic test in science is like the achievement or intelligence test to diagnose the difficulties of students faced by them in science so that treatment may be provided.
Marks are not given to students in a diagnostic test but a type of errors done by students is observed through answers of questions given by students and the special points of errors done by students which are required to know why teachers are marked.

Concept of Diagnostic Testing:

The term diagnosis has been borrowed from the medical profession. It means identification of disease by means of a patient's symptoms.
For example, when a patient comes to a doctor, the doctor initially puts some questions to gather some basic information about the disease and then uses other techniques to get more related information to identify the disease and its probable cause(s).

After careful analysis of this data, he prescribes the medicines as remedial treatment. Similarly, in the field of education, diagnosis has many such implications. Difficulties in learning occur frequently at all levels and among pupils of both high and low mental ability.

In order to handle such cases, the teacher also uses similar techniques like a doctor to diagnose the relative strengths and weaknesses of pupils in the specific area of study, analyse the causes for the same and then provides remedial measures as per necessity.

Since tools and techniques used in mental measurements are not that exact, objective and precise like the tools and techniques used in sciences, the teachers are cautioned to use the diagnostic data with great care for designing remedial programmes.

But it is used in education to determine the learning difficulties or deficiencies of the learner. Diagnostic test is a test used to diagnose strength and weakness of the learning in certain areas of study whereas diagnostic evaluation is centered on schooling processes such as the curriculum programme, administration and so on.

When learning difficulties that are left unresolved by the standard corrective prescriptions of formative evaluation and a pupil continues to experience failure despite the use of prescribed alternative methods of instruction, then a more detailed diagnosis is indicated.

To use a medical analogy, formative testing provides first aid treatment for simple learning problems and diagnostic testing searches for the underlying causes of those problems that do not respond to first aid treatment.

Thus it is much more comprehensive and detailed and the difference lies in the types of questions each of them is addressing.

The following are the salient features of Diagnostic Testing:

(i) The diagnostic test takes up where the formative test leaves off.

(ii) A diagnostic test is a means by which an individual profile is examined and compared against certain norms or criteria.

(iii) Diagnostic tests focus on an individual's educational weakness or learning deficiency and identify the gaps in pupils.

(iv) Diagnostic tests are more intensive and act as a tool for analysis of Learning Difficulties.

(v) Diagnostic tests are more often limited to low ability students.

(vi) Diagnostic tests are corrective in nature.

(vii) Diagnostic tests pinpoint the specific types of error each pupil is making and searches for underlying causes of the problem.

(viii) Diagnostic tests are much more comprehensive.

(ix) Diagnostic tests help us to identify the trouble spots and discover those areas of students' weaknesses that are unresolved by formative tests.

Dimensions of Diagnostic Test:

(i) Who can conduct → Teacher/ Researcher

(ii) Where → School/Home/Work places

(iii) On whom → Learners

(iv) Purpose → Specific strength and weakness of the learner in a particular area.

(v) Length of time → Flexible in nature

(vi) Techniques of → Test/ observation/interview etc. Assessment

(vii) Sequence → Logical and step by step

(vii) Method of → Negotiable/ Therapeutic Remediation

(ix) Support to → Learner/ Parents/ Teacher

Steps of Educational Diagnostic Test:

(i) Identification and classification of pupils having Learning Difficulties:

(a) Constant observation of the pupils.

(b) Analysis of performance: Avoiding assignments & copying from others.

(c) Informal classroom Unit/Achievement test.

(d) Tendency of with-drawl and gap in expected and actual achievement.

(ii) Determining the specific nature of the Learning Difficulty or errors:

(a) Observation.

(b) Analysis of oral responses.

(c) Written class work.

(d) Analysis of student’s assignments and test performance.

(e) Analysis of cumulative and anecdotal records.

(iii) Determining the Factors/Reasons or

Causes Causing the learning Difficulty:

(a) Retardation in basic skills.

(b) Inadequate work study skills.

(c) Scholastic aptitude factors.

(d) Physical Mental and Emotional (Personal) Factors).

(e) Indifferent attitude and environment.

(f) Improper teaching methods, unsuitable curriculum, complex course materials.

(iv) Remedial measures/treatment to rectify the difficulties:

(a) Providing face to face interaction.

(b) Providing as many simple examples.

(c) Giving concrete experiences, use of teaching aids.

(d) Promoting active involvement of the students.

(e) Consultation of Doctors/Psychologists/Counselors.

(f) Developing strong motivation.

(v) Prevention of Recurrence of the Difficulties:

(a) Planning for non-recurrence of the errors in the process of learning.

Construction of Diagnostic Test:

The following are the broad steps involved in the construction of a diagnostic test. Diagnostic Test may be Standardized or Teacher made and more or less followed the principles of test construction i.e., preparation, planning, writing items, assembling the test, preparing the scoring key and marking scheme and reviewing the test.

The Unit on which a Diagnostic Test is based should be broken into learning points without omitting any of the item and various types of items of test is to be prepared in a proper sequence:

1. Analysis of the context minutely i.e., major and minor one.

2. Forming questions on each minor concept (recall and recognition type) in order of difficulty.

3. Review the test items by the experts/experienced teacher to modify or delete test items if necessary.

4. Administering the test.

5. Scoring the test and analysis of the results.

6. Identification of weakness

7. Identify the causes of weakness (such as defective hearing or vision, poor home conditions, unsatisfactory relations with classmates or teacher, lack of ability) by the help of interview, questionnaires, peer information, family, class teacher, doctor or past records.

8. Suggest remedial programme (No set pattern).

Motivation, re-teaching, token economy, reinforcement, correct emotion, changing section, giving living examples, moral preaching.

Materials Used in Diagnostic Test:

Classroom teachers, principals, supervisors and qualified diagnosticians use the following resources and materials in making educational diagnoses more vibrant:

1. Test records (Standardized and Teacher made).

2. Pupils’ written work (themes, compositions, home assignments and test papers).

3. Pupils’ oral work (discussion, speeches and oral reading).

4. Pupils’ work habits (in class activities, participation, peer relationship, independent work, interest, effort etc.).

5. Physical and health records (school and family records about vision, hearing, dental, general).

6. Guidance and cumulative record data (family) background, anecdotal references, school activities).

7. Interview with pupils (problem or trouble and elimination of misconceptions).

8. Parent conference (pupil problems at home, parent interpretation).

9. Self-guidance (completing assignments, independent work and seeking teacher help).

10. Clinic or laboratory aids (vision tester, audio-meter eye photographs, tape recorder etc.).

Barriers in Diagnostic Tests:

(i) Attitudinal change.

(ii) Will Power and patience of the teacher.

(iii) Time Scheduling .

(iv) Sequencing of Study.

(v) Faulty method of data collection and test.

(vi) Maintaining records impartially.

(vii) Costs.

Uses of Diagnostic Test:

Diagnostic tests are useful in finding out the strengths and weaknesses of the individuals.
They help in designing courses and curriculum according to the capabilities of the learner to help him overcome his deficiencies in knowledge skills and abilities and to assist him in making the best use of his potentialities.
These are helpful in finding out the causes of problems which remain unchecked and unremedied by formative evaluation.
The tests are useful to both the attainment as well as difficulties of children whose achievements are not up to the mark.
These are helpful in locating the areas in which additional instruction is required or in which teaching method has to be improved.

How to Identify Students for Diagnostic Test:

- Poor memory.
- Habits of learning slowly and forgetting quickly,
- Lack of learning motivation,

- Lack of self-confidence,
- Relatively low self-expectation,
- Failure to grasp information effectively,
- Mix things up easily,
- Fail to transfer knowledge to the related learning areas appropriately,
- Lack of originality and creativity,
- Inability to analyze, to do problem-solving or think critically,
- Short attention and concentration span is less
- Less interaction with other students,
- Less Classroom Discussion
- Reading problem,
- Relatively poor comprehensive power,
- Slow response/decision making,

Main causes of weakness:

- Lack of understanding/ misconceptions
- Faulty teaching method
- Fear of the subject
- Incorrect study habits
- Physical and emotional factors like - poor health, some mental shock etc.
- Teacher's attitude

Remedial Teaching:

While diagnosis is the process of investigating the learner's difficulties and the reasons for this, its follow up leads to actions that may help children make up their deficiencies. This step is generally termed Remedial Teaching.

Remedial teaching focuses on skills rather than on content.

Remedial teaching is not re-teaching.
According to **Yoakman and Simpson**, "The purpose of remedial teaching is the development of effective techniques for the correction of errors in all types of learning."

According to **G.M. Blair**,
"remedial teaching is essentially good teaching which takes the pupil at his own level and by intrinsic methods of motivation leads him to increased standards of competence. It is based upon a careful diagnosis of defects and is geared to the needs and interests of a pupil."

Objectives of Remedial Teaching:

To timely solve doubts of the students

To solve the problems arise during teaching

To develop good tendencies among the students

To correct the emotional difficulties of students

To overcome deficiencies in work, study, and skills

Principles of remedial teaching:

- Teaching preparation
- Make various learning activities
- Design meaningful learning situations
- Teaching approaches
- Provide clear instructions
- Summarize the main points
- Enhance learning interest and motivation
- Show concern for the performances of individual pupils.
- Steps of effective Remedial Teaching:
- The programme that coincides most closely with the experience of successful teachers and with a sound psychology of learning calls for the following steps in the order indicated:
    1. Teach
    2. Review
    3. Test for weakness whenever they appear
    4. Follow with remedial drill units on the specific weaknesses revealed by the tests.

Types of Remedial Teaching:

For remedial teaching teacher can select any process out of the below-mentioned process as following:

1) **An arrangement of special classes -**

Students may be called for special classes arranged below-mentioned opening of school in the daytime or after the closing of the school in the evening for removing their difficulties by the teacher concerned.

2) Individual teaching -

If the teacher has sufficient time then he or she must make efforts to remove the errors of students individually.

3) Additional classes work -

These students may be given additional work in the class that is additional class work for removing their difficulties and for providing them with more opportunities to clear the doubts and errors.

4) Additional homework -
These students may be given additional homework which may not feel has to be burdened by them and the given homework may be checked by a teacher in a regular manner.

Possible cures and remedies:

Once the cause(s) having been identified, suitable remedial measures (depending upon the cause) should be suggested which may be:

Curriculum adaptation
Remedial teachers should adapt the curriculum to accommodate the learning characteristics and abilities of pupils.
Teaching should not be directed by textbooks.

Precise homework
The homework should have clear objectives and can accommodate the level and needs of pupils.

Re-teaching of the subtopic.

Computer Aided Teaching.

Categorizing the problem areas – Spelling or drawing or reading or calculation.

Remedial teacher student ratio -
ideal 1 to 1 or not more than 3 students per session.

Personal and individual attention by the remedial teacher.

No humiliation.

Special carefully devised activities.

Read- Reread- Write- Rewrite- Reproduce- Drill

Conclusion

Diagnosis of Persistent learning difficulties involves much more than diagnostic testing, but such a test is useful in the total process. The diagnostic is the test taken where the formative test leaves off. If people do not respond to the feedback corrective prescriptions of formative testing they need for a more detailed search for the source of learning error is indicated.
Teachers should exercise their discretion in the appropriate use of teaching aids. Appropriate teaching aids not only help to enhance pupils' interest in learning but will also consolidate the

knowledge they learned, thus achieving the objective of teaching. Common teaching aids are concrete objects, figures, models, flash cards, number cards, and audio-visual equipment. The design and organization of teaching materials should be people-oriented. If educational diagnosis may be added with a remedy, it will certainly be beneficial for the students.

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