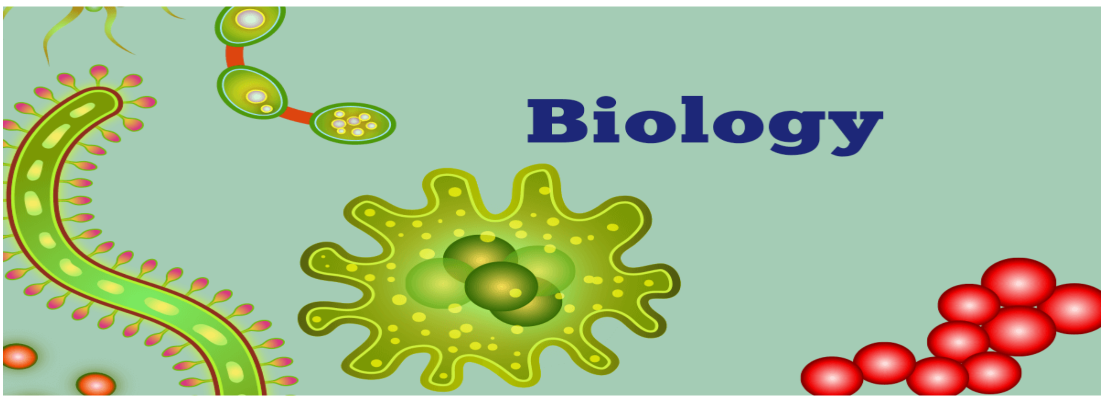
Method's of Teaching

Part 1

Third Year

Biological and Geological Sciences



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كلية التربية بالغردقة – جامعة جنوب الوادى

رؤية الكلية

كلية التربية بالغردقة مؤسسة رائدة محلياً ودولياً فى مجالات التعليم ،والبحث العلمى ،وخدمة المجتمع ، بما يؤهلها للمنافسة على المستوى : المحلى ، والإقليمى ، والعالمى .

رسالة الكلية

تقديم تعليم مميز في مجالات العلوم الأساسية و إنتاج بحوث علمية تطبيقية للمساهمة فى التنمية المستدامة من خلال إعداد خريجين متميزين طبقا للمعايير الأكاديمية القومية، و تطوير مهارات و قدرات الموارد البشرية، و توفير خدمات مجتمعية وبيئية تلبي طموحات مجتمع جنوب الوادي، و بناء الشراكات المجتمعية الفاعلة.

Content

Chapter 1

history of biology

The **history of biology** traces the study of the living world from ancient to modern times. Although the concept of *biology* as a single coherent field arose in the 19th century, the biological sciences emerged from traditions of medicine and natural history reaching back to ayurveda, ancient Egyptian medicine and the works of Aristotle and Galen in the ancient Greco-Roman world. This ancient work was further developed in the Middle Ages by Muslim physicians and scholars such as Avicenna. During the European Renaissance and early modern period, biological thought was revolutionized in Europe by a renewed interest in empiricism and the discovery of many novel organisms. Prominent in this movement were Vesalius and Harvey, who used experimentation and careful observation in physiology, and naturalists such as Linnaeus and Buffon who began to classify the diversity of life and the fossil record, as well as the development and behavior of organisms revealed by means of microscopy the previously unknown world of microorganisms, laying the groundwork for cell theory. The growing importance of natural theology, partly a response to the rise of mechanical philosophy, encouraged the growth of natural history (although it entrenched the argument from design).

Over the 18th and 19th centuries, biological sciences such as botany and zoology became increasingly professional scientific disciplines. Lavoisier and other physical scientists began to connect the animate and inanimate worlds through physics and chemistry. Explorer-naturalists such as Alexander von Humboldt investigated the interaction between organisms and their environment, and the ways this relationship depends on geography—laying the foundations for biogeography, ecology and ethology. Naturalists began to reject essentialism and consider the importance of extinction and the mutability of species. Cell theory provided a new perspective on the fundamental basis of life. These developments, as well as the results from embryology and paleontology, were synthesized in Charles Darwin's theory of evolution by natural selection. The end of the 19th century saw the fall of spontaneous generation and the rise of the germ theory of disease, though the mechanism of inheritance remained a mystery.

In the early 20th century, the rediscovery of Mendel's work led to the rapid development of genetics by Thomas Hunt Morgan and his students, and by the 1930s the combination of population genetics and natural selection in the "neo-Darwinian synthesis". New disciplines developed rapidly, especially after Watson and Crick proposed the structure of DNA. Following the establishment of the Central Dogma and the cracking of the genetic code, biology was largely split between *organismal biology*—the fields that deal with whole organisms and groups of organisms—and the fields related to *cellular and molecular biology*. By the late 20th century, new fields like genomics and proteomics were reversing this trend, with organismal biologists using molecular techniques, and molecular and cell biologists investigating the interplay between genes and the environment, as well as the genetics of natural populations of organism

The history of biology

There are moments in the history of all sciences when remarkable progress is made in relatively short periods of time. Such leaps in knowledge result in great part from two factors: one is the presence of a creative mind—a mind sufficiently perceptive and original to discard hitherto accepted ideas and formulate new hypotheses; the second is the technological ability to test the hypotheses by appropriate experiments. The most original and inquiring mind is severely limited without the proper tools to conduct an investigation;

conversely, the most-sophisticated technological equipment cannot of itself yield insights into any scientific process.

Learn how Austrian Catholic monk and botanist Gregor Mendel observed properties of heredity

An introduction to Austrian botanist, teacher, and Augustinian prelate Gregor Mendel's studies of heredity.

*Encyclopædia Britannica, Inc.*See all videos for this article

An example of the relationship between those two factors was the discovery of the cell. For hundreds of years there had been speculation concerning the basic structure of both plants and animals. Not until optical instruments were sufficiently developed to reveal cells, however, was it possible to formulate a general hypothesis, the cell theory, that satisfactorily explained how plants and animals are organized. Similarly, the significance of Gregor Mendel's studies on the mode of inheritance in the garden pea remained neglected for many years until technological advances made possible the discovery of the chromosomes and the part they play in cell division and heredity. Moreover, as a result of the relatively recent development of extremely sophisticated instruments, such as the electron microscope, the ultracentrifuge, and automated DNA sequencing machines, biology has moved from being a largely descriptive science—one concerned with entire cells and organisms—to a discipline that increasingly emphasizes the subcellular and molecular aspects of organisms and attempts to equate structure with function at all levels of biological organization.

The early heritage

Although it is not known when the study of biology originated, early humans must have had some knowledge of the animals and plants around them. Human survival depended upon the accurate recognition of nonpoisonous food plants and upon an understanding of the habits of dangerous predators. Archaeological records indicate that even before the development of civilization, humans had domesticated virtually all the amenable animals available to them and had developed an agricultural system sufficiently stable and efficient to satisfy the needs of large numbers of people living together in communities. It is clear, therefore, that much of the history of biology predates the time at which humankind began to write and to keep records.

Earliest biological records

Biological practices among Assyrians and Babylonians

Much of the earliest recorded history of biology is derived from Assyrian and Babylonian bas-reliefs showing cultivated plants and from carvings depicting veterinary medicine. Illustrations on certain seals reveal that the Babylonians had learned that the date palm reproduces sexually and that pollen could be taken from the male plant and used to fertilize female plants. Although a precise dating of those early records is lacking, a Babylonian business contract of the Hammurabi period (*c.* 1800 BCE) mentions the male flower of the date palm as an article of commerce, and descriptions of date harvesting extend back to about 3500 BCE.

date palm; biology

The Babylonians knew of the separate sexes of the date palm (*Phoenix dactylifera*) by the time of the Hammurabi period (*c.* 1792–1750 BCE). The species was one of the first plants in which sexual reproduction was recorded.

Grant Heilman/Encyclopædia Britannica, Inc.

Another source of information concerning the extent of biological knowledge of these early peoples was the discovery of several papyri that pertain to medical subjects; one, believed to date to 1600 BCE, contains anatomical descriptions; another (*c.* 1500 BCE) indicates that the importance of the heart had been recognized. Because those ancient documents, which contained mixtures of fact and superstition, probably summarized then-current knowledge, it may be assumed that some of their contents had been known by earlier generations.

Biological knowledge of Egyptians, Chinese, and Indians

Papyri and artifacts found in tombs and pyramids indicate that the Egyptians also possessed considerable medical knowledge. Their well-preserved mummies demonstrate that they had a thorough understanding of the preservative properties of herbs required for embalming; plant necklaces and bas-reliefs from various sources also reveal that the ancient Egyptians were well aware of the medicinal value of certain plants. An Egyptian compilation known as the Ebers papyrus (*c.* 1550 BCE) is one of the oldest known medical texts.

Ebers papyrus

Ebers papyrus prescription for asthma treatment.

U.S. National Library of Medicine/National Institutes of Health

In ancient China, three mythical emperors—Fu Xi, Shennong, and Huangdi—whose supposed ruling periods extended from the 29th to the 27th century BCE, were said to possess medical knowledge. According to legend, Shennong described the therapeutic powers of numerous medicinal plants and included descriptions of many important food plants, such as the soybean. The earliest known written record of medicine in China, however, is the *Huangdi neijing* (*The Yellow Emperor's Classic of Internal Medicine*), which dates to the 3rd century BCE. In addition to medicine, the ancient Chinese possessed knowledge of other areas of biology. For example, they not only used the silkworm *Bombyx mori* to produce silk for commerce but also understood the principle of biological control, employing one type of insect, an entomophagous (insect-eating) ant, to destroy insects that bored into trees.

As early as 2500 BCE the people of northwestern India had a well-developed science of agriculture. The ruins at Mohenjo-daro have yielded seeds of wheat and barley that were cultivated at that time. Millet, dates, melons, and other fruits and vegetables, as well as cotton, were known to the civilization. Plants were not only a source of food, however. A document, believed to date to the 6th century BCE, described the use of about 960 medicinal plants and included information on topics such as anatomy, physiology, pathology, and obstetrics.

The Greco-Roman world

Although the Babylonians, Assyrians, Egyptians, Chinese, and Indians amassed much biological information, they lived in a world believed to be dominated by unpredictable demons and spirits. Hence, learned individuals in those early cultures directed their studies toward an understanding of the supernatural, rather than the natural, world. Anatomists, for example, dissected animals not to gain an understanding of their structure but to study their organs in order to predict the future. With the emergence of the Greek civilization, however, those mystical attitudes began to change. Around 600 BCE there arose a school of Greek philosophers who believed that every event has a cause and that a particular cause produces a particular effect. That concept, known as causality, had a profound effect on subsequent scientific investigation. Furthermore, those philosophers assumed the existence of a "natural law" that governs the universe and can be comprehended by humans through the use of their powers of observation and deduction. Although they established the science of biology, the greatest contribution the Greeks made to science was the idea of rational thought.

Theories about humankind and the origin of life

One of the earliest Greek philosophers, Thales of Miletus (*c.* 7th century BCE), maintained that the universe contained a creative force that he called physis, an early progenitor of the term *physics*; he also postulated that the world and all living things in it were made from water. Anaximander, a student of Thales, did not accept water as the only substance from which living things were derived; he believed that in addition to water, living things consisted of earth and a gaslike substance called *apeiron*, which could be divided into hot and cold. Various mixtures of those materials gave rise to the four elements: earth, air, fire, and water. Although he was one of the first to describe Earth as a sphere rather than as a flat plane, Anaximander proposed that life arose spontaneously in mud and that the first animals to emerge had been fishes covered with a spiny skin. The descendants of those fishes eventually left water and moved to dry land, where they gave rise to other animals by transmutation (the conversion of one form into another). Thus, an early evolutionary theory was formulated.

At Crotone in southern Italy, where an important school of natural philosophy was established by Pythagoras about 500 BCE, one of his students, Alcmaeon, investigated animal structure and described the difference between arteries and veins, discovered the optic nerve, and recognized the brain as the seat of the intellect. As a result of his studies of the development of the embryo, Alcmaeon may be considered the founder of embryology.

Although the Greek physician Hippocrates, who established a school of medicine on the Aegean island of Cos around 400 BCE, was not an investigator in the sense of Alcmaeon, he did recognize through observations of patients the complex interrelationships involved in the human body. He also contemplated the influence of environment on human nature and believed that sharply contrasting climates tended to produce a powerful type of inhabitant, whereas even, temperate climates were more conducive to indolence.

Hippocrates

Hippocrates, undated bust.

Hippocrates and his predecessors were concerned with the central philosophical question of how the cosmos and its inhabitants were created. Although they accepted the physis as the creative force, they differed with regard to the importance of the roles played by earth, air, fire, water, and other elements. Although Anaximenes, for example, who may have been a student of Anaximander, adhered to the then-popular precept that life originated in a mass of mud, he postulated that the actual creative force was to be found in the air and that it was influenced by the heat of the Sun. Members of the Hippocratic school also believed that all living bodies were made up of four humours—blood, black bile, phlegm, and yellow bile—which supposedly originated in the heart, the spleen, the brain, and the liver, respectively. An imbalance of the humours was thought to cause an individual to be sanguine, melancholy, phlegmatic, or choleric. These words persisted in the medical literature for centuries, a testament to the lengthy popularity of the idea of humoral influences. For centuries it was also believed that an imbalance in the humours was the cause of disease, a belief that resulted in the common practice of bloodletting to rid the body of excessive humours.

The Arab world and the European Middle Ages

After Galen there were no significant biological investigations for many centuries. It is sometimes claimed that the rise of Christianity was the cause of the decline in science. However, while it is true that Christianity did not favour the questioning attitude of the Greeks, science had already receded significantly by the end of the 2nd century CE, a time when Christianity was still an obscure sect.

Arab domination of biology

During the almost 1,000 years that science was dormant in Europe, the Arabs, who by the 9th century had extended their sphere of influence as far as Spain, became the custodians of science and dominated biology, as they did other disciplines. At the same time, as the result of a revival of learning in China, new technical inventions flowed from there to the West. The Chinese had discovered how to make paper and how to print from movable type, two achievements that were to have an inestimable effect upon learning. Another important advance that also occurred during that time was the introduction of the so-called Arabic numerals into Europe from India.

From the 3rd until the 11th century, biology was essentially an Arab science. Although the Arabic scholars themselves were not great innovators, they discovered the works of such men as Aristotle and Galen, translated those works into Arabic, studied them, and wrote commentaries about them. Of the Arab biologists, al-Jāḥiẓ, who died about 868, is particularly noteworthy. Among his biological writings is *Kitāb al-ḥayawān* ("Book of Animals"), which, although revealing some Greek influence, is primarily an Arabic work. In it the author emphasized the unity of nature and recognized relationships between different groups of organisms. Because al-Jāḥiẓ believed that earth contained both male and female elements, he found the Greek doctrine of spontaneous generation (life emerging from mud) to be quite reasonable.

Resurgence of biology

Beginning in Italy during the 14th century, there was a general ferment within the culture itself, which, together with the rebirth of learning (partly as a result of the rediscovery of Greek work), is referred to as the Renaissance. Interestingly, it was the artists, rather than the professional anatomists, who were intent upon a true rendering of the bodies of animals, including humans, and thus were motivated to gain their knowledge firsthand by dissection. No individual better exemplifies the Renaissance than Leonardo da Vinci, whose anatomical studies of the human form during the late 1400s and early 1500s were so far in advance of the age that they included details not recognized until a century later. Furthermore, while dissecting animals and examining their structure, Leonardo compared them with the structure of humans. In doing so he was the first to indicate the homology between the arrangements of bones and joints in the leg of the human and that of the horse, despite the superficial differences. Homology was to become an important concept in uniting outwardly diverse groups of animals into distinct units, a factor that is of great significance in the study of evolution.

Other factors had a profound effect upon the course of biology in the 1500s, particularly the introduction of printing around the middle of the century, the increasing availability of paper, and the perfected art of the wood engraver, all of which meant that illustrations as well as letters could be transferred to paper. In addition, after the Turks conquered Byzantium in 1453, many Greek scholars took refuge in the West; the scholars of the West thus had direct access to the scientific works of antiquity rather than indirect access through Arabic translations.

Advances in botany

Over the period 1530–40, German theologian and botanist Otto Brunfels published the two volumes of his *Herbarum vivae eicones*, a book about plants, which, with its fresh and vigorous illustrations, contrasted sharply with earlier texts, whose authors had been content merely to copy from old manuscripts. In addition to books on the same subject, Hieronymus Bock (Latinized to Tragus) and Leonhard Fuchs also published about the mid-1500s descriptive well-illustrated texts about common wild flowers. The books published by the three men, who are often referred to as the German fathers of botany, may be considered the forerunners of modern botanical floras (treatises on or lists of the plants of an area or period).

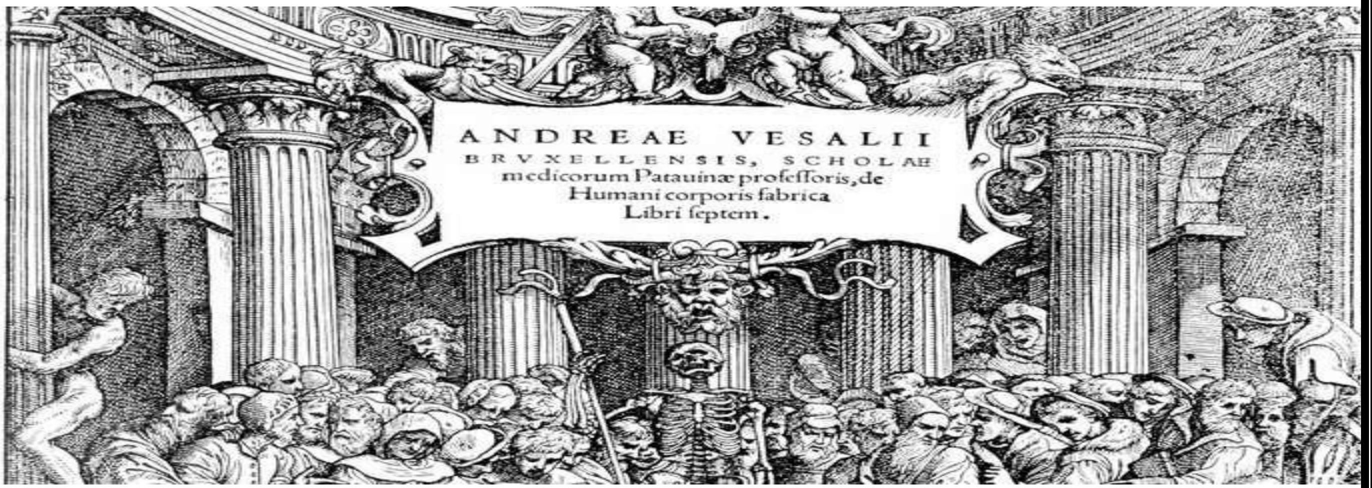
Throughout the 16th century, interest in botanical study also existed in other countries, including the Netherlands, Switzerland, Italy, and France. During that time there was a great improvement in the classification of plants, which had been described in ancient herbals merely as trees, shrubs, or plants and, in later books, were either listed alphabetically or arranged in some arbitrary grouping. The necessity for a systematic method to designate the increasing number of plants being described became obvious. Accordingly, using a binomial system very similar to modern biological nomenclature, the Swiss botanist Gaspard Bauhin designated plants by a generic and a specific name. Although affinities between plants were indicated by the use of common generic names, Bauhin did not speculate on their common kinship.

Pierre Belon, a French naturalist who traveled extensively in the Middle East, where he studied the flora, illustrates the wide interest of the 16th-century biologists. Although his botanical work was limited to two volumes, one on trees and one on horticulture, his books on travel included numerous biological entries. His two books on fishes reveal much about the state of systematics at the time, including that of not only fishes but also other aquatic creatures such as mammals, crustaceans, mollusks, and worms. In his *L'Histoire de la nature des oyseaux* (1555; "Natural History of Birds"), however, in which Belon's taxonomy was remarkably similar to that used in the modern era, he showed a clear grasp of comparative anatomy, particularly of the skeleton, publishing the first picture of a bird skeleton beside a human skeleton to point out the homologies. Numerous other European naturalists who traveled extensively also brought back accounts of exotic animals and plants, and most of them wrote voluminous records of their excursions. Two other factors contributed significantly to the development of botany at the time: first was the establishment of botanical gardens by the universities, as distinct from the earlier gardens that had been established for medicinal plants; second was the collection of dried botanical specimens, or herbaria.

It is perhaps surprising that the great developments in botany during the 16th century had no parallel in zoology. Instead, there arose a group of biologists known as the Encyclopedists, best represented by Conrad Gesner, a 16th-century Swiss naturalist, who compiled books on animals that were illustrated by some of the finest artists of the day (Albrecht Dürer, for example). But because the descriptions of many of the animals were grossly inaccurate, in many cases continuing the legends of the Greeks, apart from their aesthetic value the books did little to advance zoological knowledge.

Advances in anatomy

Like that of botany, the beginning of the modern scientific study of anatomy can be traced to a combination of humanistic learning, Renaissance art, and the craft of printing. Although Leonardo da Vinci initiated anatomical studies of human cadavers, his work was not known to his contemporaries. Rather, the appellation father of modern human anatomy generally is accorded to the Belgian anatomist Andreas Vesalius, who studied initially at the rather conservative schools in Leuven (Louvain) and Paris, where he became a successful teacher very familiar with Galen's work. In 1537 he went to Padua, where he became noted for far-reaching teaching reforms. Most important, Vesalius abolished the practice of having someone else do the actual dissection; instead, he dissected his own cadavers and lectured to students from his findings. His text, *De humani corporis fabrica libri septem* (1543; "The Seven Books on the Structure of the Human Body"), was the most extensive and accurate work on the subject of anatomy at the time and, as such, constituted a foundation of great importance for biology. Perhaps Vesalius's greatest contribution, however, was that he inspired a group of younger scientists to be critical and to accept a description only after they had verified it. Thus, as anatomists became more questioning and critical of the works of others, the errors of Galen were exposed. Of Vesalius's successors, Michael Servetus, a Spanish theologian and physician, discovered the pulmonary circulation of the blood from the right chamber of the heart to the lungs and stated that the blood did not pass through the central septum (wall) of the heart, as had previously been believed.



Vesalius, Andreas; anatomy

Woodcut depicting Renaissance physician Andreas Vesalius teaching anatomy, from the title page of the first edition of *De humani corporis fabrica libri septem* (1543).

Photos.com/Thinkstock

Advances to the 20th century

Seventeenth-century advances in biology included the establishment of scientific societies for the dissemination of ideas and progress in the development of the microscope, through which scientists discovered a hitherto invisible world that had far-reaching effects on biology. Systematizing and classifying, however, dominated biology throughout much of the 17th and 18th centuries, and it was during that time that the importance of the comparative study of living organisms, including humans, was realized. During the 18th century the long-held idea that living organisms could originate from nonliving matter (spontaneous generation) began to crumble, but it was not until after the mid-19th century that it was finally disproved by the French chemist and microbiologist Louis Pasteur, who demonstrated the self-replicating ability of microorganisms.

Biological expeditions added to the growing body of knowledge of plant and animal forms and led to the 19th-century development of the theory of evolution. The 19th century was one of great progress in biology: in addition to the formulation of the theory of evolution, the cell theory was established, the foundations for modern embryology were laid, and the laws of heredity were discovered.

The discovery of the circulation of blood

In the early 17th century, the English physician William Harvey, who studied at Padua with one of Vesalius's students, became the first to describe the full circulation of the blood through the human body. Prior to Harvey, blood was supposed to be consumed by the body and produced anew rather than continually circulated. It had also been suggested that the blood flowed through pores between the two halves of the heart and that the heart produced a vital heat, which was tempered by the air from the lungs. In his own work, however, Harvey demonstrated that the heart expands passively and contracts actively. By measuring the amount of blood flowing from the heart, he concluded that the body could not continuously produce that amount. He also was able to show that blood is returned to the heart through the veins, postulating a connection (the capillaries) between the arteries and veins that was not to be discovered until later in the 17th century. Harvey was also interested in embryology, to which he made a significant contribution by suggesting that there is a stage (the egg) in the development of all animals during which they are undifferentiated living masses. A biological dictum, *ex ovo omnia* ("everything comes from the egg"), is a summation of that concept.

The development of the microscope

The magnifying power of segments of glass spheres was known to the Assyrians before the time of Christ; during the 2nd century CE, Claudius Ptolemy, an astronomer, mathematician, and geographer at Alexandria, wrote a treatise on optics in which he discussed the phenomena of magnification and refraction as related to such lenses and to glass spheres filled with water. Despite that knowledge, however, glass lenses were not used extensively until around 1300 (an anonymous person invented spectacles for the improvement of vision probably in the late 1200s). That invention aroused curiosity concerning the property of lenses to magnify, and in the 16th century several papers were written about such devices. Then, in the late 16th century, the Dutch optician Hans Jansen and his son Zacharias invented the compound microscope. The utility of that instrument in the biological sciences, however, was not realized until the following century. Following subsequent technological improvements in the instrument and the development of a more-liberal attitude toward scientific research, five microscopists emerged who were to have a profound affect on biology: Marcello Malpighi, Antonie van Leeuwenhoek, Jan Swammerdam, Nehemiah Grew, and Robert Hooke.

Malpighi's animal and plant studies

The Italian biologist and physician Marcello Malpighi conducted extensive studies in animal anatomy and histology (the microscopic study of the structure, composition, and function of tissues). He was the first to describe the inner (malpighian) layer of the skin, the papillae of the tongue, the outer part (cortex) of the cerebral area of the brain, and the red blood cells. He wrote a detailed monograph on the silkworm; a further major contribution was a description of the development of the chick, beginning with the 24-hour stage. In addition to those and other animal studies, Malpighi made detailed investigations in plant anatomy. He systematically described the various parts of plants, such as bark, stem, roots, and seeds, and discussed processes such as germination and gall formation. Many of Malpighi's drawings of plant anatomy remained unintelligible to botanists until the structures were rediscovered in the 19th century. Although Malpighi was not a technical innovator, he does exemplify the functioning of the educated 17th-century mind, which, together with curiosity and patience, resulted in many advances in biology.

The discovery of "animalcules"

Antonie van Leeuwenhoek, a Dutchman who spent most of his life in Delft, sold cloth for a living. As a young man, however, he became interested in grinding lenses, which he mounted in gold, silver, or copper plates. Indeed, he became so obsessed with the idea of making perfect lenses that he neglected his business and was ridiculed by his family and neighbours. Using single lenses rather than compound ones (a system of two or more), Leeuwenhoek achieved magnifications from 40 to 270 diameters, a remarkable feat for hand-ground lenses. Among his most-conspicuous observations was the discovery in 1675 of the existence in stagnant water and prepared infusions of many protozoans, which he called animalcules. He observed the connections between the arteries and veins; gave particularly fine accounts of the microscopic structure of muscle, the lens of the eye, the teeth, and other structures; and recognized bacteria of different shapes, postulating that they must be on the order of 25 times as small as the red blood cell. Because that is the approximate size of bacteria, it indicates that his observations were accurate.

Grew's anatomical studies of plants

Nehemiah Grew was educated at Cambridge and is regarded by some as one of the founders of plant anatomy. In 1672 he published the first of his great works, *The Anatomy of Vegetables Begun*, followed in 1682 by *The Anatomy of Plants*. Although Grew clearly recognized cells in plants, referring to them as vesicles, or bladders, their biological significance evaded him. He is best known for his recognition of flowers as the sexual organs of plants and for his description of their parts. He also described the individual pollen grains and observed that they are transported by bees, but he did not realize the significance of that observation. Twelve years after the publication of *The Anatomy of Plants*, a German physician utilized Grew's anatomical studies in experiments to verify sexual reproduction in plants.

The discovery of cells

Of the five microscopists, Robert Hooke was perhaps the most intellectually preeminent. As curator of instruments at the Royal Society of London, he was in touch with all new scientific developments and exhibited interest in such disparate subjects as flying and the construction of clocks. In 1665 Hooke published his *Micrographia*, which was primarily a review of a series of observations that he had made while following the development and improvement of the microscope. Hooke described in detail the structure of feathers, the stinger of a bee, the radula, or "tongue," of mollusks, and the foot of the fly. It is Hooke who coined the word *cell*; in a drawing of the microscopic structure of cork, he showed walls surrounding empty spaces and referred to the structures as cells. He described similar structures in the tissue of other trees and plants and discerned that in some tissues the cells were filled with a liquid while in others they were empty. He therefore supposed that the function of the cells was to transport substances through the plant.

The use of structure for classifying organisms

Two systematists of the 17th and 18th centuries were the English naturalist John Ray and the Swedish naturalist and explorer Carolus Linnaeus. Ray, who studied at Cambridge, was particularly interested in the work of the ancient compilers of herbals, especially those who had attempted to formulate some means of classification. Recognizing the need for a classification system that would apply to both plants and animals, Ray employed in his classification schemes extremely precise descriptions for genera and species. By basing his system on structures, such as the arrangement of toes and teeth in animals, rather than colour or habitat, Ray introduced a new and very important concept to taxonomic biology.

Reorganization of groups of organisms

Prior to Linnaeus, most taxonomists started their classification systems by dividing all the known organisms into large groups and then subdividing them into progressively smaller groups. Unlike his predecessors, Linnaeus began with the species, organizing them into larger groups or genera, and then arranging analogous genera to form families and related families to form orders and classes. Probably utilizing the earlier work of Grew and others, Linnaeus chose the structure of the reproductive organs of the flower as a basis for grouping the higher plants. Thus, he distinguished between plants with real flowers and seeds (phanerogams) and those lacking real flowers and seeds (cryptogams), subdividing the former into hermaphroditic (bisexual) and unisexual forms. For animals, following Ray's work, Linnaeus relied upon teeth and toes as the basic characteristics of mammals; he used the shape of the beak as the basis for bird classification. Having demonstrated that a binomial classification system based on concise and accurate descriptions could be used for the grouping of organisms, Linnaeus established taxonomic biology as a discipline.

Later developments in classification were initiated by the French biologists Comte de Buffon, Jean-Baptiste Lamarck, and Georges Cuvier, all of whom made lasting contributions to biological science, particularly in comparative studies. Subsequent systematists have been chiefly interested in the relationships between animals and have endeavoured to explain not only their similarities but also their differences in broad terms that encompass, in addition to structure, composition, function, genetics, evolution, and ecology.

The development of cell theory

Although the microscopists of the 17th century had made detailed descriptions of plant and animal structure and though Hooke had coined the term *cell* to describe the compartments he had observed in cork tissue, their observations lacked an underlying theoretical unity. It was not until 1838 that the German botanist Matthias Jacob Schleiden, interested in plant anatomy, stated that "the lower plants all consist of one cell, while the higher ones are composed of (many) individual cells." When the German physiologist Theodor Schwann, Schleiden's friend, extended the cellular theory to include animals, he thereby brought about a rapprochement between botany and zoology. The formation of the cell theory—all plants and animals are made up of cells—marked a great conceptual advance in biology, and it resulted in renewed attention to the living processes that go on in cells.

In 1846, after several investigators had described the streaming movement of the cytoplasm in plant cells, the German botanist Hugo von Mohl coined the word *protoplasm* to designate the living substance of the cell. The concept of protoplasm as the physical basis of life led to the development of cell physiology.

A further extension of the cell theory was the development of cellular pathology by the German scientist Rudolf Virchow, who established the relationship between abnormal events in the body and unusual cellular activities. Virchow's work gave a new direction to the study of pathology and resulted in advances in medicine.

The detailed description of cell division was contributed by the German plant cytologist Eduard Strasburger, who observed the mitotic process in plant cells and further demonstrated that nuclei arise only from preexisting nuclei. Parallel work in mammals was carried out by the German anatomist Walther Flemming, who published his most important findings in *Zellsubstanz, Kern und Zelltheilung* ("Cell Substance, Nucleus and Cell Division") in 1882.

The theory of evolution

As knowledge of plant and animal forms accumulated during the 16th, 17th, and 18th centuries, a few biologists began to speculate about the ancestry of those organisms, though the prevailing view was that promulgated by Linnaeus—namely, the immutability of the species. Among the early speculations voiced during the 18th century, the British physician Erasmus Darwin (grandfather of Charles Darwin), concluded that species descend from common ancestors and that there is a struggle for existence among animals. The French biologist Jean-Baptiste Lamarck, among the most important of the 18th-century evolutionists, recognized the role of isolation in species formation; he also saw the unity in nature and conceived the idea of the evolutionary tree.

A complete theory of evolution was not announced, however, until the publication in 1859 of Charles Darwin's *On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life*. In his book Darwin stated that all living creatures multiply so rapidly that if left unchecked they would soon overpopulate the world. According to Darwin, the checks on population size are maintained by competition for the means of life. Hence, if any member of a species differs in some way that makes it better fitted to survive, then it will have an advantage that its offspring would be likely to perpetuate. Darwin's work reflects the influence of the British economist Thomas Robert Malthus, who in 1838 published an essay on population in which he warned that if humans multiply more rapidly than their food supply, competition for existence will result. Darwin was also influenced by the British geologist Charles Lyell, who realized from his studies of geological formations that the relative ages of deposits could be estimated by means of the proportion of living and extinct mollusks. But it was not until after his travels aboard the *Beagle* (1831–36), during which he observed a great richness and diversity of island fauna, that Darwin began to develop his theory of evolution. Alfred Russel Wallace had reached conclusions similar to those of Darwin following his studies of plants and animals in the Malay Archipelago. A short paper dealing with this subject sent by Wallace to Darwin finally resulted in the publication of Darwin's own theories.

Conceptually, the theory was of the utmost significance, accounting as it did for the formation of new species. Following the subsequent discovery of the chromosomal basis of inheritance and the laws of heredity, it could be seen that natural selection does not involve the sharp alternatives of life or death but results from the differential survival of variants. Today the universal principle of natural selection, which is the central concept of Darwin's theory, is firmly established.

Mendelian laws of heredity

The fame of Gregor Mendel, the father of genetics, rests on experiments he did with garden peas, which possess sharply contrasting characteristics—for example, tall versus short; round seed versus wrinkled seed. When Mendel fertilized short plants with pollen from tall plants, he found the offspring (first filial generation) to be uniformly tall. But if he allowed the plants of that generation to self-pollinate (fertilize themselves), their offspring (the second filial generation) exhibited the characters of the grandparents in a rather consistent ratio of three tall to one short. Furthermore, if allowed to self-pollinate, the short plants always bred true—they never produced anything but short plants. From those results Mendel developed the concept of dominance, based on the supposition that each plant carried two trait units, one of which dominated the other. Nothing was known at that time about chromosomes or meiosis, yet Mendel deduced from his results that the trait units, later called genes, could be a kind of physical particle that was transmitted from one generation to another through the reproductive mechanism.

Mendel's most-important concept was the idea that the paired genes present in the parent separate or segregate during the formation of the gametes. Moreover, in later experiments in which he studied the inheritance of two pairs of traits, Mendel showed that one pair of genes is independent of another. Thus, the principles of segregation and of independent assortment were established.

Mendel's findings were ignored for 35 years, probably for two reasons. Because the distinguished Swiss botanist Karl Wilhelm von Nägeli failed to recognize the significance of the work after Mendel sent him the results, he did nothing to encourage Mendel. Nägeli's great prestige and the lack of his endorsement indirectly weighed against widespread recognition of Mendel's work. Moreover, when the work was published, little was known about the cell, and the processes of mitosis and meiosis were completely unknown. Mendel's work was finally rediscovered in 1900, when three botanists independently recognized the worth of his studies from their own research and cited his publication in their work.

Biology in the 20th and 21st centuries

Just as the 19th century can be considered the age of cellular biology, the 20th and 21st centuries were characterized primarily by developments in molecular biology.

Important conceptual and technological developments

By utilizing modern methods of investigation, such as X-ray diffraction and electron microscopy, to explore levels of cellular organization beyond that visible with a light microscope—the ultrastructure of the cell—new concepts of cellular function were produced. As a result, the study of the molecular organization of the cell had tremendous impact on biology during the 20th and 21st centuries. It also led directly to the convergence of many different scientific disciplines in order to acquire a better understanding of life processes.

Technologies such as DNA sequencing and the polymerase chain reaction also were developed, allowing biologists to peer into the genetic blueprints that give rise to organisms. First-generation sequencing technologies emerged in the 1970s and were followed several decades later by so-called next-generation sequencing technologies, which were superior in speed and cost-efficiency. Next-generation sequencing provided researchers with massive amounts of genetic data, typically gigabases in size (1 gigabase = 1,000,000,000 base pairs of DNA). Bioinformatics, which linked biological data with tools and techniques for data analysis, storage, and distribution, became an increasingly important part of biological studies, particularly those involving very large sets of genetic data.

Coping with problems of the future

Of particular consequence in the biological sciences was the development of genetic engineering. In cases of genetic deficiencies and disease, genetic engineering opened up the possibility of correcting gene defects to restore physiological function, potentially improving patients' quality of life. Gene therapy, in which a normal gene would be introduced into an individual's genome in order to repair a disease-causing mutation, was one means by which researchers could potentially achieve that goal. However, the possibilities for misuse of genetic engineering were vast. There was significant concern, for example, about genetically modified organisms, particularly modified crops, and their impacts on human and environmental health. The emergence of cloning technologies, including somatic cell nuclear transfer, also raised concerns. The Declaration on Human Cloning passed in 2005 by the United Nations called upon member states to prohibit the cloning of humans, though it left open the pursuit of therapeutic cloning.

Similarly, in 2015, researchers who had developed technologies for gene editing, which enabled scientists to customize an organism's genetic makeup by altering specific bases in its DNA sequence, called for a moratorium on the application of the technologies in humans. The impacts of gene editing on human genetics were unknown, and there were no regulations in place to guide its use. Indeed, in the absence of strict regulation, a Chinese scientist moved forward with gene editing in humans, in late 2018 claiming the birth of the world's first babies carrying edited genomes. The scientist claimed to have edited human embryos to disable a gene that normally facilitates the entry of HIV into cells; the embryos were then implanted into a woman and carried to term. Meanwhile, researchers in the United States attempted to use gene editing to alter genes in human sperm, which would enable the edited genes to be passed on to subsequent generations. In particular, the researchers sought to alter genes that increase the risk of certain types of cancer, with the aim of reducing cancer risk in offspring. The debate over gene editing renewed earlier discussions about the ethical and social impacts of genetic engineering in humans, especially its potential to be used to alter traits such as intelligence and appearance.

Other challenges confronting biologists included the search for ways to curb environmental pollution without interfering with efforts to improve the quality of life for humankind. Contributing to the problem of pollution was the problem of surplus human population. A rise in global human population had placed greater demands on the land, especially in the area of food production, and had necessitated increases in the operations of modern industry, the waste products of which contributed to the pollution of air, water, and soil. To find solutions to global warming, pollution, and other environmental problems, biologists worked with social scientists and other members of society in order to determine the requirements necessary for maintaining a healthy and productive planet. For although many of humankind's present and future problems may seem to be essentially social, political, or economic in nature, they have biological ramifications that could affect the very existence of life itself.

Top ten biological discoveries

Biology is a fascinating and diverse subject area. If you're thinking of studying biology, here are ten famous discoveries to inspire you.

Aristotle (384–322 BC): classification of living things

Ancient Greek philosopher Aristotle isn't often considered when it comes to great biological discoveries, but his work on the classification of living things was revolutionary. Referred to as the 'Ladder of Life', Aristotle's classification system was used up until the 19th century. He was the first person to recognise the relationships between species, and organise accordingly.

Galen (129–161 AD): early medical experimentation

The work of Greek physician Galen revolutionised the way medical research is conducted. Galen had a major influence on the development of many fields of medicine including anatomy, pathology, physiology and neurology. Notable discoveries include the identification of the differences between veins and arteries, and recognising that the larynx generates voice. Much of his hypotheses had scientific errors but his work in pioneering the field of medical research is undeniable.

Antonie van Leeuwenhoek (1632–1723): microbiology

Antonie van Leeuwenhoek is well known for his contributions to microscopy and how he applied this to the field of biology. He revolutionised a technique for creating powerful lenses, which some speculate were able to magnify up to 500 times. Leeuwenhoek used the microscopes to find out more about the living world – his discoveries include bacteria, the vacuole of the cell and the banded pattern of muscle fibres.

Carl Linnaeus (1707–1775): modern taxonomy

A botanist, physician and zoologist, Carl Linnaeus came up with the system of naming, ranking and classifying organisms we still use today. It was his vast collection of specimens of plants, animals and shells that led him to think up a way of grouping and naming species. He separated all living things into three kingdoms – animals, plants and minerals – subdivided them into classes, then into orders and finally into genera and species. Take 'homo sapiens' – 'homo' is the genus and 'sapiens' the species.

Charles Darwin (1809–1882): theory of evolution

Probably the most famous naturalist of all time, Charles Darwin's contribution to biology and society is immense. He established that all species of life descended over time from common ancestors, with species continuing to exist through the process of natural selection. His theory of evolution was published in *On the Origin of Species* in 1859 and it caused quite the stir – he was disputing the long-held belief that all species had been created by God at the beginning of the world. Evolution by natural selection combined with Mendelian genetics is now accepted as the modern evolutionary synthesis and forms the foundations of much biological scientific endeavour.

Gregor Mendel's extraordinary contribution didn't get the recognition it deserved until long after the friar's death. He used peas to discover and demonstrate the laws of genetic inheritance, coining the terms ‘dominant’ and ‘recessive’ genes in the process. The laws were rediscovered at the turn of the 20th century and provided the mechanism for Darwin's theory of natural selection to occur. The two theories combine to form our current understanding of the evolutionary process.

Barbara McClintock (1902–1992): jumping genes

American geneticist Barbara McClintock spent her career analysing maize, where she developed a technique for identifying and examining chromosomes individually. Despite it not being immediately recognised, her work made it possible for us to map human genomes. She was awarded the Nobel Peace Prize in 1983 for her discovery of transposition and how genes could turn their physical characteristics on and off.

Watson (1928–) and Crick (1916–2004): DNA structure

James Watson and Francis Crick shot to fame in 1962 for their discovery of the structure of DNA, winning the medical Nobel Prize in the process. Their model of DNA (double helix) explains how DNA replicates, and hereditary info is coded and passed on. The discovery of structure has led to a much more developed understanding of function – used in disease diagnosis and treatment, forensics and more.

Jane Goodall (1934–): understanding chimpanzees

Our knowledge of wildlife and conservation has been transformed by Jane Goodall, the UK ethologist. Best known for her career-long studies of chimpanzees, she discovered the animals are omnivores and tool users. She's a global leader in animal rights and was awarded a PhD degree from the University of Cambridge without holding a bachelor's degree.

Wilmut (1944–) and Campbell (1954–2012): cloning a mammal

In 1996 Ian Wilmut and Keith Campbell cloned a mammal, famously named Dolly the Sheep. The pair cloned Dolly using a single adult sheep cell and a process of nuclear transfer. Dolly died after six years but cloning continues, although still not perfected and certainly not ready for human application (yet).

Contribution of famous Muslim scientists in the field of Biology

There are great contributions of Muslims scientists in Biology especially dealing with plants and animals.

Ali Alhassan Ibn Al-Haytham

1- Ibn al- Haitham

Ali Alhassan Ibn Al-Haytham (Basra, Iraq 965 – 1040)

Introduction

Ibn al-Haytham was an astronomer, biologist, mathematician, and physicist. His full name was Abu Ali al-Ḥasan, ibn al-Ḥasan, ibn al-Haytham Latinized as ***Alhazen.*** He was born in a small village of Basra(Iraq) in 965 AD. He was invited to Egypt for help to build a dam on the Nile. Then he settled in Cairo where he wrote a book which gave him enormous success, **Kitab al-Manazir**, a book on optics. Al-Haytham wrote approximately 200 books on science.

(list of books by Ibn al Haytham). After serving science he died at the age of **74 in about 1040 in Cairo, Egypt.**

Achievements

- He totally changed the ancient theories about light and the process of vision, by observing the pathway of light entering a dark room. He not only described different parts of the eye but also explained how light travel within the eye and forms image. He gave names to several parts of the eye, such as the lens, the retina, and the cornea.
- **Book of Optics**: Ibn al Haytham also set new standards in experimentation and wrote his great book "**Kitabul Manazir" in about 1021** in Arabic, which was later translated with the title of "**Book of Optics**" around 1027.
- His Book of Optics was translated into Latin and other languages and is the most influential book written on optics that is why he is also called the **father of optics**. Before his book two theories of vision were present, the extra mission ***or emission theory*** presented by ***Euclid and Ptolemy,*** and the ***intromission theory*** given by the followers of ***Aristotle and Galen.*** Ibn al Haytham presented his own theory of vision and said that light coming from the infinite number of points from an object, enters the eye to make objects visible.
- He also wrote another book on humans titled as**"Mizanul- Hikma".**

Abdulmalik Al-Asma'i bin Quraib Al-Asma'i

2- Abdul Malik Asmai (Basra, Iraq 740 – 828 A.D)

Introduction

His full name is **Abu Saeed, Abd al-Malik ibn Quraib al-Aṣma**. He was born in Basra, Iraq in 740 A.D. and died there in 828 A.D.

He worked on various subjects such as poetry, Arabic grammar, Botany, zoology and animal husbandry. He was also interested in breeding horses and camels and the classification of plants.

He is regarded as the first Muslim zoologist because he is the first Muslim scientist who studied animals in detail.

Achievements

Major books on biology written by him are

- Disposition of Man or Humanity (كتاب خلق الانسان) – *Kitab Khalaq al-Insan*
- Horses (كتاب الخيل) – *Kitāb al-Khail*
- The Camel (كتاب الابل) – *Kitāb al-Ibil*

- Sheep (كتاب الشاء) – *Kitāb al-Shā*
- Wild Beasts (كتاب الوحوش) – *Kitab al-Wuhush*
- *Kitab al farq, The book of rare animals*
- *His botanical work includes 276 plant species, such as dates, figs, olives, etc.*

Bu Ali Sena

3- Bu Ali Sina

(Bukhara, Uzbekistan, 980-1037 A.D.)

Introduction

Ibn-Sina (Latinized, Avicenna) was born in Bukhara, present-day Uzbekistan, in 980 AD. He was a ***physician, philosopher, astronomer, and poet***. He was died at the age of 56, in June 1037 in Hamadan, Iran.

Bu-Ali Sina wrote hundreds of books, among which two are the most prominent ***"Al-Qanoon Fit Tib" and "Kitab Al-Shifa".*** He is regarded as the founder of medicine and is acknowledged in medicines, by the expert of his time in east and west.

Achievements

- Ibne Sina wrote his famous book **"Al-Qanoon Fit Tib" translated in English as** "*The Canon of Medicine*", an encyclopedia of medicine. He also wrote another marvelous encyclopedia named "**Kitab Al-Shifa" (The Book of Healing**) focusing on science and philosophy.
- He worked on **psychology** and described several human psychological disorders and their causes. He described the relationship between mental and physical activities of the body, defining how the mind affects mood and behavior in humans.
- He wrote on almost every discipline i.e. **physics, mathematics, medicine, geology and geography, astronomy, human biology, chemistry, Islamic theology, logic, and poetry.** He wrote almost 450 texts over 240 survived, most of them were in philosophy.

Chapter 2 Nature of Science and the Scientific Method

Introduction

Before one can discuss the teaching and learning of science, consensus is needed about what science is and why it should occupy a place in the curriculum. One must ask: “What is science”? and “Why teach it”? A consensus answer to these fundamental questions is not easily attained, because science is characterized in different ways not only by different categories of people interested in it—practitioners, philosophers, historians, educators—but also by people *within* each of these broad categories. we should describe some different characterizations of science and consider implications for what is taught in science classrooms. Although the characterizations share many common features, they vary in the emphasis and priority they place on different aspects of scientific activity, with potential consequences for what is emphasized in science classrooms. We then describe the goals of science education associated with each perspective.

WHAT IS SCIENCE?

Science is both a body of knowledge that represents current understanding of natural systems and the process whereby that body of knowledge has been established and is being continually extended, refined, and revised. Both elements are essential: one cannot make progress in science without an understanding of both. Likewise, in learning science one must come to understand both the body of knowledge and the process by which this knowledge is established, extended, refined, and revised. The various perspectives on science—alluded to above and described below—differ mainly with respect to the process of science, rather than its product. The body of knowledge includes specific facts integrated and articulated into

The Definition of Science

Science is not merely a collection of facts, concepts, and useful ideas about nature, or even the systematic investigation of nature, although both are common definitions of science. Science is a method of investigating nature--a way of knowing about nature--that discovers reliable knowledge about it. In other words, science is a method of discovering reliable knowledge about nature. There are other methods of discovering and learning knowledge about nature (these other knowledge methods or systems will be discussed below in contradistinction to science), but science is the only method that results in the acquisition of reliable knowledge.

Different Perspectives on the Process of Science

Those who study the nature of science and the learning of science have a variety of perspectives not only on key elements of scientific practice and skills, but also on

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different ways to study the nature of science The committee recognizes that these different perspectives are not mutually exclusive and that, in considering how best to teach science, each can identify certain elements that need to be given their due attention. We summarize the key elements of a number of these viewpoints.1

Science as a Process of Logical Reasoning About Evidence

One view of science, favored by many psychologists who study scientific reasoning, emphasizes the role of domain-general forms of scientific reasoning about evidence, including formal logic, heuristics, and problem-solving strategies. Among psychologists, this view was pioneered by the work of Inhelder and Piaget (1958) on formal operations, on concept development, the type of evidence that people seek when testing their hypotheses. The image of scientist-as-reasoner continues to be influential in contemporary research. In this view, learning to think scientifically is a matter of acquiring problem-solving strategies for coordinating theory and evidence, mastering counterfactual reasoning (Leslie, 1987), distinguishing patterns of evidence that do and do not support a definitive conclusion (Amsel and Brock, 1996; Beck and Robinson, 2001; Fay and Klahr, 1996; Vellom and Anderson, 1999), and understanding the logic of experimental These heuristics and skills are considered important targets for research and for education because they are assumed to be widely applicable and to reflect at least some degree of domain generality and transferability

Science as a Process of Theory Change

This view places emphasis on the parallel between historical and philosophical aspects of science) and the domains of cognitive development in which domain-specific knowledge evolves via the gradual elaboration of existing theories through the accretion of new facts and knowledge (punctuated, occasionally, by the replacement of one theoretical framework by another. The science-as-theory perspective places its emphasis less on the mastery of domain-general logic, heuristics, or strategies and more on

1 This discussion of the different views of science is

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processes of conceptual or theory change. In this view, at critical junctures, as evidence anomalies build up against the established theory, there can occur wholesale restructurings of the theoretical landscape—a paradigm shift,

Science as a Process of Participation in the Culture of Scientific Practices

The view of science as practice is emphasized by anthropologists, ethnographers, social psychologists, and the cognitive and developmental psychologists who study “situated cognition” This view focuses on the nature of scientific activity, both in the short term (e.g., studies of activity in a particular laboratory or a program of study) and historically, published texts, eyewitness accounts). Science as practice suggests that theory development and reasoning are components of a larger ensemble of activity that includes networks of participants and institutions specialized ways of talking and writing

This perspective serves as a useful foil to the tendency of "pure" cognitive approaches to science to minimize the fact that individual scientists or groups of scientists are always part of a wider social environment, inside and outside science, with which they are in constant communication and which has strongly shaped their knowledge, skills, resources, motives, and attitudes.

What is Science?

Science is a methodical approach to studying the natural world. Science asks basic questions, such as how does the world work? How did the world come to be? What was the world like in the past, what is it like now, and what will it be like in the future? These questions are answered using observation, testing, and interpretation through logic.

Most scientists would not say that science leads to an understanding of the truth. Science is a determination of what is most likely to be correct at the current time with the evidence at our disposal. Scientific explanations can be inferred from confirmable data only, and observations and experiments must be reproducible and verifiable by other individuals. In other words, good science is based on information that can be measured or seen and verified by other scientists.

The scientific method, it could be said, is a way of learning or a process of using comparative critical thinking. Things that are not testable or falsifiable in some scientific or mathematical way, now or in the future, are not considered science. Falsifi - ability is the principle that a proposition or theory cannot be scientific if it does not admit the possibility of being shown false.

Science takes the whole universe and any and all phenomena in the natural world under its purview, limited only by what is feasible to study given our current physical and fi scal limitations. Anything that cannot be observed or measured or shown to be false is not amenable to scientifi c investigation. Explanations that cannot be based on empirical evidence are not a part of science (National Academy of Sciences, 1998).

Science is, however, a human endeavor and is subject to personal prejudices, misapprehensions, and bias. Over time, however, repeated reproduction and verification of observations and experimental results can overcome these weaknesses. That is one of the strengths of the scientific process. Scientific knowledge is based on some assumptions (after

Nickels, 1998), such as

• The world is REAL; it exists apart from our sensory perception
of it.

• Humans can accurately perceive and attempt to understand
the physical universe.

• Natural processes are sufficient to explain or account for natural phenomena or events. In other words, scientists must explain the natural in terms of the natural (and not the supernatural, which, lacking any independent evidence, is not falsifiable and therefore not science), although humans may not currently recognize what those processes are.

• By the nature of human mental processing, rooted in previous experiences, our perceptions may be inaccurate or biased.

• Scientific explanations are limited. Scientific knowledge is necessarily contingent knowledge rather than absolute, and therefore must be evaluated and assessed, and is subject to modification in light of new evidence. It is impossible to know if we have thought of every possible alternative explanation or every variable, and technology may be limited.

• Scientific explanations are probabilistic. The statistical view of nature is evident implicitly or explicitly when stating scientific predictions of phenomena or explaining the likelihood of events in actual situations.

As stated in the National Science Education Standards for the Nature of Science:

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (NSES, 1996, p. 171)

Nature of Science and the Scientific Method

“The most incomprehensible thing about the world is that it is

Nature of Science and the Scientific Method

“The most incomprehensible thing about the world is that it is comprehensible.”

The Standards for Science Teacher Preparation correctly

state that Understanding of the nature of science—the goals, values and assumptions inherent in the development and interpretation of scientific knowledge (Lederman, 1992)—has been an objective of science instruction since at least the turn of the last century. It is regarded in contemporary documents as a fundamental attribute of science literacy and a defense against unquestioning acceptance of pseudoscience and of reported research. Knowledge of the nature of science can enable individuals to make more informed decisions with respect to scientifically based issues; promote students’ in-depth understandings of “traditional” science subject matter; and help them distinguish science from other ways of knowing…

Research clearly shows most students and teachers do not adequately understand the nature of science. For example, most teachers and students believe that all scientific investigations adhere to an identical set of steps known as the scientific method, and that theories are simply immature laws. Even when teachers understand and support the need to include the nature of science in their instruction, they do not always do so. Instead they may rely upon the false assumption that doing inquiry leads to understanding of science. Explicit instruction is needed both to prepare teachers and to lead students to understand the nature of science. (NSTA, 2003, and references therein, p. 16)

Scientific Method

Throughout the past millennium, there has been a realization by leading thinkers that the acquisition of knowledge can be performed in such a way as to minimize inconsistent conclusions. Rene Descartes established the framework of the scientific method in 1619, and his first step is seen as a guiding principle for many in the field of science today:

…never to accept anything for true which I did not clearly know to be such; that is to say, carefully to avoid precipitancy and prejudice, and to compromise nothing more in my judgment than what was presented to my mind so clearly and distinctly as to exclude all ground of methodic doubt

By sticking to certain accepted “rules of reasoning,” scientific method helps to minimize influence on results by personal, social, or unreasonable influences. Thus, science is seen as a pathway to study phenomena in the world, based upon reproducibly testable and verifiable evidence. This pathway may take different forms; in fact, creative flexibility is essential to scientific thinking, so there is no single method that all scientists use, but each must ultimately have a conclusion that is testable and falsifiable; otherwise, it is not science.

The scientific method in actuality isn’t a set sequence of procedures that must happen, although it is sometimes presented as such. Some descriptions actually list and number three to fourteen procedural steps. No matter how many steps it has or what they cover, the scientific method does contain elements that are applicable to most experimental sciences, such as physics and chemistry, and is taught to students to aid their understanding of science. That being said, it is most important that students realize that the scientific method is a form of critical thinking that will be subjected to review and independent duplication in order to reduce the degree of uncertainty. The scientific method may include some or all of the following "steps" in one form or

another: observation, defining a question or problem, research (planning, evaluating current evidence), forming a hypothesis, prediction from the hypothesis (deductive reasoning), experimentation (testing the hypothesis), evaluation and analysis, peer review and evaluation, and publication.

Observation

The first process in the scientific method involves the observation of a phenomenon, event, or "problem." The discovery of such a phenomenon may occur due to an interest on the observer's part, a suggestion or assignment, or it may be an annoyance that one wishes to resolve. The discovery may even be by chance, although it is likely the observer would be

in the right frame of mind to make the observation. It is said that as a boy, Albert Einstein wanted to know what it would be like to ride a light beam, and this curious desire stuck with him throughout his education and eventually led to his incredible theories of electromagnetism. Question Observation leads to a question that needs to be answered to satisfy human curiosity about the observation, such as why or how this event happened or what it is like (as in the light beam). In order to develop this question, observation may involve taking measures to quantify it in order to better describe it. Scientific questions need to be answerable and lead to the formation of a hypothesis about the problem.

Hypothesis

To answer a question, a hypothesis will be formed. This is an educated guess regarding the question’s answer. Educated is highlighted because no good hypothesis can be developed without research into the problem. Hypothesis development depends upon a careful characterization of the subject of the investigation. Literature on the subject must be researched, which is made all the easier these days by the Internet (although sources must be verifi ed; preferably, a library data base should be used). Sometimes numerous working hypotheses may be used for a single subject, as long as research indicates they are all applicable. Hypotheses are generally consistent with existing knowledge and are conducive to further inquiry.

A scientific hypothesis has to be testable and also has to be falsifiable. In other words, there must be a way to try to make

the hypothesis fail. Science is often more about proving a scientific statement wrong rather than right. If it does fail, another hypothesis may be tested, usually one that has taken into consideration the fact that the last tested hypothesis failed. One fascinating aspect is that hypotheses may fail at one time but be proven correct at a later date (usually with more advanced technology). For example, Alfred Wegener’s idea that the continents have drifted apart from each other was deemed impossible because of what was known in the early 1900s about the composition of the continental crust and the oceanic crust.

Geophysics indicated the brittle, lighter continents could not drift or be pushed through dense ocean crust. Years later, it was shown that one aspect of Wegener’s idea, that the continents were once together, was most likely correct (although not as separate units but as part of a larger plate). These plates didn’t, however, have to plow through ocean crust. Instead, magma appears to have arisen between them and formed new oceanic crust while the plates carrying the continents diverged on either side The exact mechanism of how the plates were pushed apart from the rising magma, or were pulled apart, allowing magma to rise between them, or a combination of both, is still not completely understood. The hypothesis should also contain a prediction about its verifi ability. For example, if the hypothesis is true, then (1) should happen when (2) is manipulated. The first blank (1) is the dependent variable (it depends on what you are doing in the second blank) and the second blank (2) is the independent variable (you manipulate it to get a reaction). There should be no other variables in the experiment that may affect the dependent variable. One thing is clear about the requirement of the testability of hypotheses: it must exclude supernatural explanations. If the supernatural is defi ned as events or phenomena that cannot be perceived by natural or empirical senses, then they do not follow any natural rules or regularities and so cannot be scientifically tested. It would be diffi cult to test the speed of angels or the density of ghosts when they are not available in the natural world for scientific testing, although certainly people have tried to determine if such entities are real and testable, and it cannot be precluded that someday technology may exist that can test certain “supernatural” phenomenon.

Experiment Once the hypothesis has been established, it is time to test it. The process of experimentation is what sets science apart from other disciplines, and it leads to discoveries every day. An experiment is designed to prove or disprove the hypothesis.

If your prediction is correct, you will not be able to reject the hypothesis.

The average layperson may think of the above kind of picture when thinking of science experiments. This may be true in some disciplines, but not all. Einstein relied on mathematics to “predict” his hypotheses on the nature of space and time in the universe. His hypotheses had specifi c physical predictions about space-time, which were shown to be accurate sometimes years later with developing technology. Testing and experimentation can occur in the laboratory, in the field, on the blackboard, or the computer. Results of testing must be reproducible and verifiable. The data should be available to determine if the interpretations are unbiased and free from prejudice.

As the National Science Education Standards state:

In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.

It is interesting that other scientists may start their own research and enter the process of one scientist's work at any stage. They might formulate their own hypothesis, or they might adopt the original hypothesis and deduce their own predictions. Often, experiments are not done by the person who made the prediction, and the characterization is based on investigations done by someone else. Published results can also serve as a hypothesis predicting the reproducibility of those results.

Evaluation

All evidence and conclusions must be analyzed to make sure bias or inadequate effort did not lead to incorrect conclusions. Qualitative and quantitative mathematical analysis may also be applied. Scientific explanations should always be made

public, either in print or presented at scientific meetings. It should also be maintained that scientific explanations are tentative and subject to modification. Again, the National Science Education Standards state: It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models,

and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that

questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (NSES, 1996, p. 171)

Thus, evaluation is integral to the process of scientific method. One cannot overemphasize the importance of peer review to science, and the vigor with which it is carried out.

Full-blown academic battles have been wagged in scientific journals, and in truth, many scientific papers submitted to peer-reviewed journals are rejected. The evaluation process in science truly makes it necessary for scientists to be accurate, innovative, and comprehensive.

To better understand the nature of scientific laws or theories, make sure students understand the following definitions.

Definitions Fact:

1. A confirmed or agreed-upon empirical observation or conclusion.

2. Knowledge or information based on real occurrences: an account based on fact.

3. a. Something demonstrated
to exist or known to have existed: Genetic engineering is now a fact. That Einstein was a real person is an undisputed fact. b. A real occurrence; an event.

Hypothesis: An educated proposal to explain certain facts;
a tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation. Scientific Theory (or Law): An integrated, comprehensive explanation of many “facts,” especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena. A theory can often generate additional hypotheses and testable predictions. Theories can incorporate facts and laws and tested hypotheses.

Unfortunately, the common/non-scientific definition for theory is quite different, and is more typically thought of as a belief that can guide behavior. Some examples: “His speech was based on the theory that people hear only what they want to know” or “It’s just a theory.” Because of the nature of this definition, some people wrongly assume scientific theories are speculative, unsupported, or easily cast aside, which is very far from the truth. A scientific hypothesis that survives extensive experimental testing without being shown to be false becomes a scientific theory. Accepted scientific theories also produce testable predictions that are successful.

5 The Nature of Science and the Scientific Method

Theories are powerful tools (National Science Teachers Association, The Teaching of Evolution Position Statement): Scientists seek to develop theories that

- are firmly grounded in and based upon evidence;
- are logically consistent with other well-established principles;
- explain more than rival theories; and
- have the potential to lead to new knowledge.

Scientific theories are falsifiable and can be reevaluated or expanded based on new evidence. This is particularly important in concepts that involve past events, which cannot be tested. Take, for example, the Big Bang Theory or the Theory of Biological Evolution as it pertains to the past; both are theories that explain all of the facts so far gathered from the past, but cannot be verified as absolute truth, since we cannot go back to test them. More and more data will be gathered on each to either support or disprove them. The key force for change in a theory is, of course, the scientific method.

A scientific law, said Karl Popper, the famous 20th century philosopher, is one that can be proved wrong, like “the sun always rises in the east.” According to Popper, a law of science can never be proved; it can only be used to make a prediction that can be tested, with the possibility of being proved wrong. For example,

as the renowned biologist J.B.S. Haldane replied when asked what might disprove evolution, "Fossil rabbits in the pre-Cambrian."
So far that has not happened, and in fact the positive evidence for the "theory" of evolution is extensive, made up of hundreds of thousands of mutually corroborating observations. These come from areas such as geology, paleontology, comparative anatomy, physiology, biochemistry, ethnology, biogeography, embryology, and molecular genetics. Like evolution, most accepted scientific theories have withstood the test of time and falsify ability to
become the backbone of further scientific investigations.
Science Through the Recent Ages The term science is relatively modern. Nearly all civilizations, however, have evidence of methods, concepts, or techniques that were scientific in nature. Science has its historical roots in two primary sources: the technical tradition, in which practical experiences and skills were passed down and developed from one generation to another; and the spiritual tradition, in which human aspirations and ideas were passed on and augmented
Observations of the natural world and their application to daily activities assuredly helped the human race survive from the earliest times. In western society, it was not until the Middle Ages, however, that the two converged into
a more pragmatic method that produced results with both technical and philosophical implications.

An excellent example of the development of science and the scientific method is the demise of the geocentric view of the solar system. Although it strongly appears to the naked eye that the sun and moon go around Earth (geocentric), even ancient astral observers noted that stars moved in a different yearly pattern, and certain planets or “wanderers” had even stranger movements in the night sky. In the 16th and 17th centuries, observers began to make more detailed observations of the movements of the stars and planets, made increasingly complex with the aide of the newly invented telescope. Galileo improved the telescope enough to observe the phases of Venus as seen from Earth. With the application of mathematics to their precise measurements, it became obvious to astronomers like Copernicus, Kepler, and Galileo that the planets and Earth must revolve around the sun (heliocentric). It is necessary,

however, to backtrack here a little and make clear that, as early as the third century B.C., the Greek astronomer Aristarchus proposed that Earth orbited the sun. Earth’s spherical nature was not only well known by about 300 B.C., but good measurements of Earth’s circumference had already been made by that time. Unfortunately, throughout history, knowledge from one culture has not necessarily been passed on to other cultures or generations. New discoveries and technological advancements led to what is known as the Scientific Revolution, a period of time between Copernicus and Sir Isaac Newton during which a core transformation in “natural philosophy" (science) began in cosmology and astronomy and then shifted to physics. Most profoundly, some historians have argued, these changes in thinking brought important transformations in what came to be held as "real" and how Europeans justified their claims to knowledge.

The learned view of things in 16th-century thought was that the world was composed of Four Qualities (Aristotle's Earth, Water, Air, and Fire). By contrast, less than two centuries later Newton's learned contemporaries believed that the world was made of atoms or corpuscles (small material bodies). By Newton's day most of learned Europe believed the Earth moved, that there was no such thing as demonic possession, that claims to knowledge … should be based on the authority of our individual experience

What Are the Science Process Skills?

Science and teaching students about science means more than scientific knowledge. There are three dimensions of science that are all important. The first of these is the content of science, the basic concepts, and our scientific knowledge. This is the dimension of science that most people first think about, and it is certainly very important. The other two important dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. Since science is about asking questions and finding answers to questions, these are actually the same skills that we all use in our daily lives as we try to figure out everyday questions. When we teach students to use these skills in science, we are also teaching them skills that they will use in the future in every area of their lives. The third dimension of science focuses on the characteristic attitudes and dispositions of science. These include such things as being curious and imaginative, as well as being enthusiastic about asking questions and solving problems. Another desirable scientific attitude is a respect for the methods and values of science. These scientific methods and values include seeking to answer questions using some kind of evidence, recognizing the importance of rechecking data, and understanding that scientific knowledge and theories change over time as more information is gathered.

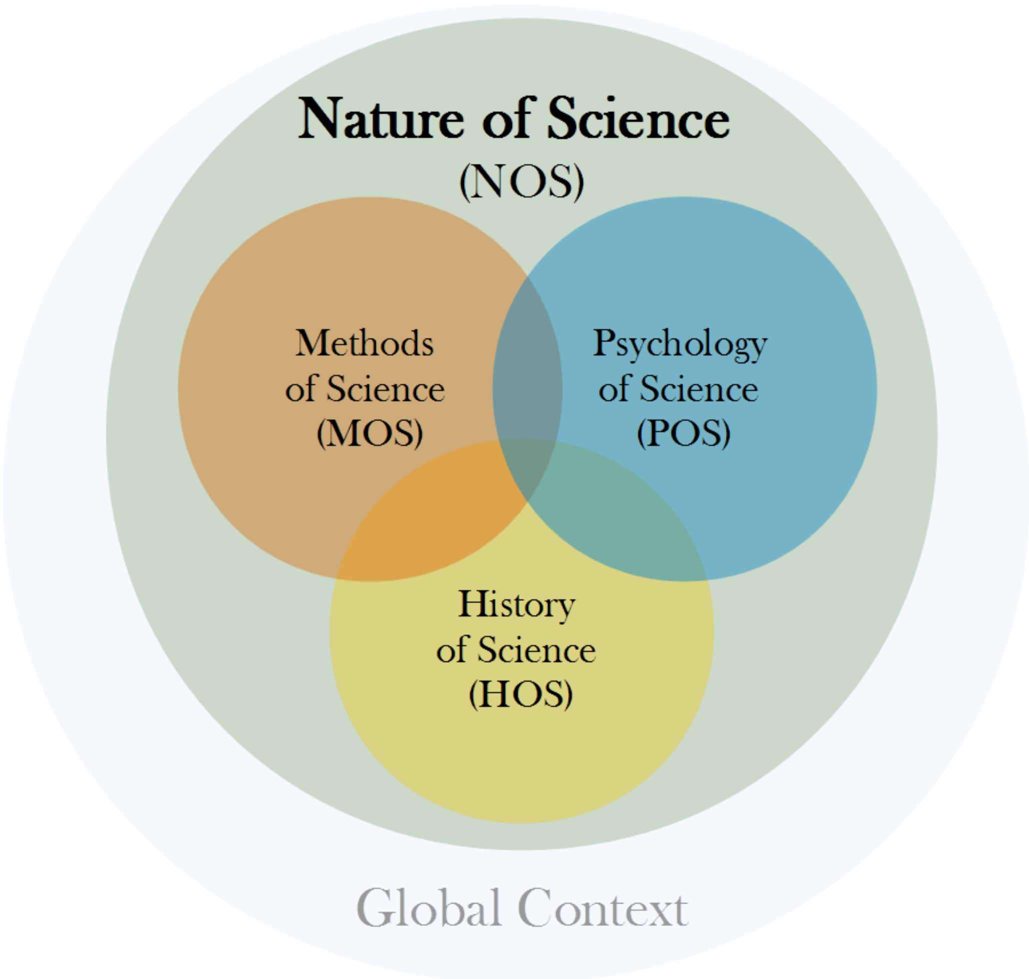
SIX BASIC PROCESS SKILLS

The science process skills form the foundation for scientific methods. There are six basic science process skills:

- Observation
- Communication
- Classification
- Measurement
- Inference
- Prediction

These basic skills are integrated together when scientists design and carry out experiments or in everyday life when we all carry out *fair*

test experiments. All the six basic skills are important individually as well as when they are integrated together. The six basic skills can be put in a logical order of increasing sophistication, although even the youngest students will use all of the



The goals of science

1-Description: The description represents the basic and first goal of science, and it is achieved through making small observations, and then reaching a conclusion.

- 2-Predicting: The possibility of anticipating the occurrence of an event or phenomenon before its actual occurrence
- 3-Explanation and clarification: Explanation and clarification is the ultimate goal of science, to determine the reasons for the occurrence of behaviors and events
- **Products of Science**
- ***Science Facts***
- They are objectively proven statements about things that really exist, or events that have actually occurred. And it is reached by direct observation (using the means of sense) or indirect observation (by using aids for the senses to overcome the limitations of these senses).
- The truthfulness of the truth depends on the truthfulness of the observation itself, and the truthfulness of the observation is determined in light of: - *
- The ability to repeat the note.
- Having more than one observer.
- Use reliable tools to support the observation and to ensure accuracy and objectivity
- Examples of scientific facts:
- A - The length of a copper rod increases with the higher its temperature.

— B - When droplets of dilute HCL are added to Zn filings, a fizz occurs and a gas arises, which ignites with a pop

— **Scientific truth is constant and does not change as long** as the observation that led to it have not changed, and the scientific truth represents the basic unit that leads to the building of scientific concepts and generalizations

— ***scientific Concepts***

— Concepts are the building units of science, and a scientific concept is viewed from two angles

— The scientific concept of being a process is: a mental process by which a group of attributes, observations, or common facts of a thing, event, and process

— A scientific concept in terms of being a product of the aforementioned mental process is: the name, term, or symbol that is given to a group of common characteristics

— **Examples of scientific concepts:** Names: light, digestion, and reaction velocity.

— Terms: chromosome, electron, and quantum. Symbols: Na and D.N.A

— **Classification of concepts:**

— Concepts can be viewed from several angles: *

— The first: in terms of the way these concepts are perceived:

— A - observational concepts: They are concepts whose meaning can be perceived through observation using the senses or auxiliary tools for the senses

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—Concepts can be viewed from several angles:

— * The first: in terms of the way these concepts are perceived:

— A - perceptible or observational concepts: They are concepts whose meaning can be perceived through observation using the senses or auxiliary tools for the senses

— Examples: - Concept: heat ... Meaning: the feeling of being cold or hot.

—Lemon: The substance that is dissolved in water will Blush Blue sunflower leaf, Blush blue litmus paper

—concepts that cannot be perceived through observation Examples: DNA: the substance that stores the genetic information of an organism

—A - Initial concepts: These are concepts that are not derived from other concepts. Such as: time, mass, and space.

—B - Derivative concepts: These are concepts that can be derived from other concepts. For example: distance = velocity x time, Power = mass x acceleration

—A - Simple concepts: These are concepts whose meanings include a small number of words.

- Examples: - The cell: the building block of an organism. Ion: a charged atom or group of atoms
- . B - complex concepts:
- are the concepts whose meanings include more words.
- Example: An atom: an integrated system of particles carrying negative charges circulating in energy levels around the nucleus, and it has two types of particles, one of which carries a positive charge and the other is not charged * The degree of complexity of the concept varies from one class to another according to the level of linguistic development of the class
- **Third: Science Generalizations**
- * Generalization in Science as a Process Mindset: It goes through three stages: (A) Noticing things, events or phenomena.
- (B) To arrive at the relationships which relate to the observed objects, events or phenomena.
- C) Formulating relationships in the form of sentences. Generalization in science as an outcome of product mindset: a sentence that describes the relationships and repetition of a set of natural things, events and phenomena
- Generalization can apply to all similar situations in all places and all times and here we call it the Principle. Example: Archimedes' Principle "If an object is submerged in a liquid, it is thrown from the bottom up. The amount of this thrust is equivalent to the weight of the displaced fluid, whose volume = the volume of the submerged object."

— If the circular applies to similar cases under certain conditions, it is called law. Such as Boyle's law, "When the temperature is fixed, the volume of a given gas is inversely proportional to the pressure applied to it." *

— If the generalization is in the testing stage, that is, the possibility of honesty and lack of honesty is possible, then it is called "hypothesis."

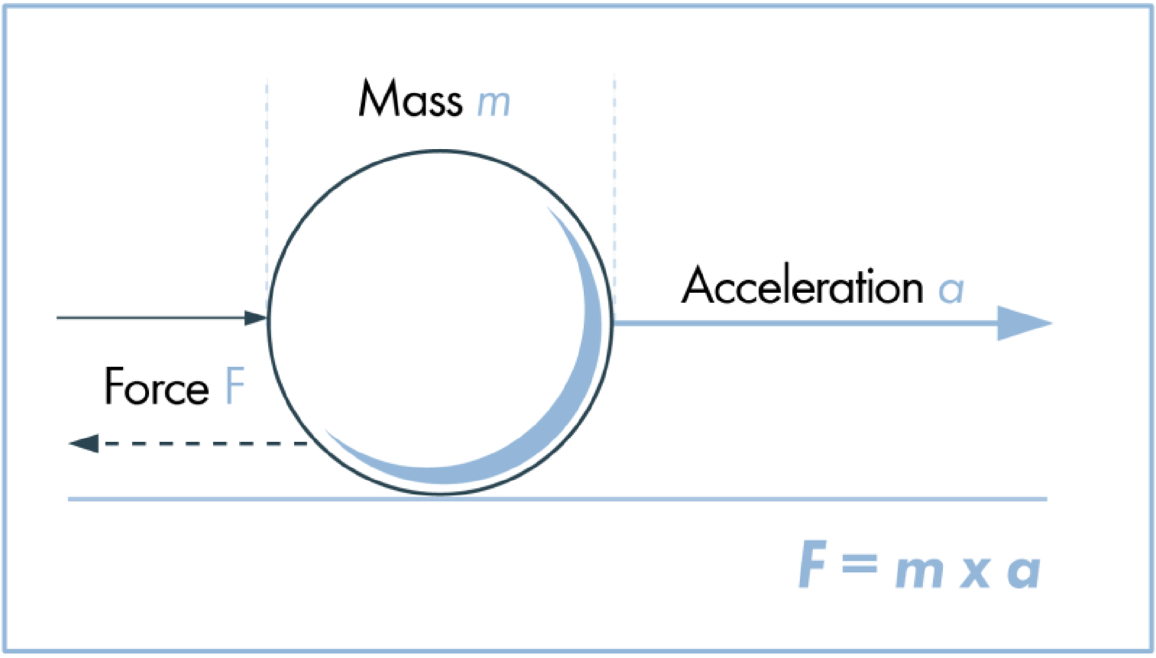
— **What Is a Scientific Theory?**

— Every scientific theory starts as a hypothesis. A scientific hypothesis is a suggested solution for an unexplained occurrence that doesn't fit into a currently accepted scientific theory

— Any scientific theory must be based on a careful and rational examination of the facts. Facts and theories are two different things. In the scientific method, there is a clear distinction between facts, which can be observed and/or measured, and theories, which are scientists' explanations and interpretations of the facts

— The theory of gravitation, for instance, explains why apples fall from trees and astronauts float in space. Similarly. What's the difference? A **scientific law** can often be reduced to a mathematical statement, such as $E = mc^2$; it's a specific statement based on empirical data, and its truth is generally confined to a certain set of conditions. For example, in the case of $E = mc^2$, c refers to the speed of light in a vacuum.

— Newton's Laws of Motion



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—Pictures of scientific law: A - deterministic laws: And it's in the picture: Availability (A) is bound to happen (B). Example: If the appropriate temperature and environment are not imposed, the bacteria reproduce by bacteremia. B - laws of probability: It is pictured: gaps from any local source. Example: If the gas pressure increases, its volume decreases when the temperature is constant

—**The scientific law has two forms**

—the mathematical form. Example: The mathematical form of Ohm's Law: c = t x m And its descriptive form:

— the voltage difference is equal to the product of the

—current intensity multiplied by the resistance

—**The scientific theory**

— It is an integrated construction of all of the above in the sense that the theory includes: (A) Scientific facts related to the phenomenon subject of theory. (B) scientific concepts related to the phenomenon subject of theory. (C) Generalizations, which are the set of laws and principles that contribute to the explanation and prediction of the phenomenon subject of the theory

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Ethics of Science

— 1- ***Testability***

— * In the natural sciences, there is no authority except for the mind, and this means that any new information must undergo a test of its reliability, and it is not added to the human balance of scientific knowledge until after this test

— **Objectivity**

— * Objectivity is the opposite of subjectivity, which means removing oneself from the situation or from the phenomenon, or from the event under study. * Objectivity criterion is very important for reasons the most important of which are: that the observation is a selective process, and thus is affected by the subjectivity of the observer.

— Objectivity requires:

— 1 - Accuracy: that is, describing the notes and recording them as they are without adding or deleting the notes.

— 2 - Comprehensiveness: taking into account all dimensions, variables and components

— ***Universality***

— Scientific knowledge has no religion, homeland, gender or ethnicity, and this necessarily requires an exchange of scientific knowledge between scientists. * The Arabs and Muslims translated from Greece and added, then Europe took from the Arabs and Muslims and added, and so on .. * Al-Alamiah achieves previous standards, as it achieves testability and objectivity

— It helps in building the self-confidence and systematic approach to day to day problems.

— It is both a product and a process. In its process form, it suggests ways and means of exploring the truth and in its product form; it presents a systematic and organized body of knowledge

— ***Scientific Honesty***

— Scientific honesty requires the scientist to be careful in describing and recording scientific phenomena and observations, and for the scientist to return scientific knowledge to its discoverers.

— In order to achieve scientific honesty, it is necessary to investigate what others have done, and thus one of the basic characteristics of science, which is cumulative, emerges

— **Hypothesizing**

- * Scientific hypothesis: a sentence under test that begins with a set of observations, but because of the lack of information necessary to reach beyond the observations, or to reach specific inferences, the scientist resorts to formulating a number of assumptions
- When Newton saw the apple fall to the ground, he formulated a hypothesis: that the earth has a force that attracts other bodies, and by analogy with that, the validity of the hypothesis was tested that the moon has a force that attracts other bodies

- **Experimenting**
- Experience: An artificial situation that the scientist uses to collect data and information about a phenomenon, or to verify the validity of previously reached information, or to test the validity of a hypothesis, or come to new facts and laws, or verify its validity.
- In experimentation, the scientist may resort to fixing some variables, and changing others by increasing or decreasing, excluding, or adding, in order to study the causal relationships, that is, the relationship between the effect of a certain variable on another variable

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https://www.youtube.com/watch?v=TkvjDZseD4k

https://www.youtube.com/watch?v=ui8X_TTFIzI

- https://www.youtube.com/watch?v=dgvOL6ZELuc

Exercise 1:

Select a Science lesson and plan it in a way that helps in training your students on fours of skills included in the table.

Exercise 2:

Select a science lesson and plan it according to the steps of the experimental method mentioned above.

Exercise 3:

Read an article about the history of some scientific ideas and trace the way in which scientists may disagree about the interpretation of scientific phenomena.

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Exercise 4:

How is the popular use of the word theory different from the scientific use the word?

Exercise 5:

Describe activities that you could use to introduce and reinforce the skills necessary to engage in science inquiry.

Exercise 6:

How do the selected articles exemplify the nature of science and the characteristics of science inquiry? If you were going to use these in the classroom, what changes would you make?

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Exercise 7:

Select a science lesson and show us how to plan and teach it in a way which demonstrates that science could be a common language among all humans.

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Exercise 8:

Select a science lesson and re organize it in a way that show the spirit of scientific inquiry.

Exercise 9:

Tell us in one page how science benefited you on the personal level.

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Exercise 10:

Tell us how science made you different from other people who did study as much science as you studied.

CHAPTER 3

Objective ofTeaching biology

Focus Questions:

- What are objective-related principles and their implications to teaching?
- What are the three domains of learning objectives?
- How do we write good lesson objectives?

Guiding Principles in Determining and Formulating Learning Objectives

1. "Begin with the end in mind."
2. Share lesson objective with students.
3. Lesson objectives must be in the two or three domains – knowledge (cognitive), skill (psychomotor), and values (affective).
4. Work on significant and relevant lesson objectives.
5. Lesson objective must be aligned with the aims of education as embodied in the Philippine Constitution and other laws and on the vision-mission statements of the educational institution of which you are a part.
6. Aim at the development of critical and creative thinking.
7. For accountability of learning, lesson objectives must be SMART, i.e., Specific, Measurable, Attainable, Result-oriented and Relevant, Time-bounded and Terminal.

Taxonomy of Objectives

With educational taxonomy, learning is classified into three domains namely: (1) **cognitive,** (2) **affective,** (3) **psychomotor** or **behavioral.**

Bloom's taxonomy of cognitive domain. Benjamin Bloom (1956) led his group in coming up with the list of instrucyional objectives in the cognitive domain. Arranged from lowest to the highest level, they are as follows:

Knowledge or recall – knowledge of terminology and connventions, trends and sequences, classifications and categories, criteria and methodologies, principles, theories, and structure; e.g to identify the capital of the Philippines.

Comprehension – relate to translation, interpretation, and extrapolation; e.g. to interpret a table showing the population density of the world.

Application – use pf abstractions in particular situations; e.g to predict the probable effect of a change in temperature on a chemical.

Analysis – objectives relate to breaking a whole into parts; e.g to deduce facts from a hypothesis.

Synthesis – puttingparts together in a new form such as a unique communication, a plan of operation, and a set of abstract relations; e.g to produce an original piece of art.

Evaluation – judging in terms of internal evidence or logical consistency and external evidence or consistency with facts developed elsewhere; e.g to recognize fallacies in an argument.

Bloom identified six levels within the cognitive domain, ranging from simple recall or recognition of facts as the lowest level, through increasingly more complex and abstract mental levels, to the highest level which was identified as evaluation. See Figure 3-a and 3-b.

Figure 3-a **Bloom's Taxonomy**

Figure 3-b **Anderson's Taxonomy**

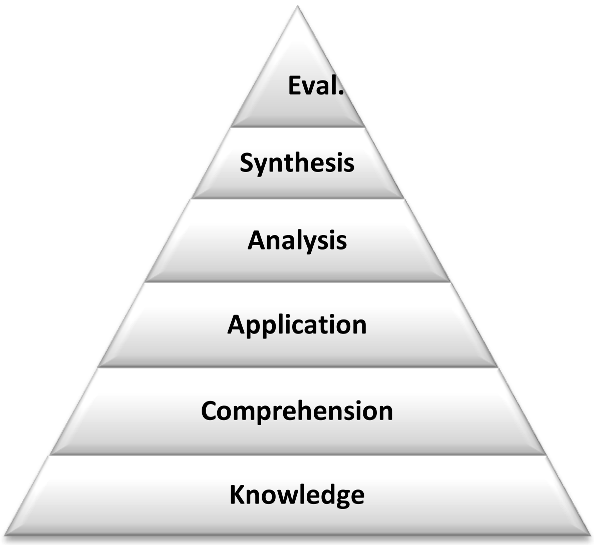


Figure 3-a

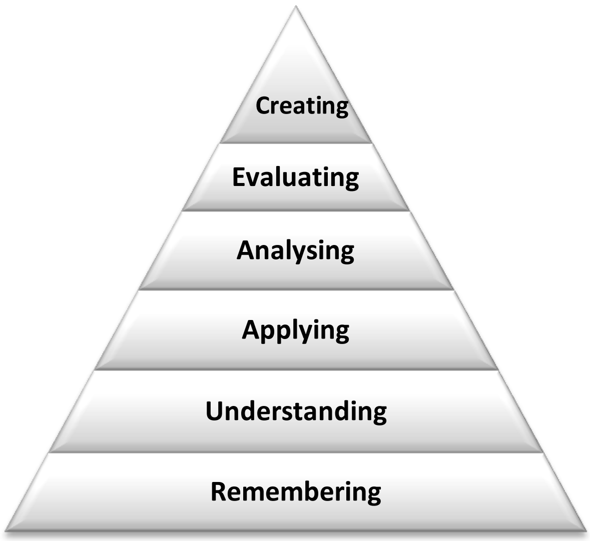


Figure 3-b

Anderson's taxonomy of cognitive domain. In the 1990's, Anderson, Bloom's former student, together with a team of cognitive psychologists revisited Bloom's taxonomy in the light of the 21st century skills. This led to Anderson's taxonomy in 2001. Study figure 3-b. Determine for yourselves the differences between the cognitive taxonomy of Bloom and that of Anderson.

Table 1a Definitions of Anderson's Revised Taxonomy

Definition	**Verbs**
Remembering: Can the student recall or remember the information?	Define, duplicate, list, memorize, recall, repeat, reproduce, state
Understanding: Can the student explain ideas or concepts?	Classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase
Applying: Can the student use the information in a new way?	Choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write
Analysing: Can the student distinguish between the different	Appraise, compare, contrast, criticize, diffirentiate, discriminate, distinguish,

parts?	examine, experiment, question, test
Evaluating: Can the student justify a stand or decision?	Appraise, argue, defend, judge, select, support, value, evaluate
Creating: Can the student create new product or point of view?	Assemble, construct, create, develop, formulate, write

Schultz, L. (2005). Bloom's Taxonomy. Accessed on September, 2006. http://www.odu.edu/educ/llschult/blooms_taxonomy.htm

Krathwohl's taxonomy of affective domain.

Figure 4 Krathwohl's Taxonomy

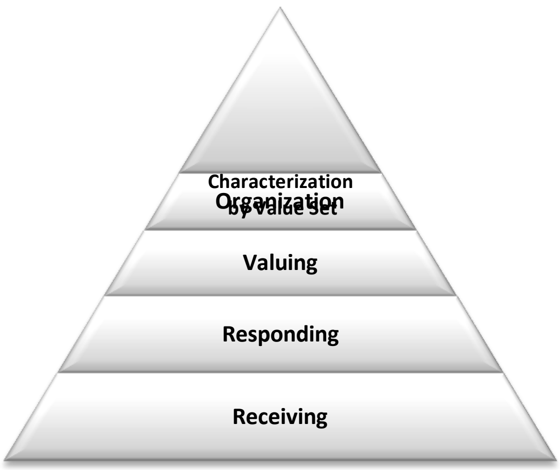


Table 1b Krathwohl's Taxonomy of Objectives in the Affective Domain

Level	What it is	Learning Outcome/s	Verbs	Sample Objective
Receiving	Refers to the	Learning	Differentiates,	Listens

	learner's sensitivity to the existence of certain ideas, material, or phenomena and willingness to particular phenomena of stimuli such as classroom activities, textbook, music, etc.	outcomes in this area range from the simple awareness that a thing exists to selective attention on the part of the learner	accepts, listens (for), to reponds to. asks, chooses, identifies, locates, points to, sits erect, etc.	attentively, shows sensitivity to social problems.
Reponding	Is not only being aware of the stimulus but reacting and responding to the stimulus.		Answers, assists, complies, discusses, helps, performs, practices, presents, reads, reports, writes, etc.	Examples of objectives in the responding level e.g. to contribute to group discussions by asking questions, to listen attentively during group

				presentation, to complete homework, to read beyond assignment, to obey rules, to participate in class discussion, to show interest in subject, to enjoy helping others, to read for enjoyment.
Valuing	Is concerned with the worth or value of a student attaches to a particular object, phenomenon, or behavior. Willing to be perceived by others as valuing certain	This ranges in degree from the simpler acceptance of a value to the more complex level of commitment		Desiresto improve group skills Assumes responsibility for the effective functioning of the group Appreciates the role of science in the

	ideas, materials, or phenomena. Examples include: To increase measured proficiency in, to relinquish, to subsidize, to support, to debate. e.g to argue over an issue involving health care			daily life, shows concern for others' welfare, demonstrates a problem-solving approach, etc.
Organizing	Organization is to relate the value to those already held and bring it into a harmonious and internally consistent value system			: recognizes the need for balance between freedom and responsibility in a democracy Understands the role of

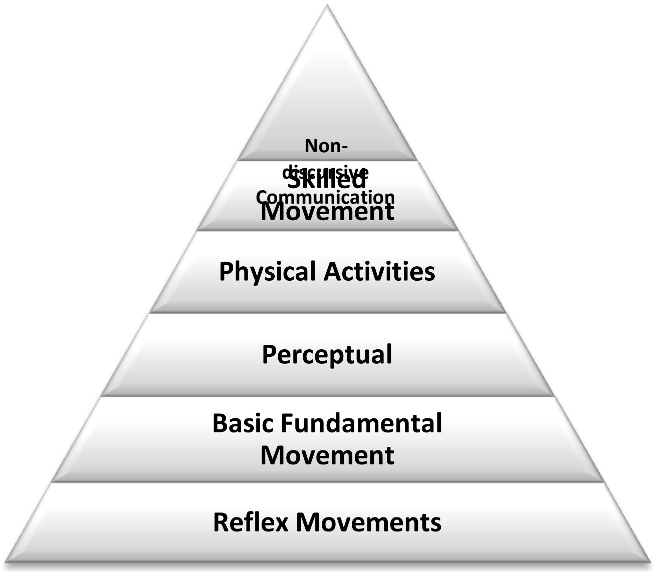
	or philosophy. Bringing together different values, resolving conflicts among them, and starting to build an internally consistent value system – comparing, relating and synthesizing values and developing a philosophy of life.			systematic planning in solving problems, accepts responsibility for own behavior.
Characterization	At this level, the person has held a value system that			Displays self reliance in working independently,

	has controlled his behavior for a sufficiently long time that a characteristic "life style" has been developed. Behavior is pervasive, consistent and predictable. Objectives are concerned with personal, social, and emotional adjustment.			cooperates in group activities, maintains good health habits, Uses an objective approach in problem solving, Displays a professional commitment to ethical practice on a daily basis Revises judgments and changes

Source: **Krathwohl, D.r., Bloom, B.S.,** and **Masia, B.B.** (1964). *Taxonomy of Educational Objectives: Handbook II": Affective Domain.* New York: David McKay Co.

Anita Harlow's taxonomy of the psychomotor domain.

Figure 5 **Harlows's Taxonomy of Objectives in the Psychomotor Domain**

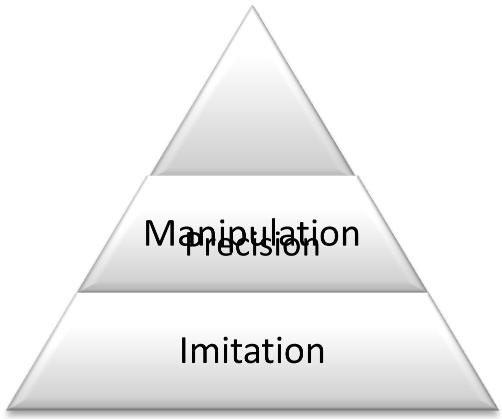


Level	**Description**	**Examples**
Reflex Movement Actions elicited without	Learning in response to some stimuli.	Flexion, extension, strech, postural adjustments
Basic fundamental movement	Inherent movement patterns which are formed by combining of reflex	Pushing, pulling, manipulating, e.g. to run a 100-yard dash
Perceptual Abilities	Perceptual refers to interpretation of various stimuli that enable one to make adjustments to the environment. Visual, auditory, kenisthetic, or	Coordinated movements such as jumping ope, punting, or catching.

Level	Description	Examples
	tactile discrimination. Suggests cognitive as well as psychomotor behavior.	
Physical Activities	Require endurance, strength, vigor, and agility which produces a sound, efficiently functioning body	Examples are: all activities which require a) strenuous effort for longer periods of time; b) muscular exertion; c) a quick, wide range of motion at the hip joints; and d) quick, precise movements.
Skilled Movements	The result of the acquisition of a degree of efficiency when performing a complex task.	Skilled Examples are: all skilled activities obvious in sports, recreation, and dance.
Non-discursive communication	Is communication through bodily movements ranging from posture to gestures, creative movements facial expression, act a part in a play through sophisticated	Examples include: body postures, gestures, and facial expressions efficiently executed in skilled dance movement and choreographics.

Level	Description	Examples
	choreographics. (Harlow, 1972)	

Moore (1998) also gave three levels of learning in the psychomotor domain. They are as follows:



Level	Performance
Imitation	Model skills
Manipulation	Performs skills indepedently
Precision	Exhibits skills effortlessly and automatically

Source: K.D Moore and C. Quinn. Classroom Teaching Skills. McGraw-Hill Companies, 1998.

Table 2a Key Words for the Taxonomy of Educational Objectives:

Cognitive Domain Taxonomy	Examples of infinitives	Examples of direct objects

Classification **1.0 Knowledge** 1.1 Knowledge of specifies to acquire, to identify, to recall, to recognize	To define, to distinguish, meaning(s), definitions, referents, elements, facts, factual information, (sources), (names), (dates), (events), (persons), (places), (time periods), properties, examples, phenomena	Vocabulary terms, terminology ,
1.2 Knowledge of ways and means of dealing with sprcifics	To acquire, to identify, to recall, to recognize Styles, formats,actions, processes, movements, continuity, developments, trends, sequences, causes, relationships, forces, influences, areas, types, features, classes, sets, divisions, arrangements, classifications, categories, criteria,	Forms, conventions, uses, usage, rules, ways, devices, symbols, representaions,

	basics, elements,	
	methods, techniques,	
	approaches, uses,	Principles,
1.3 Knowledge of	procedures, treatments	generalizations,
universals and		propositions,
abstractions in a field	To acquire, to identify,	fundamentals, laws,
	to recall, to recognize	pricipal elements,
	Implications, theories,	
	bases, interrelations,	
2.0 Comprehension	structures,	
	organizations,	
2.1 Translation	formulations	Meanings, samples,
Transform, to give in		definitions,
own words, to		
illustrate, to prepare,	To translate, to	
to read, to represent,	trnsform, to	
to change, to	abstractions,	
rephrase, to restate	representations, words,	
	phrases	
2.2 Interpretation		Relevancies,
Rearrange, to		relationships,
differentiate, to		
distinguish, to make,		
to	To interpret, to reorder,	
draw, to explain, to	to essentials, aspects,	
demonstrate	new views,	
	qualifications,	Consequences,
2.3 Extrapolation	conclusions, methods,	implications

To conclude, to	theories, abstractions	
predict, to		
differentiate, to		
determine, to extend,	to write, to tell, to relate,	
to interpolate	to produce, to	Priciples, laws,
	constitute, to transmit,	conclusions, effects,
3.0 Application	to originate, to modify,	methods, theories,
	to document	abstractions, situations,
		generalizations,
	to propose, to plan, to	processes, phenomena,
	product/to design, to	procedures
	modify, to specify	
4.0 Analysis		
4.1 Analysis of elements		Elements, hypotheses,
		conclusions,
		assumptions, statments
		of fact, statements of
	To estimate, to infer,	intents, arguments,
	conclusions, factors,	particulars
4.2 Analysis of	ramifications, meanings,	
relationships	corollaries, effects,	
	posibilities	relationships,
		interrelations,
		relevance, relevances,
	to apply, to generalize,	themes, evidences,
	torelate, to choose, to	fallacies, arguments,

4.3 Analysis of organizational principles	develop, to organize, to use, to employ, to transfer, to restructure, to classify	cause-effects, consistency, consistencies, parts, ideas, assumptions,
5.0 Synthesis		
5.1 Production of a unique communication	to distinguish, to detect, to identify, to classify, to discriminate, to recognize, to categorize	forms, patterns, purposes, points of view, techniques, biases, structures, themes, arrangements, organizations,
5.2 Production of a plan or proposed set of operations	to analyze, to contrast, to compare, to distinguish, to deduce	structures, patterns, products, performances, designs, works, communications, efforts, specifics, compositions
5.3 Derivation of a set of abstract relations	to analyze, to distinguish, to detect, to deduce	Plans, objectives specifications, schematics, operations, ways, solutions, means
6.0 Evaluation	to produce, to derive, to develop, to combine, to organize, to synthesize, to classify, to deduce, to develop, to formulate, to	Phenomena, taxonomies, concepts, schemes, theories,

6.1 Judgment in terms of internal evidence 6.2 Judgments in terms of external criteria	modify to judge, to argue, to validate, to assess, to decide To judge, to argue, to consider, to compare, to contrast, to standardize, to appraise	relationships, abstraxtions, generalizations, hypotheses, perceptions, ways, discoveries Accuracies, consistencies, fallacies, reliability, flaws, errors, precision, exactness Ends, means, efficiency, econimies, utility, alternatives, courses of action, standarnds, theories, geberalizations

Source: Newton D. Metfessel, William B. Michael, and Donald A. Kersner, "Instrumentation of Bloom's and Krathhwohl's Taxonomies for the Writing of Educational Objectives, "Psychology in the Schools, July 1969, pp. 227-231 as quoted by Allan C. Ornstein, Strategies for Effective Teaching.

Table 3 Key Words for the Taxonomy of Educational Objectives: Psychomotor Domain

Taxonomy Classification	Examples of infinitives	Examples of direct objects
1.0 Reflex Movements	To flex, to stretch, to straighten, to extend, to inhibit, to lengthen, to shorten, to tense, to stiffen, to relax	reflexes
2.0 Fundamental Movements	To crawl, to creep, to slide, to walk, to run, to jump, to gasp, to reach, to tighten, to support, to handle	Changes location, moves in space while remaining in one place, move extremities in coordinated fashion
3.0 Perceptual Abilities	To catch, to bounce, to eat, to write, to balance, to bend, to draw from memory, to distinguish by touching, to explore	Discrimination visually, discriminates auditory, discriminates kinesthetically, discriminates tactually, coordinates two or more perceptual abilities
4.0 Physical Abilities	To endure, to improve, to increase, to stop, to start, to move precisely, to touch, to	Exerts tension, moves quickly, stops immediately, endures

5.0 Skilled **6.0 Nondiscursive Communication**	bend To waltz, to type, to play the piano, to file, to skate, to juggle, to paint, to dive, to fence, to golf, to change To gesture, to stand, to sit, to express facially, to dance skillfully, to perform skillfully, to paint skillfully, to play skillfully	fatigue Changes or modifies basic body movement patterns, uses a tool or implement in adaptive or skilled manner Moves expressively, moves interpretatively, communicates emotions, communicates esthetically, expresses joy

Source: Adapted from Anita J. Harlow, A Taxonomy of the Psychomotor Domain (New York: McKay, 1972) pp. 246, quoted by Allan C. Ornstein, Strategies for Effective Teaching.

How to write Lesson Objectives

Mager (1998) cites the following characteristics of objectives:

1) It describes student performance.
2) An objective is about ends rather than means.
3) An objective describes the conditions under which the performance occurs on the job.
4) An objective describes the standard of acceptable performance.

Standards and Competencies in the K to 12 Curriculum

define what students should know and be able to do.

Performance Standards describe how well students need to achieve in order to meet content standards.

Competencies are more specific versions of the standards.

Here is a sample of content and performance standards and competencies for Health subject lifted from the draft of the Curriculum Guide for K to 12 of the Deapartment of Education:

Content Standard: The learner demonstrates understanding of the importance of good eating habits.

Performance Standard: The learner observes healthy eating habits daily.

Competencies: *The learner ...*

- Distinguishes healthful from unhealthful foods.
- Relates the consequences of eating unhealthful foods.
- Practices good eating habits that can help one grow healthy.
- Eats regular meals without skipping breakfast.
- Chooses healthful foods

Unit III

CHAPTER 2

Selection and Organization of Content

"There are dull teachers, dull textbooks,

dull films, but no dull sybjects."

Focus Questions:

- What guiding principles must be observed in the selection and organization of content?
- What is the structure of the subject matter that we teach?
- How can students be helped in the construction of a more enriched knowledge-base?
- What strategies can be empoyed for teaching conceptual understanding, thinking skills in the different levels, and values?

Introduction

What knowledge is truly essential and enduring? What is worth teaching and learning? Our leaders in the basic education level came up with the Philippine Elementary Learingcompetencies (PELCs) and Philippine Secondary Learning Competencies (PSLCs) in 2001. The "intended" content of what we teach is laid down in such document. In the K to 12 Curriculum, standard and competencies are also spelled out. This means that we are not entirely free in the selection of our content. They are a "given". But how they are organized and presented in the classrooom, ultimately depends on you. Below are some priciples to guide you.

Guiding Principles in the Selection and Organization of Content

1. **One guiding principle related to subject matter content is to objective the following qualities in the selection and organization of content:**
    a. Validity
    b. Significance
    c. Balance
    d. Self-sufficiency
    e. Interest

f. Utility
g. Feasibility

2. **At the base of the structure of cognitive subject matter content is facts. We can't do away facts but be sure to go beyond facts by constructing an increasingly richer and more sophisticated knowledge base and by working out a process of conceptual understanding.**

   Here are a few ways cited by cognitive psychologists (Ormrod, 2000) by which you can help your students:

   a. Providing opportunities for experimentation
   b. Presenting the ideas of others
   c. Emphasizing conceptual understanding

   Here are some specific strategies that can help you develop conceptual understanding in your students: (Ormrod, 2000)

   - Organize units around a few core ideas and themes.
   - Explore each topic in depths.
   - Explain how new ideas relate to students' own experiences and to things they have previously learned.
   - Show studnets – through the things we say, the assginments we give, and the criteria we use to evaluate laering – that conceptual understanding of subject matter is far more important than knowledge of isolated facts.
   - Ask students to teach to others what they have learned.
   - Promote dialogue.
   - Use authentic activities.

3. **Subject matter content is an integration of cognitive, skill and affective elements.**

   a. The structure of subject matter content

      (1) ***Cognitive (****Ormrod, 2000)*

a. Fact is an idea or action that can be verified.

b. Concept is a categorization of events, places, people, ideas.

c. Principle is the relationship(s) between ans among facts ans concpets.

d. Hyphotheses are educated guesses about relationships (principles).

e. Theories refer to a set of facts, concepts, and principles that describes

f. Laws are firmly established, thoroughly tested principle or theory.

(2) ***Skills***

a. Manipulative Skills

b. Thinking Skills

- **Divergent thinking**
  a. Fluent thinking
  b. Flexible thinking
  c. Original thinking
  d. Elaborative thinking
- **Convergent thinking**
- **Problem solving**
- **Metaphoric thinking**
- **Critical thinking**
  a. Verbal reasoning
  b. Argument analysis
  c. Hypothesis testing
  d. Decision making
- **Creative thinking**

a. **Awareness**
b. **Curiosity**
c. **Imagination**
d. **Fluency**
e. **Flexibility**
f. **Originality**
g. **Elaboration**
h. **Perseverance**

(3) *Attitudes and Values*

Shall we teach values?

Values have a **cognitive dimension**. When we teach the value of honesty, we ask the following questions: What is meant by honesty? Why do I have to be honest? The **affective dimension –** You have to feel something towards honesty. You have to be moved towards honesty as preferable to dishonesty. The **behavioral dimension** – You practice honesty and so lead an honest life.

How can we teach values?

- **By deutero-learning** – Your student learns by being exposed to the situation, by acquainting himself with a setting, by following models, pursuing inspirations and copying behavior. **YOUR CRITICAL ROLE AS MODELS IN AND OUTSIDE THE CLASSROOM CANNOT BE OVEREMPHASIZED.**
- **By positively reinforcing good behavior.**
- **By teaching the cognitive component of values in the classroom.**

Unit III
CHAPTER 3

Selection and Use of Teaching Strategies

"Different folks, different strokes."

Focus Questions:

- What principles should guide us in the selection and use of teaching strategies?
- What are the implications of these principles to the teaching-learning process?

Gu

iding Principles in the Selection and Use of teaching Strategies

Here are some guiding principles in the selection and use of appropriate yeaching strategies:

1. Learning is an active process.
2. The more senses that are involved in learning, the more and the better the learning.
3. Emotion has the power to increase retention and learning.
4. Learning is meaningful when it is connected to students' everyday life.
5. Good teaching goes beyond recall of information.
6. An integrated teaching approach is far more effective than teaching isolated bits of information.

Collecting Classroom Examples

Intelligence	**Example of Classroom Activities**	**Examples from My Classroom**
Verbal-Linguistic	Discussions, debates, journal writing, conferences, essays, stories, poems, storytelling, listening activities, reading	
Logical-Mathematical	Calculations, experimentations, comparisond, number games, using evidences, formulating and testing of hypothesis,	

	deductive and inductive reasoning	
Spatial	Concept maps, graphs, charts, art projects, metaphorical thinking, visualization, videos, slides, visual presentation	
Bodily-Kinesthetic	Role-playinh, dance, athletic activities, manipulatives, hands-on demonstrations, concept miming	
Musical	Playing music, singing, rapping, whistling, clapping, analyzing sounds and music	
Interpersonal	Community-involvement projects, discussions, cooperative learning, team games, peer tutoring, conferences, social activities, sharing	
Intrapersonal	Student choice, journal writing, self-evaluation, personal instruction, independent study, discussing feelings, reflecting	
Naturalist	Ecological field trips, environmental studyu, caring for plants and animals,	

	outdoor work, pattern recognition	
Existentialist	Reflection, diary / journal entry	

Source: Harvey F. Silver, et al. So Each May Learn, Virginia: Association of Supervision and Curriculum Development, 2000, p. 20) Added by the authors

Figure 8 Collecting Classroom Examples

Learning Style	**Examples of Classroom Activities**	**Examples of My Classroom**
Mastery Exercise – practice	Direct instruction Drill and repitition Demonstrations Competitions Activities that focus on: • Organizing and managing information • Practicing a skill • Observing • Describing • Memorizing • Categorizing	
Interpersonal Experience – personalize	Team games Learning circles Role playing Group investigation Peer tutoring Activities that focus on:	

	• Describing feelings • Emphathizing • Responding • Valuing	
Understanfing Explain – prove	Inquiry Concept formation Debate Problem solving Independent study Essays Logic problems Activities that focus on: • Classifying • Analyzing • Using evidence • Applying • Comparing and contrasting • Evaluating	
Self-Expressive Explore – produce	Divergent thinking Mataphors Creative art avtivities Imaging Open-ended discussion Imagery Creative problem solving Activities that focus on:	

	• Hypothesizing • Synthesizing • Symbolizing • Creating • Metaphorical expression • Self-expression	

Source: Harvey F. Silver, et al. So Each May Learn, Virginia: Association of Supervision and Curriculum Development, 2000, p. 37)

An integrated approach incorporates successful, research-based and brain-based instructional strategies. The following are some research findings cited by Patricia Wolfe in her book Brain Matters: Translating Research Into Action (2001):

Some research findings about the brain (Wolfe, 2001):

1. Without rehearsal or constant attention, information remains in working memory for only about 15 to 20 seconds. This implies the need for memory aids.
2. Learning is a process of building neural networks. This network is formed through concrete experience, representational or symbolic learning, and abstract learning. The three levels of learning are concrete, symbolic, and abstract.
3. Our brains have difficulty comprehending very large numbers because we have nothing in our experience to "hook" then to.
4. The eyes contain nearly 70 percent of the body's sensory receptors and send millions of signals every second along the optic nerves to the visual processing of the brain.

5. There is little doubt that when information is embedded in music or rhyme, its recall is easier than when it is in prose.

Brain-Based Strategies

1. Involving students in real-life or authentic problem solving
2. Using projects to increase meaning and motivation
3. Simulations and role plays as meaning makers
4. Classroom strategies using visual processing

GRAPHIC ORGANIZERS FOR CLASSIFICATION

Figure 9

Categories

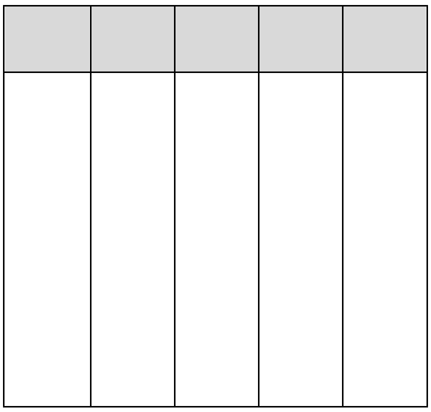


Figure 10

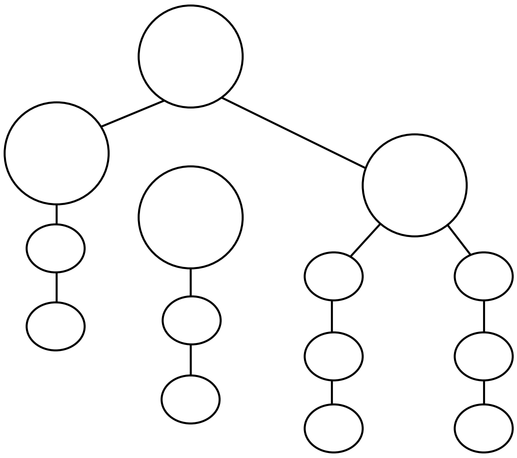


Figure 11 For Analogy

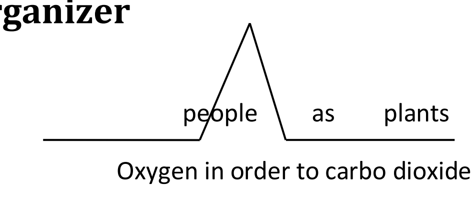


Figure 12 Hierarchical topical organizer

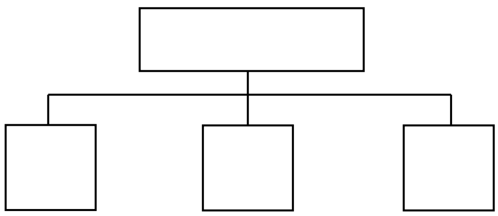
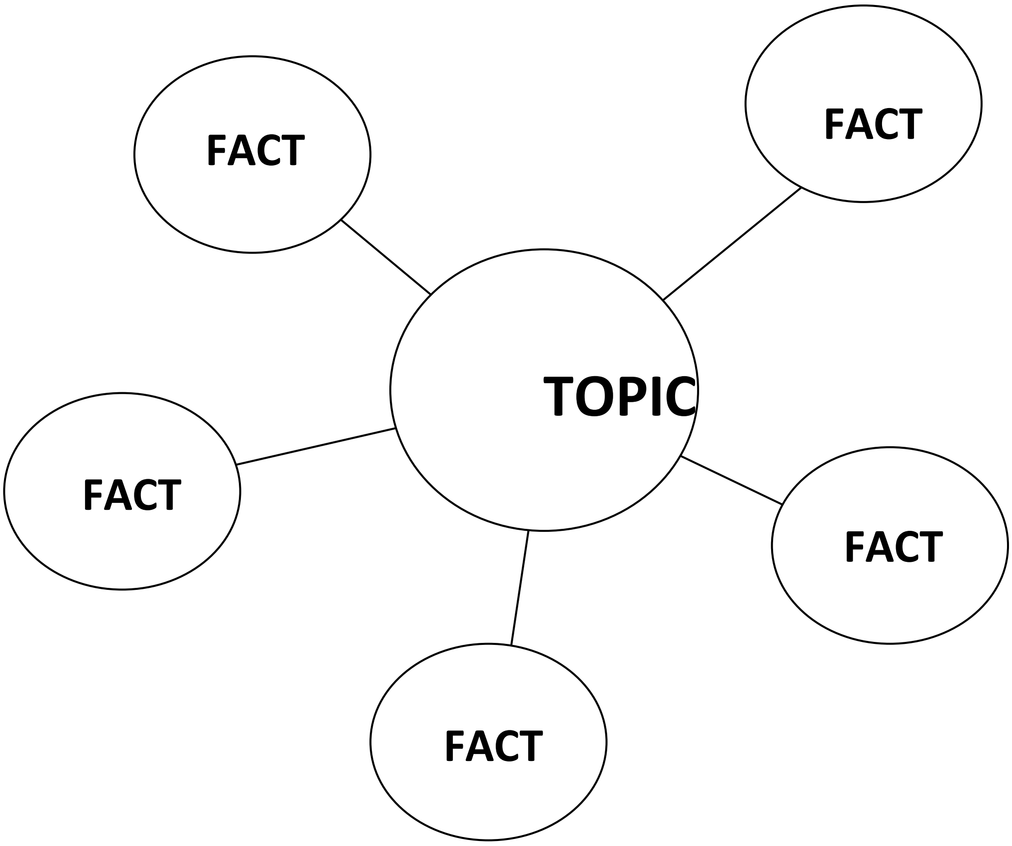


Figure 13



5. Songs, jingles, and raps
6. Mnemonic strategies
7. Writing strategies
8. Active review
9. Hands-on activities

An integrated approach is also interdisciplinary and multidisciplinary.

An instructional approach is also integrated when it includes the axquisition of knowledge, skills as well as values.

10. There is no such thing as best teaching method. The best method is the one that works, the one that yields results.

Exercise 11:

Study the taxonomy of educational objective in the cognitive domain, and apply the "knowledge" category on a science lesson or unit.

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Exercise 12:

Do you think that affective objectives in science are important in teaching biology**? Explain.**

Exercise 13:

Analyze a unit in biology **textbook and extract the psychomotor skills included in it.**

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Exercise 14:

— **Analyze a unit in science textbook and extract the scientific facts included in it.**

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Exercise 15:

— **Analyze a unit in science textbook and extract the *Science Process Skills* included in it.**

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Exercise 16:

— **Analyze a unit in** biology **textbook and extract the scientific Concepts included in it.**

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CHAPTER 4

PREPARATION FOR biology TEACHING

PREPARATION FOR biology TEACHING

2.1 Introduction

Pupils attend school to learn. They learn a variety of things both inside and outside the classroom. They also come in contact with people, events, sound, and lights and so on. When they come in contact with them, they are influenced by them. You can say that they interact with these things, events, people, sound and light.

This interaction is experience. Pupils interact with the behaviour of the teacher, his expression, statement, comments and so on. They also interact with other pupils in the classrooms and outside the classroom. We can say that they exercise all that the teacher and other people do. When they experience all these things, they form their own impression and opinion, express their own feelings and behave in particular ways because of their experiences. In order to make this experience which it wants all the children to have in the school to enable them grow as worthy individuals and citizens, there is therefore the need to organize these experiences.

2.2 CURRICULUM

When curriculum as an area of study is mentioned even among elites, people stare. Some out rightly enquire “what is that?” others could simply say oh! Education, subtly blaming you for using the word curriculum when you could have more reasonably used ‘education’, as though the two concepts are synonymous. This is unfortunate because curriculum studies as an area of study is one that almost everyone is interested in, and contributing to, at one time or another. Some are unconscious evaluators of the curriculum, as when even the market woman is comparing products of primary schools today with those of the colonial days, or contribute to school discipline as when they scold or discharge truant students from loitering outside the school premises during school hours. These, however, are unconsciously done; but the more conscious these contributions are, the more that can be derived there from. This is why, is it necessary to have at least a working definition of such crucial concept as curriculum.

Curriculum has been defined variously by scholars. There is no consensus as to what could be accepted as a definition of curriculum. This has necessitated numerous attempts at defining this concept.

The concept of curriculum has gone through many developmental stages as much as the area of study itself. Thus, we can say that the concept of curriculum has been developmental as curriculum development. At this time, when education inspectors visit the schools, they would enquire from the principal "where is the curriculum". At another time, it referred to the syllabus-subject matter. We hear people then; talk of the curriculum of Biology, English, Agricultural Science, etc. This concept of curriculum has stayed with us for quite a long time. The National Policy on Education (1981 revised), in discussing the subjects to be taught at the junior secondary school level states: *"The curriculum should be structured as follows…".* The policy went on to give a list of subjects that would be studied under the three broad areas of core subjects, pre-vocational subjects and non-vocational electives.

It has also come to be seen as the study programmes of the school as in primary school curriculum, secondary school curriculum, etc., and this also is very much within us today.

Summarily, the curriculum has been identified and has been used in four ways as: -

i. A school's written courses of study and other curriculum materials.
ii. It has also been used in reference to the subject – matter taught to students.
iii. It has occasionally been used to refer to all the courses offered in a school.

iv. It has generally come to be used to refer to the planned experiences of the learner, under the guidance of the school.

Specifically, other definitions of curriculum include “a course of reflection, expression and action”, Schostak (1989). Here Schostak has presented in very few words, a very broad definition of the concept of curriculum. It could be taken here to include the ideas – objectives and policies, the resources as well as the implementation programmes.

It has also been defined as “all the experiences which are provided to the students under the school”, Okafor (1984). The author went on to explain that these experiences may not be attained within the school environment but must be a product of “planning and purposive direction, which should have a built –in flexibility”.

According to Sowards (1977), “Curriculum is the term designating the experiences a school system provides for its students”. While noting that these experiences could be restricted to the classroom, he observed that the common practice in the United States is to identify the curriculum as all the experiences students have under the direction of the schools, activities earlier seen as extra-curricular, now inclusive.

Alexander (1950) observed that many American educators believe that curriculum should be defined more comprehensively to include “all learning opportunities provided by the school”. Again, he explains that this conception of curriculum includes such school provided activities as games and athletics and such services as guidance.

According to Cooky-Gam (1989), “Curriculum is generally conceived as a group of prescribed course or sequence of subjects required for certification”. This is the one of the narrow views of curriculum, but he went on to say that to many people, it is made up of those essential things that the children must learn in school if they are to be considered as ‘educated persons'. He then explained that a good curriculum is the total environment in which education take place.

These fairly broad views of curriculum go to support Tanner (1975) in his definition which sees curriculum as "planned and guided learning experiences and intended learning outcomes formulated through systematic reconstruction of knowledge and experience, under the auspices of the school, for the learner's continuous and willful growth in personal – social competence".

In spite of all the attempts at the definition of curriculum, these are not as much as a scratch, there seems not to be a generally acceptable one. Regardless of the efforts at broadening the scope of the concept, it does not seem as though we have got one that satisfactorily covers the concept of curriculum. This problem is not particularly very surprising since the root – word has similar short – coming on its face value.

Curriculum comes from the Latin root – word "currus" (running). It came to be used to describe the "race course" by contestants, in those days. In education, it was figuratively used to refer to the course programme ran by students towards their certification. In its very narrow sense, it referred simply to the subjects the learners of any programmes have to cover before they could be said to have completed that class. It is now being broadened to include all the experiences the child is exposed to on race towards being educated, or in reference to a particular programme.

Cooky – Gam (1980), in analyzing this root, concludes thus "all what pupils do or learn at school, from the day they are admitted into, until the day they leave the school may rightly come under the term 'curriculum'. This classification in the root word has affected the various scholars perceptions of the concept.

Curriculum could be referred to as all the consciously planned programme of and for the school, for the education of the child. Here, it includes all the programmes of the school; programme of studies, activities and guidance, as well as the programmes for the school. These include the various government policies, aims, goal and objectives, policies of implementation and personnel, sessions and terms calendars, facilities and services (medical, library, utilities, etc) and all that the governments and their employees in the area of education plan and execute in the effort to get the learners educated.

The various definitions of curriculum fall within particular schools of thought. These schools of thought could be seen through three major movements that existed before Tyler's model. These are the traditionalists, the progressives and the constructionists.

The ideas of these schools have implication for all curriculum decisions. It guides their definition of curriculum, their sources of curriculum experiences, curriculum planning designs, who should be involved in planning the curriculum, etc.

Summarily, the traditionalists try to maintain the status-quo. They believed in the use of concepts, methods and generalization in particular subjects, as bases for curriculum development. They therefore define curriculum as syllabus, subjects or as a course of study. For them, the source of curriculum experiences should be in areas of concepts and generalization in subject areas- the content of work in these areas. Their emphasis of curriculum designer is based on the subject specialists who are "expert" in their various fields of study. These people, while making provision for order and specialization, make the curriculum too technically rigid for comfort.

The progressives on their part emphasize curriculum construction from the perspective of the child – his interests, needs and characteristics. They thus define curriculum as "all those experiences of the child which the school in any way utilizes to influence", "those experiences which each child selects, accepts and incorporates" into him or herself, to act with, in and upon subsequent experiences". They have also defined curriculum as "a reconstruction of knowledge and experiences" (Iroaganachi, 1990). To these people, child study should form the basis of curriculum purpose and experiences, while the curriculum design should be child-centered. The child psychologist therefore and representatives of child - interest areas, should pioneer the planning of any curriculum for the child.

The progressives introduced the very necessary consciousness of the needs and interests of the child. They do not, however, seem to have thought of the practical application of their thought in their extremity. In the definition of the child, for instance, whose needs should be considered, there is the child of the upper class and the lower class, the urban and the rural backgrounds, low socio-economic and the high socio-economic, etc. Besides, there exists even within the same setting, individual differences, and yet the need, and interest of a particular child, varies from time to time.

The constructionists contend that the needs and problems of the society should serve as bases for curriculum construction. (Rugg, 1947 in Mkpa, 1987) assert that the curriculum is "the very stream of dynamic activities that constitute the life of young people and their elders". They believe that all areas of societal life should be represented in curriculum planning process.

2.2.1 Scope of the Curriculum

The scope of the curriculum covers the various educational policies and decrees, the resources – human and material, the content and learning experiences, organization and methods, evaluation procedures as well as the evaluation of the products (ultimate evaluation).

2.2.2 Types of Curriculum

Three major types of curriculum can be identified. These are:

i. **The Official Curriculum**: This could be seen as the theory part of the curriculum – projections, expectations, and ideas.

ii. **The Actual Curriculum**: This is the product of the official curriculum.

iii. **The Hidden Curriculum**: It is those learning experiences which learners acquire through informal interactions with their environment – other learners, teachers, materials, etc. It is hidden because it is neither written nor purposive.

2.2.3 Curriculum Organization designs

This is the co-ordination of things in a way that would help achieve anticipated purpose. Four major designs of curriculum organization have been identified. These are: -

i. The subject centered curriculum design
ii. The broad field curriculum design
iii. The activity/experience curriculum design and
iv. The core curriculum design

2.2.4 Sources of Curriculum Experiences

The traditionalists see the source of curriculum experiences from concepts, generalization and methods, the progressives insist that the child and his needs and interest should form the basic source of curriculum experiences, while the constructionists will maintain for the child to be integrated properly into t/he society; the curriculum should be based on needs and aspirations of the society.

2.2.5 Sources of Curriculum Objectives

Tyler suggested three key sources of curriculum objectives as: Studies of the learners themselves; Studies of contemporary life outside the school and Studies of suggestions from subject-matter specialists.

2.3 THE SYLLABUS

In the Nigerian context, a syllabus could be described as condensed outline or statement of the main points of a course of study springing up from the broad curriculum for a school year. If therefore, a school teaches ten subjects, it should have ten different curricula that’s one each for every subject. If the school runs a three year programme like Junior Secondary or

Senior Secondary, then the school should have three syllabi each for the ten subjects.

In Nigeria, Government through its Ministry of Education and sometimes, in conjunction with the Universities and Examination bodies issue detailed syllabi to be taught in different subjects. In this way, and by regular inspection and external examinations, the Government ensures its control over the content and quality of education provided in its schools all over the country.

When a school curriculum/syllabus is to be drawn-up, however, we need to be guided by the needs, problems, concern, interest, and aspirations of both the child and the society. We must not forget to look into all the areas of human living which the school can help to develop. For instance, the Nigerian schools now emphasize science and technology because the nation needs scientific and technological development in order to become an "advanced" country. In order to cater for all aspects of the child's growth and development, a balanced syllabus would include relevant topics in science, social studies, creative arts, language arts, religious instructions, physical and health education and provision of practical and manual work so as to restore the dignity of labour to the child.

In any area of knowledge listed above is worthy of consideration in drawing up of a syllabus, Wilkins (1975) warns us that before we include a topic under any of them, we should ask ourselves the following questions and be convinced that the answer are positive:

1. Is its learning necessary as a stage in achieving general educational aims?
2. Can it be satisfactorily taught if to be learnt by an average pupil in the class?
3. Is the topic more appropriate to this particular grade level than to any other level?
4. Have the pupils' sufficient learning foundations for the topic?

5. Is the topic in any way related to pupils' environment?
6. Is it related to other subjects the pupils are learning?
7. Does it follow naturally from previous learning?
8. Will it broaden the pupil's understanding?
9. Does it provide variety and interest in learning?

Having got positive answers to most if not all the above questions, you can now begin to list topics to be learned under each area of learning in the sequence you feel is most appropriate for their learning. They are usually grouped according to the year and term in which they would be taught to and learnt by children. Number of topics chosen should be able to cover the available time, should also indicate special teaching, and learning methods to be adopted, the textbooks to be used as main and reference text, and many other resource materials.

It should be noted that a syllabus can either be an examination syllabus or a school syllabus. A brief detail of these forms of syllabi is very important.

SCHOOL SYLLABUS

This contains statements of general and specific objectives, learning activities and learning strategies for the guidance of teachers. For example, Grade II Teachers' syllabus published by the Federal Ministry of Education in 1974 contains much details, such a syllabus can be interchangeably referred to as the school curriculum since it contains all aspects of a child's education which the school is charged with. Thus, the school syllabus will be the same as the school curriculum from which the teacher draws the scheme of work and sets up lesson plans.

The school syllabus serves as a guide to the teacher. It contains the objectives, suggested learning activities, teaching strategies and evaluation devices. The school syllabus is usually drawn up in each subject for each class for a period of one year. In many cases, it is divided into terms, usually three terms. A good syllabus also suggests the sequence of experiences to be offered.

EXAMINATION SYLLABUS

This consists of a brief statement of the requirements, regulations and content of an examination. The examination syllabus is usually set up by an independent examination body which specializes in testing. Examples are the West African Examination Council (WAEC), National Examination Council (NECO), Educational Testing Services, New Jersey or the London University Examinations. In Nigeria for instance, some schools prepare their students for both the WAEC and NECO examinations.

Some students prepare themselves for General Certificate of Education examination on their own when they are attending secondary schools. It is advisable to note this difference in the meaning of syllabus so that we do not equate the total experiences which each child is exposed to in the school with the minimal knowledge which he is supposed to have in order to pass a certain examination. The school syllabus or curriculum is intended to prepare the child as a well – adjusted citizen. The examination syllabus calls for the fulfillment of certain requirement of an examination in order to get a certificate.

2.4 THE SCHEME OF WORK

Education authorities and examining bodies usually give teachers a broad school curriculum which contains worthy objectives and topics to be taught to achieve those objectives. This curriculum is divided into syllabi depending on the number of years. When a syllabus is divided into the number of terms in a school year, it is then referred to as the scheme of work. A good scheme of work, set out at the beginning of the school term, is a good guide for the teacher to know how much he is expected to cover and should then strive to cover. It also helps the teacher to know when a topic is coming up and when to gather the necessary materials that would make teaching of the topic more effective. For most teachers, weekly schemes of work are preferred since they are more concise tasks to try accomplishing.

In order to draw up a meaningful scheme of work for a particular class, the teacher concerned needs not only to look at the syllabus meant for that class alone, but also to consult with that for the previous year of study and the year that will follow.

Moreover, no matter how carefully prepared a scheme is, sometimes a teacher may not be able to teach all he planned within a given time due to unforeseen circumstances like industrial actions, late resumption of students, mid-term breaks, inter-house sports, class boycotts, differences in the rates of learning between one class and another, and so on. It is in the light of this that it is advisable for teachers to draw up new schemes at the beginning of every term, taking into account the short-comings noticed in the previous term’s scheme. This also helps prevent the teacher from becoming stale and stagnant in his approach to teaching.

Finally, schemes are guides not masters. Therefore, the teacher needs not be a complete slave to his scheme and a scheme can leave room for some flexibility.

2.5 THE LESSON NOTE

The idea behind asking teachers to write careful lesson notes is not just to add more to their already heavy burden of teaching under difficult conditions, but also to aid their memory. The lesson note is the recipe of the teacher’s preparation and planning. The rule seems to be that lesson notes should be long enough to indicate clearly what is going to happen during the course of a lesson, but not so detailed that they run into many pages.

An advantage of teachers writing fairly detailed lesson notes is that if the normal teacher, for one reason or the other, cannot teach the particular lesson he has written notes for, a different teacher can take his place, follow the note made and teach the topic on his behalf.

Authors are almost in agreement that there is no standard format for the preparation of lessons. So many variables affect the choice of a particular format over others. The choice could be depended on a uniform pattern chosen by a particular secondary, primary school, zonal education board, etc. Subsequently, it could also be influenced by the choice of format. The proponent of each format advance some merits in the use of that format. The teacher who is allowed a choice, should choose the one that he can consult in the class with the greatest ease and without embarrassment

Essentially, however, there are some basic facts that are important in any lesson presentation. These include: Date, Lesson Topic, Time/duration, Class, Class Size, Specific Objectives, Entering Behaviour, Materials, Instructional Techniques, Set Induction, Instructional Procedure, Content Development, and Performance Assessment/Evaluation.

These basic facts of lesson preparation can be fitted into any lesson format of choice. Some of the formats that could be used include the following:

4.2 Subject:…………………………………………………….

Topic:…………………………………………………….

Class:…………………………………………………….

Time:……………………………………………………..

Date:……………………………………………………...

Objective:………………………………………………..

Previous Knowledge:……………………………………..

Apparatus:……………………………………………….

PROCEDURE:

Introduction:……………………………………………...

Step I:……………………………………………………..

Step II:…………………………………………………….

Step III:……………………………………………………

Conclusion:………………………………………………….

Assignment: …………………………………………………

'Onorie, (1979)'

4.3 An example of tabular format:

(Eneogwe, 1994)

Date:……………….. Time/Duration:……………………………………

Class:………………. Class Size:………………………………………..

Subject Matter:………………………………………………………………

Lesson Topic:……………………………………………………………….

Specific Objectives:…………………………………………………………

(a) Cognitive Domain. (As applicable)

(b) Affective Domain. (As applicable)

(c) Psychomotor Domain. (As applicable)

Entry Behaviour:

Material Required:

Lesson Development:

Step	Content Development	Teacher's activities	Students activities	Strategies
1	Do	Do	do	Do
2	Do	Do	do	Do
3	Do	Do	do	Do

2.6 THE LESSON PLAN

A lesson plan is a daily guide to instruction. It is an outline of day to day learning activities. A good lesson plan is a guide to effective instruction as it directs the teacher in a manner that a compass directs a navigator its bearing. Because teachers conventionally have other responsibilities besides teaching, lesson plan should be as simple as possible in design. A lesson plan is a daily outline of the learning activities for pupils of a specified academic level or class. It is usually drawn up after the preceding lesson. A lesson plan should never be prepared several weeks in advance. The teacher will like to take advantage of the extent of materials covered in the preceding lesson and the success or failure of pass lessons. The lesson plan provides the instructional order to be followed by the teacher in order that no important item may be forgotten. The lesson plan divides the instruction into three parts: Introduction, presentation and these are preceded by objectives which may be stated instructionally or behaviourally or both when the need arises. The objectives the teacher has for his lesson. The lesson plan thus has the following:

General information: School, subject, class, time and duration, topic unit, age.

Objectives: what product, process or affective objectives does the teacher have for this lesson? These should be written in precise terms. They can be stated either instructionally or behaviourally.

Instructional objectives are stated in terms of what the teacher is going to do during a particular lesson. It is called instructional objective because it focuses attention on the teaching process or strategies rather than on the learning.

Examples are to:

(a) show students the various parts of a tree

(b) demonstrate the practice of weeding using a hoe

(c) indentify the cause of stunted growth in plants

(d) state Newton's 1st law of motion.

On the other hand, behavioural objectives are stated in term of the outcomes the teacher expects from his teaching. Attention is thus shifted from the teacher to the learner. The distinction between instructional and behavioural objectives is stating the former in terms of what the teacher does while the later is stated in terms of the learning outcomes. When performance statements are defined or described, they are expressed in measurable terms, the s

kill, knowledge and attitude which a student is expected to demonstrate at the completion of instruction; they become behavioural objectives (Popham, 1969). Example: given a diagram of a mature plant cell, the students should be able to label the cell wall, nucleus, cell membrane and chloroplast.

This is a behavioural objective because:

1. The objective is stated in clear unambiguous terms which the teacher could recognize when it is attained by the student.
2. It is stated in terms of the behaviour of the learner.

The following list of action verbs will help teachers formulate behavioural objectives: compare, record, demonstrate, describe, state, draw, apply, show, label, dissect, predict, list etc.

RESOURCES: What equipment, teaching aids, text materials will be needed.

INTRODUCTION: This relates to how the teacher will prepare students for this lesson either by review of previous lesson or by prying into the planned lesson. Sometimes, the terms “previous knowledge” or “entry behaviour” could be used interchangeably.

LEARNING ACTIVITIES: (Presentation/development) lecture, laboratory work, discussion, etc. should fit the objectives.

TIME ALLOTMENT: Approximately how long you expect each activity to last.

EVALUATION AND ASSIGNMENT: How would you access if students have learned what you have taught? This is by asking the students questions. It is done by simply converting the stated behavioural objectives into questions which of course are in measurable terms. The teacher may give the students some work to do at home and in the school. All these should be contained in the lesson note.

NOTE: it is important to draw a distinction between the uses of the words ‘lesson note’ and ‘lesson plan’. In some quarters, they are argued to mean the same thing. But technically, they do not mean the same thing. The difference between the two concepts is in the matter of details. The lesson note is more detailed than the lesson plan. This detail is in the area of the content development or steps. For instance: In agriculture where the teacher wants to teach the topic “cultural practices”. The first content development which is now step I is ‘definition of cultural practices’. In the lesson note under teacher’s activities, the teacher will write thus: The teacher defines cultural practices as those activities that are carried out on the farm in the process of producing a crop or rearing an animal. While in the lesson plan the teacher will write: The teacher defines cultural practices. It Can be been that in the lesson note, it was more detail while in the lesson plan it was only skeletal providing directions and not the facts of the topic under discussion. It is therefore wise to advice that the lesson note should be used by beginning teachers so that in teaching he can make reference to his lesson note where he is not sure of what to be said. While a practicing teacher can comfortably use the lesson plan since he has been teaching the topic year in year out.

Lesson Planning: -

Proper planning of the lessons in key to effective teaching . A daily lesson planning consists of teaching points, specification to be achieved, organization of an orderly sequence of learning activities, actual test items to which pupils are to be exposed Lesson Planning is essential because, effective learning takes place only if content in presented in an integrated and correlated manner G.H. Green says “The teacher who has planned his lesson wisely related” to his topic and to his classroom without any anxiety, ready to embark with confidence upon a job he understands and prepared to carry in to a workable conclusion. He has foreseen the difficulties that are likely to arise, and prepare himself to deal with them. He knows the aims that lesson is intended to fulfill, and he has marshaled his own resources for the purpose. And because he is free of anxiety he will be able to estimate the value of his work as lesson proceeds, equally aware of failure and success and prepared to learn from both.

A daily lesson plan is confined to only one period. The contention presented in the form of teaching points. The learning activities discussed in detail. The test items may be in the form of an essay or short answer or objective type questions.

Suggestions to improve lesson plan: -

1. It is important to highlight only the key concepts or relation and save most of the time for them.
2. It must be made in the context of overall unit plan and should be continuous from day to day.
3. To make the lesson plan fit a long-range schedule the teacher must give careful attention to important ideas of the textbook for a particular day.

Steps in lesson planning (Herbartion steps)

1. Introduction: - This stage prepares the students for new knowledge. This step is important but, must be brief. It must test previous knowledge of the child. Curiosity of pupils can be aroused by some experiment, chart, model, story, discussion etc.

2. Presentation: -

The actual lesson begins at this stage. The teacher makes use of different teaching aids to make lesson effective. Teacher must involve students to make lesson interesting.

3. Association: -

The new ideas must be associated with daily life situation by citing suitable examples and drawing comparison with related concepts. This step is important as principles are established.

4. Generalization: -

An effort must be made so that, students draw the conclusion themselves. Teacher should guide the students only if their generalization in either incomplete or irrelevant.

5. Application: -

The knowledge gained through the lesson must be applied to certain situations. This step is conformity with the general desire of the students to make use of generalization in order to see for themselves if the generalizations are valid in certain situations or not?

6. Recapitulation: -

At this last stage, teacher tries to ascertain whether his students have understood and grasped the subject or not. This cheeks the effectiveness of the lesson.

All these six steps are herbarium try gives for lesson planning. Teacher can guide lines and in many lessons it is not possible to follow all the methods

Advantages of lesson plan: -

1. It stimulates the teacher to ask questions.

2. It provides freedom in teaching.

3. In induces confidence among teachers.

4. Lesson planning make the work, regular, organized and systematic.

5. It saves a lot of time.

Sample proforma for lesson plans: -

1. For problem solving method: -

Sub: - Topic: -

Class: - Time: -

Objectives: -

Instructional material: -

- Creating a situation or posing problem:
- Defining and delimiting the problem:
- Collecting and interpreting data:
- Formulating hypothesis:
- Experimentation (Test of hypothesis) : -
- Drawing conclusion:
- Generalization and application:

2. **Laboratory Method: -**

Sub: - Topic: -

Class: - Time: -

Objectives: -

Material required: -

Introduction: -

Direction for the experiments: -

Grouping students: -

Demonstration (If required): -

Guidance and supervision during laboratory work.

3. **Lecture cum Discussion method:-**

Sub: - Topic: - Class:-

Time: - Objective:-

Pervious knowledge:-

Introduction (motivation):-

Assignments to each group for self-study

Date and period for discussion:-

Initiation of discussion by teacher

Discussion by each group in turn:-

Role of teacher:-

Main learning points:-

Evaluation:-

Follow- up assignments:-

Check your progress:-

1) What are the advantages of preparing lesson plans?

2) What are the determinants of effective teaching? Explain.

2.7 CONCLUSION

Preparation for the teaching of Science at any level of education should be able to embrace the curriculum, the syllabus, the scheme of work, the lesson plan, and lesson note, to make the teaching more meaningful. The success achieved in imparting knowledge, to an extent, will largely depend on the teaching/learning situation. This will also include the teachers' ability select the approach that he can use maximally in order to achieve the stated objectives of the lesson.

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https://www.youtube.com/watch?v=mcDZL8xH_7Y

https://unacademy.com/lesson/natural-science-aims-objectives/RVVWT6NW

https://www.youtube.com/watch?v=JDEHA06RQbc

CHAPTER 5

INSTRUCTIONAL TECHNIQUES AND METHODOLOGY

INTRODUCTION

Instruction refers to a set of activities and interaction design to facilitate desirable changes in the behaviour of a learner. According to Heinich et. Al. (1982), it is "Communication specifically designs to broaden and extend the field of experience of learner". On the other hand, technique is a way of doing something.

In the context above, an instructional technique is a way by which any chosen method can best be used to deliver a particular topic to the learners.

4.2 INSTRUCTIONAL TECHNIQUES

There are two major instructional techniques that are in use in our today's science teaching. They include: Questioning and Motivation.

4.2.1 Questioning

Questioning is the art of interrogation. It involves putting a series of words understood by the learner and which compel him into thinking in order to make a reasonable response understood by the questioner. Question is an indispensable tool in teaching.

KINDS OF QUESTIONS

There are many kinds of questions and these include: -

i. Testing questions
ii. Drill of Fact Questions
iii. Guide Questions
iv. Review Questions

4.2.1.1 Testing Questions

Just as the name implies, they are asked to find out or test the learner's knowledge and skills in a particular field of study. It could be asked before the lesson starts in order to test knowledge.

4.2.1.2 Drill or Fact Questions

This is great use in training the students in memory work. Drill questions call for facts previously learned. This involves recall and do not need much thinking. For instance, a learner can be drilled to learn facts in English Language with the following questions:

A. What is the opposite of go?

B. What is the feminine gender of me?

4.2.1.3 Guided Questions

It is of use in the middle of lessons in leading the learner to give intended and pre-determined answers, ideas and facts without his being told by the teacher. For example, a teacher who wants to teach the student 3 + 3 + 3 = 9 can lead him to discover the answer (9) by himself by asking him the following question: How many mangoes would you get if your father, mother and sister give you three mangoes each?

4.2.1.4 Review Questions

This type is asked at the end of the lesson to reconsider or re-examine what has been taught in order to find out whether or not the students understood and the part of the lesson that needs further explanation.

4.2.2 Purpose of Questioning

Questioning stimulates the student's

1. Thinking and reasoning
2. To test the student's previous knowledge
3. To help prepare the student for the new lesson
4. To enable the teacher to evaluate the progress of his students.

4.2.3 Qualities of a Good Question

1. A good question must be relevant to the lesson taught.
2. The question should be well – worded, clear and definite
3. A good question should not be suggestive to its answers
4. Questions should be framed to suit the age of the students

5. The questions should be simple enough to be understood by the learners.
6. Questions that require though and extended answers should be used in most cases for they stimulate students' thinking.
7. Questions should be designed.

4.2.4 Motivation

"Motivation", according to McFarland (1974), refers to the way in which urges, drives, desires, aspirations, stravings or needs direct, control or explain the behaviour of human beings. Shartle (1956) defines motivation as 'a reported urge or tension to move in a given direction to achieve a goal'. Motivation, therefore, provides the drive which urges the individual to perform certain tasks, or carry out activities aimed at achieving certain goals. If the teacher wants to improve the performance of students in school, they (students) should be highly motivated.

There are various forms of motivation used in the classroom.

4.2.4.1 Punishment and Reward

Punishment is pain or penalty or discomfort inflicted on a person who breaks a rule in order to prevent him from breaking that rule another day and others from copying his examples. The various forms of punishment used in motivating students include: Corporal punishment used in motivating students include: Corporal punishment used in motivating students include: Corporal punishment and non-corporal punishment. Corporal punishment involves beating and whipping, while non-corporal does not involve inflicting of such bodily pains, but includes: suspension, dismissal or expulsion, detention after school, task, fines, and loss of marks, cutting grass, disgrace or general compound cleaning.

Reward, in the school context, is what the learner receives in return for good done. Rewards can be material or non-material. Material rewards are physical things, example: Cash, shield, medal, souvenirs. While non-material rewards are non-physical things, example: Praises, applause and duty past. It is a part of a good class management not only to punish the student for committing an offence, but also, to reward him for good performance in class.

A reward is an incentives to hard – work and self-discipline. Other forms of reward include: prizes, praise, honour, placement, etc.

4.2.4.2 Knowledge of Results

The knowledge of one's result, whether positive or negative, might inspire the student to work very hard. If the student fails exams, he might like to improve in the subsequent test or exam thereby making his goal to be success. if he passes very well, he might keep it up and if he fails, he might like to work harder.

4.2.4.3 Competitions

In a competitive class, the student is made to work hard for a certain goal. It encourages those students that are slow in learning to meet up with others' performance. For instance, to be the best student in Agricultural Science or any other subject, the student has to work hard so as to out-compete each other.

4.2.5 Reasons for Motivation

1. Motivation arouse the student's zeal and one aroused, goal is set and work towards achieving the goal.
2. It keeps the students active until their set goals are achieved.
3. It acts as energizing agents to the students.

4.3 METHODOLOGY

The teacher should select the method that he can handle effectively. This means that, if the teacher is competent in a particular method, he should not employ another method that cannot be effectively used.

The size of the class should determine the method to be used by the teacher.

Age of the students is another factor to be taken into consideration. Also, their previous knowledge on the topic and their general ability. The method of instruction for the learners who are high achievers should not be used for a mixed ability class.

The teacher should choose a method based on the instructional resources available for an effective use of a method. Where there are no materials or equipment for laboratory experiments or demonstration, the teacher cannot be expected to be effective.

The teacher should also consider the time that the lesson will take place. If a method is selected that makes the students sit passively, he should not expect positive response from them.

Generally, teachers should vary in their methods of teaching as many time as the need may arise. It is quite possible for a teacher to introduce his lesson with one method and then goes on to change his method when the lesson is being developed. The times of which he changes the methods of teaching should depend on the skill or attitude that is being developed in the students.

The main teaching methods use in presenting skill or scientific information to the students include the following: -

4.3.1 Question and Questioning Method

The questioning method is also known as the Socratic Method. It owes its name and tribute to Socrates. It involves the use of effective questioning skills to achieve desired result. This method is philosophical in nature and involves determining present opinion, destroying present opinion on subject. The questioning method has the following as its advantages;

1. It encloses learner's participation because without learner's response to questions, learning cannot take place.
2. It leads to learning by conviction

3. It is democratic in approach because the teacher and learners work together
4. It develops mental ability

The disadvantages of questioning method are:

1. It leads to the development of inferiority complex due to phase of the questioning session.
2. The questioning method is useful only to learners who have developed nature independent reasoning abilities.

4.3.2 The Lecture Method

The lecture method is the oldest and most popular method in usage. The lecture method is teacher – centered and lacks materials and infrastructure needed to facilitate a change in behaviour. The lecture method is the one in which the teacher is the custodian of knowledge and wisdom. The teacher is seen as the Alpha and Omega as well as the sole repertoire of educational content in lecture method. The advantages of lecture method include;

1. The lecture method saves time as it enables the teacher to complete his work according to plan.
2. It leads to the development of the cognitive domain of learning of the teacher as well as pupils who must master content through rate memorization.
3. It saves cost and materials because the teacher hardly goes out of his way to prepare learning materials for his pupils. His concern is to deliver his lesson and nothing else.

The disadvantages of lecture method include:

1. The lecture method does not give cognizance to needs and interests of learners.
2. The lecture method does not lead to rich learning experience because in most cases, instructors are more concerned with the facts of subject matter and not their mode or medium.

3. Learners are subject to teacher's idiosyncrasy expressed either in attitude to life, mannerism or physical as well as emotional handicap.
4. The lecture method is teacher – centered. The learner does nothing, but listens.

4.3.3 The Demonstration Method

This is a method in which theoretical explanation is backed by practical manipulation of instruments for learners to see. The objective of this method is that, at the end of the lesson, learners shall equally handle these materials and manipulate or classify them. The demonstrative method has the advantages of:

1. Making learning practical
2. Setting clear objectives
3. Developing manipulative skill

The disadvantages are that

1. It tasks the learner's ability to concentration
2. It may prove dangerous to learners since they may not be aware of safety precaution.

4.3.4 The Discovery Method

The discovery method guides the learners to discover for himself, t he content of the unit of instruction. In discovery method, relevant materials and procedures are exposed to the learners to utilize and at the end, pupils observe and search for facts and arrive at conclusions. The disadvantage of this method is that it is time consuming and it can be expensive especially when it enta**ils** experiments**.**

4.3.5 Discussion Method

The discussion method is a collective learning method because the learners proffer solutions aimed at solving the educational problem together. Discussion method calls for contribution form each member of the class as each child is given the chance to think and express his opinion relating to the unit of instruction. The advantages of discussion method are:

1. Discussion method is learner centered
2. Discussion method encourages individual as well as collective participation
3. In discussion method, knowledge is pooled together and evaluated
4. Discussion method makes the class lively and interesting

The disadvantage of the discussion method are as follows: -

1. The class may be disorganized due to arguments
2. Discussion method is time consuming due to long discussion on trivial aspects of the lesson.
3. It encourages chorus answers if there is no proper classroom management.

4.3.6 The Project Method

The focus of teaching and learning today, is the child. His needs and interests serve as the basis of motivation for learning to take place. Pupils should be given appealing and interesting tasks to explore, experiment and find solutions on their own. The project should not take too long to accomplish, or learners shall lose interest in the activity.

A typical example of a project in educational technology is to ask learners to produce stencils. As they go about accomplishing this project, they learn lettering skills. Note; letters in upper and lower cases and how to use these letters effectively for headings and labels. The following are the merits of the project method.

1. Project method is learner – centered and ensures learners' participation.
2. It encourages co-operative group participation since learners work in groups, they aim to overcome difficulties in order to achieve the desired objective.

3. This method presents real life situation and is therefore relevant to the child.
4. In project method, the educational objective is clear, the learner knows his goal.
5. Project method ensures wide and diversified knowledge and creativity.
6. Project method encourages analytical thought and promotes intensive development.

4.3.7 Laboratory Method

Laboratory method of teaching is an activity carried out by an individual or a group, for a purpose of making personal observations of processes, products or events. The essence of employing laboratory method in teaching is to verify principles of scientific laws or theory which are already known to students.

Another reason is to determine the relationship between cause and effect.

Two procedures are associated wit laboratory method. The first one is the laboratory exercise, which consists of activities carried out in order to provide practice in designing and interpreting experiment. The second type of it, it the experiment which are procedure used for the purpose of testing a supposition.

The advantages of laboratory method include: -

1. Laboratory method offers students the opportunity to handle and use such equipment like microscope, burners, balance, as well as wheatstone.
2. With laboratory method, the students are opportuned to repeat some experiments and perform an original experiment in the laboratory base on student project.
3. Laboratory method increases students' ability for critical thinking and acquisition of basic concepts, principled and facts of science.

4. It leads to better retention of information and development of favourable attitude towards science.

Guidelines for the use of laboratory method:

1. Since students depend on the teachers' direction and guidance in their laboratory work, the procedure for any investigation should be simple and clear.
2. The activities for the students' laboratory exercise should be based on the students' background, available equipments and materials needed for successful completion of the exercise.

4.3.8 Individualized Method of Teaching

Individualized method of teaching involves a teaching and learning activity between a teacher and a student. That is to say that a particular teacher concentrates with a particular student in all the learning experiences. The system also assumes that all the children in a particular class should cover the same fixed amount of materials in a particular period. Individualized method has been applied under different approaches which involve individually prescribed instruction, self-directed learning, personalized instruction, as well as independent study.

Individualized learning is a programmed instruction in which the learning programmes are essentially information presented in carefully structured steps and the pace of learning depends on the individual student.

Advantages of individualized method of teaching include:

1. The individual learner learns at his own pace, so there is no problem of anybody being left behind.
2. The student is continuously participating in the learning process
3. Individualized method of teaching reduces student's anxiety as he depends on himself and he sees the result of his efforts almost immediately.

4. It can be used effectively and immediately to make up for lack of background in particular members of the class.

The disadvantages of individualized method include:

1. Individualized method seems to emphasize only two areas of knowledge, namely, the cognitive and the psychomotor – domain.
2. It is time consuming and makes a high demand for materials and equipment.
3. There is little or no group interaction or competition.

4.3.9 The Field Trip Method

Field trip is an excursion taken outside the classroom for the purpose of making relevant observations and also obtaining some specific information. Field trip affords the students opportunity to become actively engaged in observing, collecting, classifying and manipulating objects. Field trip is one of the most enjoyable and exciting experiences for students studying science.

Advantages of field trip method include:

1. Field trip allows a class to engage in activities that are too noisy to be done in the classroom.
2. Field trip helps to add reality to, and verification of scientific laws.
3. Most field experiences make demand of all senses, thus, the students gain complete picture of the concept than from any other method of teaching science.

The disadvantages of field trip;

1. Field trips are extra financial burden both for the school and the students because it involves unbudgeted costs in transportation and money for food.
2. Field trip is difficult to plan apart from the fact that it takes time more than class period.
3. Field trips are difficult to administer

Guidelines for the use of field trips;

1. The teacher should carry first-aid kits in the case of accidents.
2. The teacher should first make up the trip so that all dangers and opportunities are known before hand.

4.3.10 The Inductive and Deductive Method

The word is formed by induction. This means method of discovering through reasoning. The teacher teaches the students a particular fact and it helps them to discover a general rule from the fact. Example, if a teacher teaches students that a cow is a mammal because it feeds the young ones with milk, they would then know that the human being, goat, sheep, pig, are all mammals science they have a similar characteristic, but fowl, fish, snake are not.

On the other hand, deductive method is just the opposite of inductive method. It involves teaching the child the general and allowing him to reason and discover the particular rule from one fact. The teacher can teach the child that man, sheep, goat, dogs are all mammals. They could observe and say things they have in common. Let them also observe reptiles and what they have in common.

CHAPTER 6

PLANNING OF INSTRUCTION IN biology TEACHING

INTRODUCTION

This chapter focuses on the planning instruction in Agricultural Science. The chapter centres on the structuring of a course of study, definition of a course of study and the component of a course of study. The main purpose is to provide the teacher with the basic requirement for effective teaching and learning. In applying planning to education, there are or course, special problems. To establish objective for the education service, amid the uncertain values of our profit-oriented brand of democracy, is exceptionally different.

Instruction refers to a set of activities and interaction designed to facilitate desirable change in the behaviour of a learner. It is a communication specifically designed to broaden and extend the learner's field of experience (Heinrich, 1982). Thus, an instruction is "a deliberately organized combination of people, materials, facilities and procedures which interact co-operatively for the purpose of achieving predetermined instructional objectives" (Inyang-Abia, 1988).

At a micro-level (i.e. individual, small group or class level), an instruction may consist of an individual, a few students or class of learners performing some instructional objectives according to pre-designed instructional plan to achieve pre-specified instructional objectives.

Success in any venture is best assured by planning. Accidental success is possible, but rather in fragment. More planning does not guarantee success, but it does assure consideration of the factors and conditions regarded as most essential to success. It may be said that we are living in a planning age. Planning is required to make intelligence procedures in political, social, economic, industrial and business realms, follow specifications established by careful thought and long-range planning. In public affairs, planning wards and planning commissions, local, state and national are becoming more numerous. It is true that much of our civilization just grew like topsy, but we are now rallying on the great potential and effectiveness of programs based upon design and plans.

5.2 A COURSE OF STUDY

Since the principal business of the school is to facilitate learning, little justification seems necessary for emphasizing instructional planning. The primary reason for instructional planning is that, teaching is a creative rather than a mechanical type of activity.

A course of study is a plan which spells out the scope and teaching order of all the learnable activities provided for a particular group of students in a particular subject, says Agricultural Science, in a particular programme. This is a guide for teachers to select the students’ activities and the materials that are suitable to be used and the trainer by which these materials and the students’ activities could be organized. Wheeler (1971) summarizes a course of study as that part of the curriculum organized for the classroom.

Students change from year to year and new classes coming on are different. Each day and every lesson being new situations which are entirely new, not only students change but both society and business constantly undergo modification. The constantly shifting programme of business and educational scenes and the learning situations can be effectively met only by adequate learning activities that will bring a change to the learners. The modern point of view and philosophy regarding education places planning and education at a premium. Teaching has become recognized as a creative actively wherein the teachers serves as the directors of learning and not merely as disposer of facts and information.

COMPONENTS OF A COURSE OF STUDY

In the previous sub-chapter, we looked at the definition of course study. Here we shall treat the various components that constitute a course of study. They include the following; course rationale the intension learning outcome, the telling question, the concept map and the content.

3.2.1Course Rationale

This is an elaboration of the title of the course which relates the content or the specific topic of the interests and needs of the students. It may also involve a description or significance of the content. A course nationale, in combination with other things, states the following; Reasons for the course which involves the reason “why” the topic is to be taught, selected. The goals of the course which it seeks to achieve at the end, within a given community, society or among the individuals. The benefits of studying the course to the students.

Putting the learning outcome into practice, is one of the consideration or reason which the teacher seeks to achieve over a particular course content. Are the students able to carry out what they learn? For instance, the "why" of the course in Dairy Production could be that protein is lacking in feeding growing children. To go about this is to first of all, produce expert that will handle Dairy Production. The goal is to reduce protein deficiency and increase protein supply in the society.

The satisfaction and benefit of the course to the students is the acquisition of the skills needed in Dairy Management like this. The student can establish a Dairy Farm on individual basis.

5.2.2The intended Learning Outcome

There are some psychologists who argue that teacher – oriented objective or aims are necessary to show a lot what the teacher is expected to do. Such people then style the teachers oriented objectives as student expected outcome". The focus in this text, however, is on student-oriented behavioural actives. The major interest is in measuring how well the students have achieved the objectives and not how well the teacher claims to habe achieved his/her goal of teaching the skills. These learning outcomes are derived from the seeds of the society. In short, they are the object of the lesson.

5.2.3The Telling Question

These are the fundamental basic requirement or questions the course tries to find out or about the concept. Each of the questions given will require the understanding ability, attitude, interest and attributes which the students posses in finding solution to the question given to him. It is an instrument that asses the performance of the teacher.

The teaching a topic such as castration in farm animal, the telling questions could be:

i. What is castration?

ii. The importance of castration

iii. How do you castrate an animal?

5.2.4The Concept Map

A concept map is a plan showing the keywords or ideas in the concept as they relate to each other. A unit is defined as a means and unified pattern or instruction in order to achieve important educational objectives.

A chapter of a large block of material in a textbook does not necessarily constitute a unit. In addition, a distinction must be made between the primary, secondary and territory concepts. Primary concept refers to the teachable topic a teacher intends the students to understand, say “Breeding in Poultry”. Secondary, the concept above could be treated under sub-headings such as inbreeding and Crossbreeding making up the secondary concept. These two sub-headings can also be looked upon from minor sub-headings such as Selection Mating and Laying of Eggs. The map looked thus:

Breeding in Poultry

(Primary Concept)

Mating

Egg Laying

Selection

Selection

Egg Laying

Mating

Secondary concepts

In breeding

In breeding

2.5 The Course Content

Although content selection is submerged in Tyler's selection of learning experience, it can be identified on its own concept according to Saylor and Alexander (1966) are "those faces, observations, data, perceptions, discernment, sensibilities, designs and solutions drawn from what the mind of man have comprehended from experience and those contrasts of the mind that recognize and rearrange those products of experience into love, ideas, concepts, generalizations, principles, plans and solution" (Mkpa, 1987).

To Audrey and Nicholas (1978), it is simply "the knowledge skill, attitude and values to be learned". While Hyman (1973) sees it as the knowledge, skills and process and values, knowledge analyzed as "Faces, explanations principles and definitions" skills and processes as reading writing, calculating and values as "concerned with good and bad, right and wrong, beautiful and ugly" (Mkpa, 1987). These three definitions have the common attribute of accepting skills and values as part of the content which facts.

Content could therefore be seen as the subject- matter, the syllabus the body of knowledge yet to be studied. It is the "what" of any teaching and learning. The "what" of a study, of any achievement. The content of any particular course of study is determined by many factors which include the need of the society, the age of the student, pupils' or students' entry behaviour, the competence of the teacher and available facilities and equipments.

5.2.5.1 The Need of the Society

The society is the sole determined of a course of study. This is because whatever the teacher and the student do in the classroom can only be reflected in the society. It therefore stands that the society's need will be what the teacher will consider when planning a course of study, so that the output will be beneficial to the society.

5.2.5.2 The Age of the Students

The developmental age of the students with their mental age should be taken into consideration in choosing a particular content of a course of study. This is in consonance with teaching from known to unknown. What is above the understanding ability of the student should not be included in the course content because the impact will not be felt among the children.

5.2.5.3 Pupils' Entry Behaviour

This deals with what the student has known before coming to the class. In preparing course content, the teacher should relate it to what the students already know. Before a student is given any admission into any tertiary institution, it is assumed that such a student has successfully passed his O' Level Examination in subjects relevant to his course of study. For example, a student offered admission to read Agric. Science and a student should be expected to have done Chemistry in his secondary school days.

Competence of the Teacher

Mastering the subject is one factor a teacher considers in choosing a course of study. It is assumed by students that teachers are always very correct, so any mistake made is misleading. The student cannot be revertalized. This will affect a given society where the mistake is made. The teacher must have to know the content of his course very well before choosing if for the students to study.

Available Facilities and Equipment

The facilities and equipment needed for a particular course should be available in the school library or laboratory before such a course could be taught effectively otherwise, the teacher has to make an arrangement for alternative. To facilitate effective learning, instructional materials or aids are very important, for this will help make the course of study understandable. Students learn faster and can co-ordinate very well when a lesson goes with aids and facilities.

5.3 DESIGNING A UNIT OF STUDY

One of the first steps a teacher usually takes, after accepting a position in a school system, is to find out what he is supposed to teach. In some schools, districts and individual schools, the curriculum has been carefully designed and course of study for each of the subjects have been made.

A unit has been defined as a means of organizing instructional materials into large related and unified patterns of instruction in order to achieve important educational objectives. A chapter or a large block of material in a textbook does not necessarily constitute a unit. In addition, a distinction must be made between a resource unit and a teaching unit.

A resource unit constructed by teachers for the use of teachers. It includes more suggestions than any one teacher could possibly use, and provides the raw materials for teaching units or for daily lesson plans. An individual teacher may, of course, prepare a resource unit but many advantages of co-operative thinking are lost. A teaching unit is usually prepared by the classroom teacher or with the help of his class for use in a particular class. For example, a unit of course of study in the general Agric. Course might be disposal of weeds.

A unit of study is a fractional part of a course of study designed for a period of time and for a group of students. It can be divided into lesson which makes up the teachable periods of the unit. Example, plant diseases may be a course of study which will last for two weeks.

UNIT MEANING AND LESSON MEANING OF CLASSIFICATION

1: CLASSIFICATION OF 1: CLASSIFICATION OF PLANT

PLANT DISEASES DISEASES

UNIT

2: PRINCIPLES OF PLANT LESSON VIRUSES, BACTERIA & PLANT DISEASE CONTROL

2: DISEASES LESSON

3: LESSON MECHANICAL CONTROL

4: BIOLOGICAL & CHEMICAL CONTROL

5.4 THE CLASSIFICATION OF BEHAVIOUR EXPECTED OF CHILDREN

5.4.1COGNITIVE

5.4.1.1 Knowledge: This is the recall of facts or remembered information in the same pattern or form as it was given to the learner. It includes those behaviour and test – situations which emphasize the remembering either by recognition or recall of ideals, materials and phenomena. When the teacher tells children to repeat after him “children say cat!, cat!, again Cat!!!. The teacher is drilling his class here on learning at the knowledge level. In evaluation, it often takes such terms as who, what, where, etc. some operative verbs for stating objectives at this level include; define, list, name, outline, identify, select, state, recite, etc.

5.4.1.2 Comprehension: Here, the teacher looks for understanding. The emphasis here is on the grasp of meaning and intent of the materials. The children have advanced from rote, to the level of understanding what they are saying. The child at this level of cognition can give some explanations of the “why” in the context of the learning. Verbs used include; explain, convert, infer illustrate, re-unite, narrate, etc. are suggestions for stating instructional objectives at this level.

5.4.1.3 Application: This is the level of utility and transfer. The child must be able to apply the facts or information and ideas again in any learning situation outside the classroom. Any learning that cannot be applied is a useless learning. The learner there might apply his knowledge or just from one situation to another. The verb include; use, apply, compute, solve, prepare, demonstrate, are suggested for stating instructional objectives at this level.

5.4.1.4 Analysis: This emphasizes the breakdown of the materials into its component parts so as to understand its organizational pattern. This may include the identification of the parts and recognition of the organization principles (Mkpa, 1986). It marks the beginning of the high thinking process. At his level, the trainer can draw distinctions between broken down facts. Verbs – differentiate, discriminate, analyze, outline, subdivide, and distinguish, etc. are suggestions for stating instructional objectives.

5.4.1.5 Synthesis: This is the level of originally and creativity. It involves bringing facts, ideas, Clements, parts, etc. together to form a whole. "it is a process of working with these elements part, etc. and combining them in such a way as its re-institute a pattern or structure and clearly these refer" (Mkpa, 1986). From the illustration above, the learner picks up the acceptable parts to him and with his own ideas, builds a new definitions original to him. Verbs; combine, create, compose, plan, modify, design, contrast, etc. are suggested for stating objectives at this level.

5.4.1.6 Evaluation: This is the judgment level. It is the highest level of the cognitive domain by Bloom's taxonomy. It involves the use of criterial standard for appraising the extent to which particulars are accurate, effective, and economical or satisfying (Mkpa, 1987). It judges the value of a work, how consistently logical a material is, and how adequately correct the conclusions reached. It is the "why" of a stand. He not only can recite a definition now, but understands it. Can use it, know the various parts of the definition and their implications, can build his own definition from there, and can also critique the definition and others.

It is the end process of cognitive domain. Verbs; criticize, explain, support, appraise, justify describe, etc. are suggested stating objectives facilities and equipments.

5.4.2 Affective

The intended learning outcomes also has an aspect of affective domain. Affective domain covers the objectives which describes in "*interest, attitudes and values and the development of appreciation and adjustment" (*Mehrens & Lehman, 1976). The affective domain is also subdivided into five classes arranged from the simple to the complex. These are: receiving, responding, valuing, organization and characterization by value or value complex.

5.4.3 Pysho-Motor Domain

This is concerned with motor skills and manual dexterity noticed in writing, laboratory and physical skills, etc. it is emphasized by such subjects as Physical Education, health science, Music and all of the vocational subjects like Agricultural Science. Just like other domain, it has hierarchical classifications level: Reflex movement, Basic fundamental movement, Perceptual abilities, Physical abilities, Skilled movement and Non-discursive communication.

5.6 CONCLUSION

Planning of instruction for the teaching of Science at any level of education should embody planning of instruction, structuring of a course of study, definition of a course of study and the components of a course of study. When all these afore-mentioned points are considered, it will improve the educational standard of the society, individual and provide a basis for self-reliance in life.

CHAPTER 7

INSTRUCTIONAL AIDS IN SCIENCE TEACHING

INTRODUCTION

Good communication is one of the hallmarks of effective teaching. Just as students who cannot learn effectively, teachers who cannot communicate well with their students cannot teach effectively. Effective communication requires that adequate resource be utilized in helping students to learn.

Instructional aids are materials which the teacher can utilize to communicate effectively with the learners. In other words, they are the materials the teacher utilizes to assist in the realization of the set objectives of instruction. The achievement of t he objectives of any lesson by a teacher is dependent on the availability and effective use of learning resource. Lack of these resources (instructional aids) in our schools has been a major problem in the instructional process.

Ideally, no effective teaching can take place without the use of equipments, facilities and materials. They are indispensable tools for good teaching and learning.

6.2 MEANING OF INSTRUCTIONAL AIDS

Instructional aids are those facilities, equipments, and materials utilized by the teacher to illustrate emphasis and explain a lesson with the intention of making the lesson clear to the learners (Umoren, 1998). Instructional aids are devices that assist the teacher in transmitting by permitting more effective multi-sensory approach to learning than just words can provide.

According to Ekpe (1999), instructional aids are devices which can be used to make learning experience more concrete, more realistic and more dynamic.

Also, instructional aids or learning media can be defined as all resources which may be used by the learner to facilitate the acquisition and evaluation of knowledge, skills and morals (Inyang-Abia, 1998).

From the above definitions, instructional aids in Science can be seen as materials which help in making the teaching and learning of Science more effective and efficient than ordinary words can do. Examples of teaching aids in Science include: charts, models, regalia, mock-ups, flannels, television, video, etc. These materials enable the learner to see, hear, touch and smell.

6.3 CLASSIFICATION OF INSTRUCTION AIDS

Instructional materials are classified in a variety of ways to suit the needs of the classifier and his audience. Broadly, instructional aids can be classified into visual audio and audio – visual.

6.3.1 Visual Materials

These are instructional materials that can be seen. They stimulate the sense of sight. Examples are charts, boards, images, models or real objects.

6.3.2Audio Materials

These instructional materials can be heard. They appeal to the sense of hearing. Examples are radio, cassette tapes, etc.

6.3.3Audio-Visual Materials

These are instructional aids that stimulate the senses of hearing and sight simultaneously. They can be seen and heard at the same time. Examples are television, video tapes.

6.4 TYPES OF INSTRUCTIONAL AIDS

Another way of classifying instructional materials is according to their source. Based on this, instructional materials can be classified as teacher-made and commercially bought.

6.4.1Teacher-Made Aids

These are the instructional aids designed and produced by the teacher. The teacher used locally available resource to produce materials which facilitate effective teaching and learning. Teacher – made aids have the following advantages:

iv. The teacher is competent in their use.

v. They are cheaper than those bought from the market.

vi. Being locally made, they are suitable for the environment.

vii. Their production makes the teacher resourceful.

However, they have the following disadvantages:

a. They are time consuming in production

b. They are liable to errors.

c. They are not durable.

6.4.2 Commercially Bought Aids

These are the materials which are bought and used by the teacher to enhance effective teaching and learning. These materials have the following advantages:

i. They save time

ii. They are durable

iii. They can be used for more than one lesson.

Their disadvantages are as follows:

a. They are costly

b. They may be above the competence level of the teacher.

6.5 CRITERIA FOR SELECTING INSTRUCTIONAL AIDS IN SCIENCE

It is obvious that there is a wide variety of instructional materials available for the teacher to use in the process of teaching.

However, in selecting and using particular materials for the teaching of Science, many factors have to be considered. These factors or criteria include the following:

- Instructional objectives
- Relevance
- Learner's characteristics
- The content of the lesson
- Economic and socio-cultural factors
- Teacher's competence

6.5.1Instructional Objectives

The selection and use of any instructional material should take cognizance of the instructional objectives. The materials to be selected should facilitate the achievement of the specified instructional objectives. The materials should be used properly in developing the needed skills in the learners.

6.5.2Relevance

Another criterion for the selection of instructional materials is the relevance of such materials. Any material selected must be appropriate to the lesson. It should be able to link the learner's previous knowledge to the present lesson.

6.5.3Learner's Characteristics

The selection of any instructional materials should take into consideration the characteristics of the learners in terms of their age and learning capability. The material should be at the level of the learners.

6.5.4The Content of the Lesson

In selecting instructional materials in Science, the content of the lesson should be considered. Any instructional materials to be selected should be up-to-date and accurate and should present sufficient information in the achievement of the intended learning outcome of the lesson. The formal of the material selected should match the subject matter and the topic.

6.5.5Economic and Socio-Cultural Factors

Another consideration for the selection of instructional materials is the economic and socio-cultural factors. This is in terms of the availability of the materials, the cost for its production or purchase and the acceptability of the material (i.e its compatibility with the culture of the people). Selected materials should be affordable and easily obtainable.

6.5.6Teacher's Competence

The level of competence of the teacher is another crucial thing to consider in the selection of instructional materials. Any material to be selected should not be above the competence level of the teacher. It should be such that can be operated easily by the teacher.

6.6 GENERAL PRINCIPLES OF INSTRUCTIONAL MATERIAL UTILIZATION

Instructional materials are not ends in themselves, but means of attaining specific instructional functions. To be successful in utilizing instructional materials, the following principles should be followed:

iii. The instructional materials should be appropriate to the instructional task, format and learner's characteristics. It should be noted that no one medium is best at all times for all purposes and for all members of the learners.

iv. The teacher should be conversant with the materials to be used in the instructional process.

v. The materials should be evaluated in terms of the suitability to the objectives, appeal to learners, cost effectiveness and learner's level.

vi. The right environmental conditions for the utilization of the instructional materials should be created.

6.7 ADVANTAGES OF INSTRUCTION MATERIALS IN TEACHING

The use of instructional materials in teaching Science has several advantages. Some of these advantages are as follows: -

1. Instructional materials make teaching and learning effective and efficient. The use of teaching materials enables the learners make use of their various senses thereby making them learn effectively and consequently effective teaching takes place.

2. The use of equipment and materials in teaching enables learners to develop problem-solving skills and positive attitudes, and to develop functional knowledge and manipulative skills. The acquisition of these skills in Science is an essential way of preparing youths for functional existence in the society.

3. The use of instructional materials in teaching science arouses learners' interest, focusing their attention on the lesson. With the use of these materials, the learners not only listen to the teaching, but see some of the things explained practically. This makes them develop interest in the lesson and pay more attention to it.

4. Instructional materials help to combat time factor in teaching. The use of these materials saves the time to be spent in making diagram or sketches on the board.

5. Instructional materials concretize the instruction. The use of materials makes learning materials real to the learners. Since they can see, hear and (or) touch some of the things being taught, there is an elimination of doubt about the learning material.

6. The production of learning materials makes the teacher resourceful. It develops his skills in designing and creativity.

7. Instructional materials make for quick recall of lesson. Since learners make use of their various senses, learning is made effective with a high level of retention which makes the recall of the lesson easy. The use of instructional materials reduces the tendency to forget the lesson.

8. When models and real objects are used, they help to combat cost. The use of models or regalia makes learning more concrete without extra cost of purchasing other materials.

6.8 CONCLUSION

Instructional materials are indispensable tools for good (effective and efficient) teaching and learning. They make learning concrete, interesting and effective. It has been seen that no effective teaching and learning of Agricultural Science can take place without the use of instructional materials.

The Agricultural Science teacher should endeavour to at least make use of locally available resources in producing materials that will enhance effective teaching and learning.

However, the principles for the utilization of these materials and the criteria for their selection should be followed so as to bring about an appreciate use of these materials.

CHAPTER 8

LESSON PRESENTATION SKILLS

7.1 INTRODUCTION

Having fully prepared for the lesson, the next vital step is to put the plan into operation. No matter how wonderful your plan looks on paper, it will not teach itself. Neal, Butts and Clemmons (1979). This is where the teacher's entire personality comes into making the lesson exciting an interesting. The teacher must love and enjoy his teaching for that enjoyment to be transmitted to the students. If he is bored with the lesson, the students will almost certainly feel bored. It is the duty of the teacher to make his presentation what he wants it to be.

In his lesson presentation, the teacher should ensure that he makes his voice audible enough to reach the students at the back without necessarily shouting. He should try not to stand at one place throughout his lesson. This will spread his influences; give all the students a sense of belonging and effect close control. He should also keep the students alert with questions at intervals. He should not encourage chorus response so that he can ascertain correctly the level of understanding of his students. He must equally allow them to get involved in the lesson and probe into the topic.

A lesson could be rounded – up with a though provoking question or problem which can occupy them until the next lesson. It could be based on the already completed lesson or on the lesson yet to be taught, and could form their assignment for that lesson.

Finally, it must be pointed out that no teacher puts down everything he is going to do in the class on paper. A good teacher, therefore, must be ingenious.

SKILLS IN LESSON PRESENTATION

7.2.1Set Induction

Set induction skills are those actions and statements made by the teacher that are designed to relate the objective of the lesson to the experience of the students. Here, the teacher sets the attention of the students on the topic or hand. The major idea is simply to get the interest of the students and gets them ready for the new lesson. There is therefore no rigid rules as to how the teacher can do this. It could be a review of the previous lesson if it has relevance to the new one, questions on the claimed previous knowledge stated under entering behaviour, relevant jokes, riddles, stories, short drama, or demonstration. The introduction should essentially serve to link the day's lesson with what has been covered previously, motivate the pupils to discover how the skill or lesson will be valuable to them and give a general background of the topic that he is about to cover.

TYPES OF SET INDUCTION

There are three types of set induction, these include:

i. Orientation set

ii. Transition set

iii. Evaluation set

7.2.1.1 Orientation Set

The attributes of orientation set include the following: -

a. It is used primarily to direct the students' attention to the presentation which the teacher is about the make.

b. It can be used to aid in classifying the learning outcome of the lesson presentation.

c. It provides a framework which enables the students visualize the content of the teacher's presentation.

d. It employs one activity or object picture or person which the teacher knows the students have interest on.

7.2.1.2 Transition Set

This processes the following characteristics as:

a. It is used primarily to make for transition from the known to the unknown, simple to complex and from the already covered lesson to a new one.

b. It relies heavily on the use of examples and students activities which they are interested in and familiar with.

7.2.1.3 Evaluation Set

It is characterized by the following:

a. It is used mainly to evaluate the learnt experience before moving mto a new one.

b. It concentrates on students derived activities that demonstrate understanding of previously learnt content.

c. It could be used to evaluate a discussion

WHEN TO USE SET INDUCTION

1. To introduce a new concept
2. To initiate a discussion
3. To introduce a film, a television programme
4. To prepare student for a field trip
5. To introduce a laboratory experiment
6. To present a guest speaker

FUNCTIONS OF SET INDUCTION

1. Stimulates students' interest and involvement in the lesson.
2. Creates an organizing framework for ideas, principles and information which is to follow.
3. Extend understanding and application of abstract ideas through the use of example and analogy.
4. Focuses students' attention on the lesson.

7.2.2 Silence and Non-verbal Cues

Training in the use of silence and non-verbal cues is aimed at remedying the tendency for teachers to talk too much. Silence can have a powerful effect if used intuitively, and non-verbal cues can often be more effective than verbal ones. Non-verbal cues are categorized under four broad headings:

7.2.2.1 Facial Cues

A smile, a frown, serious or quizzical look

7.2.2.2 Body Movement

Moving towards the responding pupil or adopting pupil or towards a pupil that is no paying attention to the lesson can be of great significance in encouraging the pupil or catching the attention of the later one.

7.2.2.3 Head Movement

'Yes' and 'No' nods or the cocking of head.

7.2.2.4: Gesture

Pointing to a pupil, motioning to continue or to stop

7.2.3 Stimulus Variation

Training in the skill of stimulus variation is aimed at helping student-teacher to avoid teaching styled likely to induce boredom in their pupils. A stimulus situation that changes in different ways is one of the most powerful influences in maintaining orientating activity by the learners. Examples of ways the stimulus can be varied include:

1. Carefully instructed teaching materials and approaches to the subject.

Teachers are trained in: (a) Movement (b) Gesture (c) Focusing (d) Interaction style and (e) Shifting sensory channel.

For example, a lesson in Agriculture can be made more lively by making the pupils touch, smell and taste crop parts, in addition to listening to the description of what the crops look like.

Stimulus variation refers to those teachers' activities, sometimes planned and some other times spontaneous, designed to develop and maintain high level of students' attention during the course of the lesson.

7.2.3.1 Functions of Stimulus Variation

The functions include:

1. To change the pace or speed of the lesson
2. To focus and maintain students' attention on the lesson
3. To provide special emphasis on the point in the lesson or presentation.

7.2.3.2 Types of Stimulus Variation

There are four types of stimulus variation used mostly in lesson presentation:

1. **Focusing Variation**: This is the teacher's way of intentionally directing the students' attention through specific gestures or verbal statements or a combination of both. Some verbal explanations that can aid in focusing include:

i. Look out through the window

ii. Listen closely to this

iii. Watch out for the results

Some other mode of focusing can be gestural in nature. The teacher can sometime turn to the direction of on object or nod his head or use a pointer or clap his hands, gain attention at a particular fact. They could be a combination. Students saying; look at this diagram. He may face a certain direction and say; listen closely to this. Those among other things can aid the teacher focus students' attention on his lesson.

2. **Pausing**: This is a planned silence and can be used by the teacher at interval to induce attention in the students. However, pausing should be well planned, otherwise when overused; it tends to reduce its usefulness.

3. **Shifting Sense**: The teacher must take advantage of the students' five senses and plan to appeal to them. They are: sight, smell, taste, feel and learning.

4. **Kinesic Variation**: This is the teacher's ability to move from one location of the class to another in order to improve students' concentration. Sometimes, when this is excessive, it will have a negative effect.

7.2.4Closure

This is something the teacher says or does to bring his lesson to an appropriate end. It is used to bring fact together and make sense for students' remembering. The initiative of the teacher is called for in an affective closure.

1. This is the opposite of set induction

2. Closure is achieved when the major purposes and principles of the lesson, or a portion of it, are judged to have been learned, so that new knowledge can be related to past knowledge. It is more than a quick summary of the material covered in a lesson. In addition to pulling major points together and acting as a cognitive link between needed feeling of achievement.

Closure can either be instructional or cognitive. Instructional closure is reached when the lesson is completed and the teacher has shown the link between past knowledge and new knowledge. Cognitive closure is reached when the pupils love reaches closure and the link between old and new knowledge.

7.2.4.1 Types of Closure

1. **Review Closure**: This type of closure provides survey of the important points. It attempts to draw the students' attention to the important points. The major point is reviewed as related to the concept map of the lesson.

2. Transfer Closure: This type of closure can be done by the teacher by asking the students to take home an assignment which will summarize the lesson taught. This helps to draw the students' attention to the salient points contained in the lesson. It also demands the students' development of new knowledge from a previously learned lesson.

3. Unsuspected Closure: This is used where there have been no previous plan to close the lesson and something happens when the teaching exhibits. It can only be used when the situation happens to present itself and the teacher is smart enough in picking it up. It is an unplanned event to provide a natural closure to a discussion. It helps the students exchange knowledge to a new situation.

7.2.4.2 Purpose of Closure

i. To draw the attention of the students to the end of the lesson

ii. To help organize students' learning and typing them into a meaningful whole.

iii. To consolidate the major points the students have learnt

7.2.4.3 Guidelines for Use of Closure

1. Make the objective of the lesson clear once more
2. Develop the structure of the lesson
3. Make sure the students understood what you have taught

METHODS OF TEACHING GENERAL SCIENCE

2.0 Objectives

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

- Develop an understanding of different methods of teaching science.
- Develop an understanding of lecture-cum-discussion method.
- Develop an understanding of laboratory method and its utilization in teaching of mathematics.
- Develop an understanding of importance of observation method in science teaching.
- Develop an understanding of project method.
- Develop an understanding of problem solving method.

2.1 INTRODUCTION:

I think teaching is an art and there are born teachers. But there are majority of teachers, who can improve upon by experience of practice and utilization of various methods of teaching science. The basic aim of teaching any subject is to bring about desired change in behavior. The change in behavior of child will be indicated through children's capacity to learn effectively.This is only possible by adopting various methods of teaching. The teacher cannot utilize any method to any type of students in any type of environment. He / She has to choose and adopt the right method of teaching keeping in mind the capability of the students and the curriculum. Thus, method in a way of presentation of the content in the classroom. But, it in however very important to keep in mind that a method is not an end in itself but is used to achieve the set aims of teaching. You should also keep in mind that, same method should not be used at all times but there should be flexibility in using it as for as situations circumstances, and condition in a particular case. You should use various methods depending upon demand of the situation. The method which in a particular class under a particular circumstance, may be a total failure for other teacher. However, some set criteria for selection of a method of teaching will be discussed further in the following paragraphs.

Principles for selecting methods:-

There are some guiding principles for determining teaching methods. They are as follows:-

1. Principle of sense of achievement through interest and purpose.
2. Principle of active cooperation.
3. Principle of capability of students of particular class.
4. Principle of realization of meaning of education i.e., “I bring up”, “I nourish”, “Drawing art”.
5. Psychological principle i.e., need, interest, of students.

6. Principle of individual difference i.e., different potentialities of students.

2.2 METHODS OF TEACHING GENERAL SCIENCE:-

All the methods of teaching science can be classified into two types:-

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

(i) Teacher-Centred Methods:-

:-

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

(ii) Pupil-Centred Methods:-

This process emphasizes on need, requirement, interest and capability of students. The students are active participants where in their skills and abilities are developed. The climate in the classroom is conducive where in flexibility in there. Teacher and students jointly explore the different aspects of problem. The role of the teacher in to create a problematic situation, have materials and resources available to the students, and help them identify issues, state hypotheses, clarify and test hypotheses and draw conclusions

. **2.2.1 LECTURE-CUM-DISCUSSION METHOD:-**

This method is a combination of lecture method and discussion method. This is very helpful in building an active verbal interaction between the teachers and students. The teacher delivers the lecture and provides some time (10 minutes) after the lecture for discussion among the students and teacher in the classroom. The student's views, comments experiences, problems, difficulties in understanding any point or portion of the lecture come to teacher's knowledge and teacher replies, and clarifies the doubts. It is an important strategy in stimulating the students interests and assess their understanding of the concept. It is a process in which interaction goes on in between teacher and students, where in question and answer are asked and given by both the teacher and students making the process interactive, and effective. The basic purpose of this method is to disseminate information and attain educational objectives by learning. The discussion in the class is intended to be a give and take between teacher and students. This method helps students to apply critical thinking power in various situations. Higher learning skills like analyzing, synthesizing, generalizing are given front seat.

PRINCIPLES OF LECTURE-CUM-DISCUSSION METHOD:-

The Principles are as follows:-

1. The teacher should be aware of needs of learners.
2. The teacher must arouse interest in the subject and sustain in the mind of students.

3. Teacher must use visual aids and use ICT.

4. The teacher must take enough time to build mental pictures, with new concepts, previous knowledge, moving from simple to difficult ideas, for better conceptual development.

ROLE OF TEACHER

The teacher has to perform following roles:-

1. Encourage students to participate in discussion.
2. Ensure, student's attention span is maintained.
3. Pre plan and prepare properly for discussion and support ideas with factual evidence and examples.
4. Encourage student taking than teacher talking.
5. If possible give time before hand so that, the discussion becomes productive.
6. Do not dominate rather get the discussion started set goals, summarize, mediate and clarify.

MERIT OF LECTURE-CUM-DISCUSSION METHOD:-

1. It creates democratic environment in the class.
2. Develops and improves communication skills of students.
3. It brings about attitudinal change among students.
4. It helps in assessing the factual knowledge of the students.

LIMITATIONS OF LECTURE-CUM-DISCUSSION METHOD:-

1. It is helpful for mature students.
2. If it is not properly used, then the principle of "learning by participating" is not achieved.

3. If teacher does not handle students effectively then the students may be in disciplined rather than participation.

4. If not managed properly, it will not help all types of students in the class.

5. Teacher must control his emotions else this may result in wrong output.

SUGGESTION FOR IMPROVEMENT:-

1. The teacher must maintain good eye contact with students in order to make the process meaningful.
2. The teacher must actively involve students.
3. The teacher must instruct clearly.
4. Must keep the group focused on the task.
5. Teacher should use good time management techniques and evaluate students as they learn in the class.
6. Teacher should not read extensively from lecture notes or text books.
7. Teacher must not ignore participant's comments and feedback.

LABORATORY METHOD:-

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

laboratory activity. The experience in a laboratory is very rich in personal satisfaction as they gain it firsthand. The sense of excitement and challenge help them to achieve some tangible him.

PRINCIPLES OF LABORATORY METHOD:-

1. It follows the principle of learning by doing.
2. It follows psychological principle, where students age, lord and interest is taken into consideration.
3. The work should be Pre-organized and Pre-selected.
4. Teacher must see that, students are allowed to work independently without much interference.
5. The teacher must ensure that apparatus and equipments should be checked pair hand.
6. Teacher must see that students are able to follow in struction and record their observation properly.

ROLE OF TEACHER:-

1. Teacher must be a facilitator of the process of doing experiments by students.

2. Teacher must check the apparatus previously, so that it goes on smoothly.

3. The practical work must be Pre-organized and Pre-selected.

4. The skills of handling apparatus, drawing, diagrams, careful observations taking necessary precautions, must be developed among students.

5. The teacher must be that, the student is doing experiment properly by following proper procedure.

MERITS OF LABORATORY METHOD:-

The Merits are listed below:-

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

LIMITATIONS OF LABORATORY METHOD:-

The limitations of this method are as follows:-

1. It is expensive and uneconomical.

2. It is time consuming as it takes much time in some experiments to come to conclusion.

3. It expects a lot from students and teacher.

4. It does not guarantee that, students would be equally efficient in solving problems outside laboratory.

5. All students cannot be expected to be skilled workers.

6. Most of the students are either not ready or lack to ability to undertake original work.

SUGGESTIONS TO IMPROVE:-

1. This method should not be considered independently but should form a part of the total science programme.

2. The practical work must be pre-planned.

3. It is imperative that same individual laboratory work must be done by every student.

4. Instead of performing the experiments started in the book should be little modified for better result.

5. Before experiment in performed the purpose must be clarified to the students.

Dr. Chandana Patnaik
Asst. Prof. CSSM,
Chamber, Mumbai

3.0 Objectives: -

In this unit, an overview of following points will be given to you. After reading this unit, you would be able to:

- Formulate instructional objectives of teaching science.
- Plan a teaching unit of science.
- Plan a lesson effectively according to different approaches.
- Know the process of developing improvised teaching aids in general science.

3.1 Introduction: -

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

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

According to B.S. Bloom

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

According to E.J. Frust,

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

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

Educational Objectives

(EO)

learning Experience (L.E) Change of Behavior (B.E)

This show learning experiences are provided by teaching activities to achieve educational objectives and change of behavior is evaluated in terms of educational objectives.

Objectives are of two types: -

i) Educational Objectives.

ii) Teaching / Instructional Objectives.

Educational Objectives: -

These objectives are broad and related to educational system and school.

Teaching / Instructional Objectives: -

These objectives are narrow and specific and are concerned with classroom teaching. The educational objective stretches to a longer period of time say from primary level to university level, where as instructional objectives may be realized within the stipulated period of 40 minutes duration. For example – Educational objectives is “To develop the feeling of national integration”. This includes several teaching objectives like knowledge, understanding, application, interest, attitude of national integration.

3.2 Formulation of instructional objectives: -

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

(A) Classroom Instructional Objectives: -

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

Specifications: -

i) The pupil recalls……

a) The facts, terminology.

b) The definition of various laws, principles.

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

d) The concept of classification of substances.

e) The names of types of diseases.

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

iii) The pupil recognizes………

a) Different apparatus used in various experiments.

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

Specifications: -

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

ii) The pupil cites examples of metals and metalloids.

iii) The pupil classifies plant kingdom and animal kingdom.

iv) The pupil selects appropriate for performing experiment.

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

vi) The pupil defects errors in a given example.

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

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

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

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

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

Specifications: -

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

ii) The pupil formulates hypothesis to organize the elements.

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

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

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

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

vii) The pupil predicts various applicability of laws.

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

ix) The pupil interprets various graphs, charts etc.

x) The pupil translates statements into symbols.

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

Specifications: -

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

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

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

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

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

vi) The pupil records the observation accurately and neatly.

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

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

ix) The pupil draws conclusions.

x) The pupil summarizes observations after the experiment.

B) Personality Objectives

5. The pupil develops interest in science.

Specifications: -

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

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

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

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

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

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

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

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

ix) The pupil meets scientist astronauts etc.

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

6. The pupil develops positive scientific attitude.

Specifications: -

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

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

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

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

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

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

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

viii) The pupil faces problems with full confidence.

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

Specifications: -

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

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

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

Check your progress: -

1. Define educational objectives.
2. What is instructional or classroom objective?

3.3 Unit Planning: -

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

- Preston

‘Outline of carefully selected subject matter which has been isolated because of its relationship to pupils.

- Sanford

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

- Wisely

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

Points to be kept in mind while planning for a unit: -

1. It must be related to social and physical environment of the pupils.
2. It must take into account the previous experiences of pupils.
3. It must provide now experiences to the pupils.
4. It must not be too lengthy, so that pupil's interest is sustained.
5. It should be flexible so as to allow different types of students to explore their capacities.
6. It should be the result of cooperative planning of teacher and pupil as far as possible.

Steps of Developing a Teaching Unit

1. Preparation or motivation: -

The pupils establish the purpose and one motivated to achieve it. The motivation must be self-directed. This is required throughout the lesson.

2. Knowing the previous experience: -

It is always advisable to start with the pupils where they are this is helpful in knowing the background so that duplication or danger of non-understanding can be arrived. This can be done by questioning.

3. Presentation: -

In this step new experiences are given to the students. These may be direct or vicarious care must be taken to present adequate amount of new experience that can be digested by pupils.

4. Organization of learning: -

The student should get opportunity to bring their learning together so that they may establish relationship between the new experiences and assimilate them.

5. Summarization: -

This is usually done at the end of the teaching unit to bring together all the learning. This may be done at internals during the progress of the unit organization and summarizations go together.

6. Review and drill: -

During the progress of unit, there is a chance of forgetting some part of it and not comprehending same. This requires to review or drill the new content taught for better retention from time to time during the lesson.

7. Evaluation: -

Evaluation should be done to know the level of achievement of students. This can be done either by written from or oral form after short intervals. i.e., after a week or fortnight. This can also be done by interview self-check test, puzzles etc. The final test given grades to the pupils and tests effectiveness of teaching.

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https://www.edsys.in/innovative-science-teaching-methods/

https://www.youtube.com/watch?v=XIYrc9p1gOI

https://www.youtube.com/watch?v=uMPk722ETLU https://www.stem.org.uk/best-evidence-science-teaching

https://www.youtube.com/watch?v=4YG5d8xL_hw

CHAPTER 9

Assessment in biology teaching

Why Is Assessment Important?

Asking students to demonstrate their understanding of the subject matter is critical to the learning process; it is essential to evaluate whether the educational goals and standards of the lessons are being met.

July 15, 2008

Assessment is an integral part of instruction, as it determines whether or not the goals of education are being met. Assessment affects decisions about grades, placement, advancement, instructional needs, curriculum, and, in some cases, funding. Assessment inspire us to ask these hard questions: "Are we teaching what we think we are teaching?" "Are students learning what they are supposed to be learning?" "Is there a way to teach the subject better, thereby promoting better learning?"

Today's students need to know not only the basic reading and arithmetic skills, but also skills that will allow them to face a world that is continually changing. They must be able to think critically, to analyze, and to make inferences. Changes in the skills base and knowledge our students need require new learning goals; these new learning goals change the relationship between assessment and instruction. Teachers need to take an active role in making decisions about the purpose of assessment and the content that is being assessed.

Grant Wiggins, a nationally recognized assessment expert, shared his thoughts on performance assessments, standardized tests, and more in an Edutopia.org interview. Read his answers to the following questions from the interview and reflect on his ideas:

- What distinction do you make between 'testing' and 'assessment'?
- Why is it important that teachers consider assessment before they begin planning lessons or projects?
- Standardized tests, such as the SAT, are used by schools as a predictor of a student's future success. Is this a valid use of these tests?

Do you agree with his statements? Why or why not? Discuss your opinions with your peers.

When assessment works best, it does the following:

Provides diagnostic feedback

- What is the student's knowledge base?
- What is the student's performance base?
- What are the student's needs?
- What has to be taught?

Helps educators set standards

- What performance demonstrates understanding?
- What performance demonstrates knowledge?
- What performance demonstrates mastery?

Evaluates progress

- How is the student doing?
- What teaching methods or approaches are most effective?
- What changes or modifications to a lesson are needed to help the student?

Relates to a student's progress

- What has the student learned?
- Can the student talk about the new knowledge?
- Can the student demonstrate and use the new skills in other projects?

Motivates performance

For student self-evaluation:

- Now that I'm in charge of my learning, how am I doing?
- Now that I know how I'm doing, how can I do better?
- What else would I like to learn?

For teacher self-evaluation:

- What is working for the students?
- What can I do to help the students more?
- In what direction should we go next?

How do you use the different types of assessment in your classroom to promote student learning?

School closures and remote or hybrid learning environments have posed some challenges for educators, but motivating students to learn and grow remains a constant goal.

Some students have lost a portion of their academic progress. Assessing students in meaningful ways can help motivate and empower them to grow as they become agents of their own learning.

There’s so much more to assessments than delivering an end-of-unit exam or prepping for a standardized test. Assessments help shape the learning process at all points, and give you insights into student learning.:

The major purpose of assessment in schools should be to provide interpretative information to teachers and school leaders about their impact on students, so that these educators have the best information possible about what steps to take with instruction and how they need to change and adapt. So often we use assessment in schools to inform students of their progress and attainment. Of course this is important, but it is more critical to use this information to inform teachers about their impact on students. Using assessments as feedback for teachers is powerful. And this power is truly maximized when the assessments are timely, informative, and related to what teachers are actually teaching.

Six types of assessments are:

- Diagnostic assessments
- Formative assessments
- Summative assessments
- Ipsative assessments
- Norm-referenced assessments
- Criterion-referenced assessments

What's the purpose of different types of assessment?

Different types of assessments can help you understand student progress in various ways. This understanding can inform the teaching strategies you use, and may lead to different adaptations.

In your classroom, assessments generally have one of three purposes:

1. Assessment *of* learning
2. Assessment *for* learning
3. Assessment *as* learning

Assessment of learning

You can use assessments to help identify if students are meeting grade-level standards.

Assessments of learning are usually **grade-based**, and can include:

- Exams

- Portfolios
- Final projects
- Standardized tests

They often have a concrete grade attached to them that communicates student achievement to teachers, parents, students, school-level administrators and district leaders.

Common types of assessment of learning include:

- Summative assessments
- Norm-referenced assessments
- Criterion-referenced assessments

Assessment for learning

Assessments for learning provide you with a clear snapshot of student learning and understanding *as you teach* -- allowing you to adjust everything from your classroom management strategies to your lesson plans as you go.

Assessments for learning should always be **ongoing and actionable**. When you're creating assessments, keep these key questions in mind:

- What do students still need to know?
- What did students take away from the lesson?
- Did students find this lesson too easy? Too difficult?
- Did my teaching strategies reach students effectively?
- What are students most commonly misunderstanding?
- What did I most want students to learn from this lesson? Did I succeed?

There are lots of ways you can deliver assessments for learning, even in a busy classroom. We'll cover some of them soon!

For now, just remember these assessments aren't only for students -- they're to provide you with actionable feedback to improve your instruction.

Common types of assessment for learning include formative assessments and diagnostic assessments.

Assessment as learning

Assessment as learning **actively involves students** in the learning process. It teaches critical thinking skills, problem-solving and encourages students to set achievable goals for themselves and objectively measure their progress.

They can help engage students in the learning process, too! One study "showed that in most cases the students pointed out the target knowledge as the reason for a task to be interesting and engaging, followed by the way the content was dealt with in the classroom."

Another found:

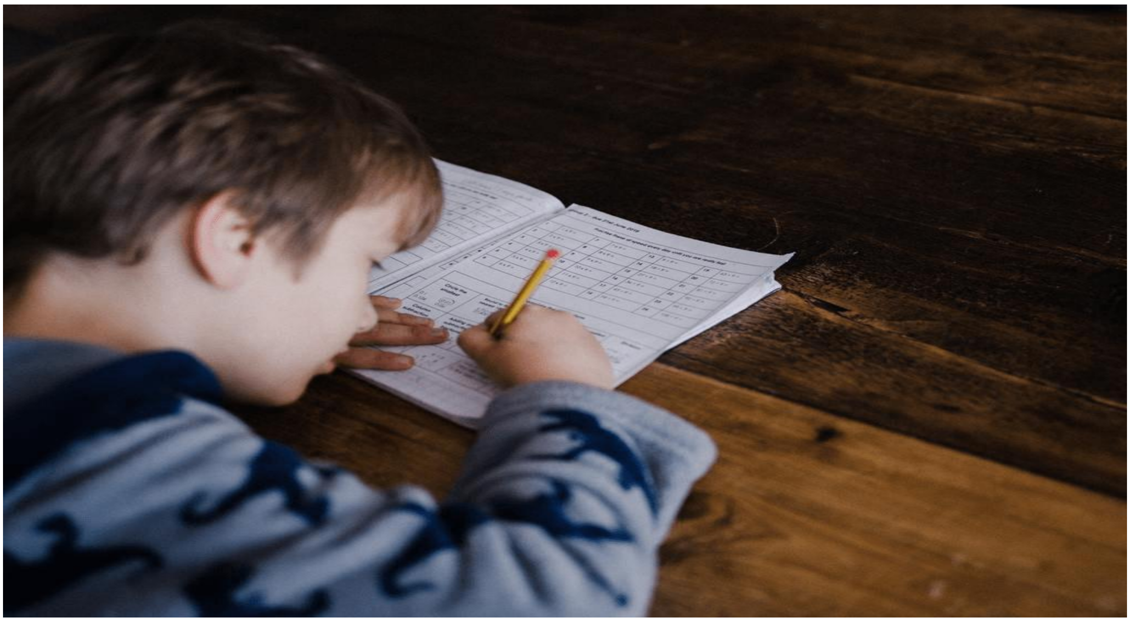
"Students develop an interest in mathematical tasks that they understand, see as relevant to their own concerns, and can manage. Recent studies of students' emotional responses to mathematics suggest that both their positive and their negative responses diminish as tasks become familiar and increase when tasks are novel" Douglas B. McLeod

Some examples of assessment as learning include ipsative assessments, self-assessments and peer assessments.

6 Types of assessment to use in your classroom

There's a time and place for every type of assessment. Keep reading to find creative ways of delivering assessments and understanding your students' learning process!

1. Diagnostic assessment



Let's say you're starting a lesson on two-digit multiplication. To make sure the unit goes smoothly, you want to know if your students have mastered fact families, place value and one-digit multiplication before you move on to more complicated questions.

When you structure **diagnostic assessments** around your lesson, **you'll get the information you need to understand student knowledge and engage your whole classroom**.

Some examples to try include:

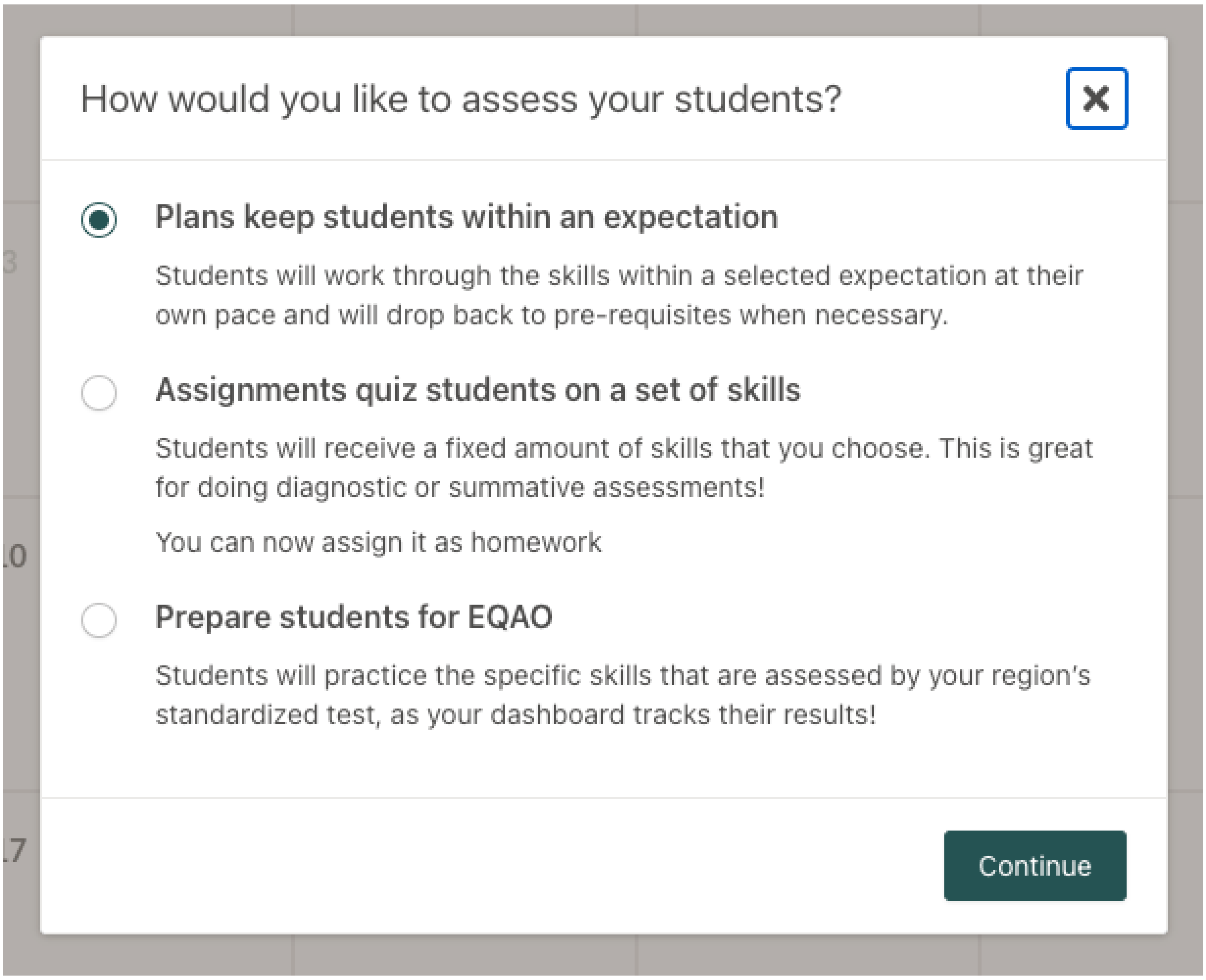
- Short quizzes
- Journal entries
- Student interviews
- Student reflections
- Classroom discussions
- Graphic organizers (e.g., mind maps, flow charts, KWL charts)

Diagnostic assessments can also help benchmark student progress. Consider giving the same assessment at the end of the unit so students can see how far they've come!

Using Prodigy for diagnostic assessments

One unique way of delivering diagnostic assessments is to use a game-based learning platform that engages your students.

Prodigy's assessments tool helps you align the math questions your students see in-game with the lessons you want to cover.



To set up a diagnostic assessment, use your assessments tool to create a *Plan* that guides students through a skill. This adaptive assessment will support students with pre-requisites when they need additional guidance.

Want to give your students a sneak peek at the upcoming lesson? Learn how Prodigy helps you pre-teach important lessons.

2. Formative assessment

Just because students made it to the end-of-unit test, doesn't mean they've mastered the topics in the unit. **Formative assessments** help teachers understand student learning while they teach, and provide them with information to adjust their teaching strategies accordingly.

Meaningful learning involves processing new facts, adjusting assumptions and drawing nuanced conclusions.

“Current research indicates that acquired knowledge is not simply a collection of concepts and procedural skills filed in long-term memory. Rather, the knowledge is structured by individuals in meaningful ways, which grow and change over time.”

In other words, meaningful learning is like a puzzle — having the pieces is one thing, but knowing how to put it together becomes an engaging process that helps solidify learning.

Formative assessments help you track how student knowledge is growing and changing in your classroom in real-time. While it requires a bit of a time investment — especially at first — the gains are more than worth it.

Some examples of formative assessments include:

- Portfolios
- Group projects
- Progress reports
- Class discussions
- Entry and exit tickets
- Short, regular quizzes

When running formative assessments in your classroom, it’s best to keep them **short, easy to grade and consistent**. Introducing students to formative assessments in a low-stakes way can help you benchmark their progress and reduce math anxiety.

How Prodigy helps you deliver formative assessments

Prodigy makes it easy to create, deliver and grade formative assessments that keep your students engaged with the learning process and provide you with actionable data to adjust your lesson plans.

Use your Prodigy teacher dashboard to create an *Assignment* and make formative assessments easy!

Assignments assess your students on a particular skill with a set number of questions and can be differentiated for individual students or groups of students.

For more ideas on using Prodigy for formative assessments, read:

They can assist with communicating student progress, but they don't always give clear feedback on the learning process and can foster a "teach to the test" mindset if you're not careful.

. Try creating assessments that deviate from the standard multiple-choice test, like:

- Recording a podcast

- Writing a script for a short play
- Producing an independent study project

No matter what type of summative assessment you give your students, keep some best practices in mind:

- Keep it real-world relevant where you can
- Make questions clear and instructions easy to follow
- Give a rubric so students know what's expected of them
- Create your final test after, not before, teaching the lesson
- Try blind grading: don't look at the name on the assignment before you mark it

Effective Questioning and Reacting Techniques

Focus Questions:

- For a highly interactive classroom, what are the various types of questions asked?
- What are some questioning skills that teachers should develop to generate interaction?
- How can a teachewr improve his/her questioning skills?
- What are some effective reacting techniques?

Types of Questions according to Purpose

For Assessing Cognition

For Verification

For Cretive thinking

For Evaluating

For productive thinking

For Motivating

For Instructing

Types of Questions according to Level / Answer

Low level of questions

High level of questions

Convergent questions

Divergent questions

Questioning skills

1. Varying type of question
2. Asking non-directed questions
3. Calling on non-volunteers
4. Rephrasing
5. Sequencing logically
6. Requiring abstract thinking
7. Asking open-ended questions
8. Allowing for sufficient wait time
9. Assessing comprehesion
10. Involving as many as possible

How to improve Questioning Techniques

1. Know your own style of questioning
2. Request a colleague to critique your own style as to:
    a. Kind of questions often asked
    b. Amount of wait-time provided
    c. The type of responses required
3. Increase your own repertoire of type of questions.

4. Consider the individual abilities and interests of the students.
5. Spend time reflecting on the type of questions you ask

How to Encourage Questions from Students

Here are some tips:

1. The teacher's qiuestioning technique is the key in encouraging the students to ask correct, relevant and high level questions.
2. Attend to their questions
3. Praise the correctly formulated questions.
4. Allot an appropriate time slot for open questioning.

Handling Pupils' Repsonse

The following techniques can help:

1. Providing feedback on the correctness or incorrectness of a response.
2. Giving appropriate praise to high quality responses.
3. Making follow up questions
4. Redirecting questions
5. Following up a student's response with related questions
6. Re-phrasing the seemingly unclear question
7. Showing non-verbal encouragement
8. Encouraging learners to ask questions

Exercise:

Tell us in one page how many types of assessment you used in Teaching?

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Exercise:

Design Short true or false Test in biology?

Exercise:

Tell us in one page Why Is Assessment Important?

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Exercise:

Design **Exercise:**

Tell us in one page Why Is Assessment Important?

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Exercise:

Design Short M.C.Q Test in biology?

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