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## كلية التربية بالغرذقة - جامعة جنوب الوادي

### رؤية الكلية

كلية التربية بالغرذقة مؤسسة رائدة محلياً ودولياً في مجالات التعليم، والبحث العلمي، وخدمة المجتمع، بما يؤهلها للمنافسة على المستوى: المحلي، والإقليمي، والعالمى.

### رسالة الكلية

تقديم تعليم مميز في مجالات العلوم الأساسية و إنتاج بحوث علمية تطبيقية للمساهمة في التنمية المستدامة من خلال إعداد خريجين متميزين طبقاً 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.

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# **Chapter 1**

## **history of chemistry**

The **history** of chemistry is an interesting and challenging one. Very early chemists were often motivated mainly by the achievement of a specific goal or product. Making perfume and soaps did not require much **theory**, just a good recipe and careful attention to detail. There was no standard way of naming materials (and no periodic table that everyone could agree on). However, the science developed over the centuries.

Major progress was made in putting chemistry on a solid foundation when Robert Boyle (1637-1691) began his **research** in chemistry. He developed the basic ideas for the behavior of gases; gases could thereafter be described mathematically. Boyle also helped pioneer the idea that small particles could combine to form molecules. Many years later, John Dalton used these ideas to develop the atomic theory.

The field of chemistry began to develop rapidly in the 1700s. Joseph Priestley (1733-1804) isolated and characterized several gases: oxygen, carbon monoxide, and nitrous oxide. It was later discovered that nitrous oxide ("laughing gas") worked as an anesthetic. This gas was used for that purpose for the first time in 1844 during a tooth extraction. Other gases discovered during that time were chlorine, by C.W. Scheele (1742-1786) and nitrogen, by Antoine Lavoisier (1743-1794). Lavoisier has been considered by many scholars to be the "father of chemistry".

Chemists continued to discover new compounds in the 1800s. The science also began to develop a more theoretical foundation. John Dalton (1766-1844) put forth his atomic theory in 1807. This idea allowed scientists to think about chemistry in a much more systematic way. Amadeo Avogadro (1776-1856) laid the groundwork for a more quantitative approach to chemistry by calculating the number of particles in a given amount of a gas. A lot of effort was put forth in studying chemical reactions. These efforts led to new materials being produced. Following the invention of the battery by Alessandro Volta (1745-1827), the field of electrochemistry (both theory and application) developed through major contributions by Humphry Davy (1778-1829) and Michael Faraday (1791-1867). Other areas of the discipline also progressed rapidly.

It would take a large book to cover developments in chemistry during the twentieth century and up to today. One major area of expansion was in the area of the chemistry of living processes. Research in photosynthesis in plants, the discovery and characterization of enzymes as biochemical catalysts, elucidation of the structures of biomolecules such as insulin and DNA —these efforts gave rise to an explosion of information in the field of biochemistry.

[Chemistry: How it all started](#)

**Chemistry began the moment our ancestors became human.**

In the very early 1700s the Elector of Saxony and King of Poland, August the Strong, locked an alchemist in his laboratory and told him to make gold. The young alchemist, Johann Friedrich Böttger, failed in his royally-appointed task. Instead he helped create a substance far more beautiful and useful than gold – porcelain. And in a happy fairy-tale ending, the king was pleased. For this was no longer a feudal world, but a growing commodity-driven society, and until that time porcelain had to be imported at great expense from a technologically more advanced China to feed a growing European appetite for beauty and luxury. Wealth flowed to the king, for the new Meissen porcelain soon proved popular and a grateful king made Böttger, originally a pharmacist's apprentice, a baron.

One more story, this one beginning in the gutter: Around 1669 Hamburg resident Hennig Brandt believed he might have discovered the fabled Philosopher's Stone, which could turn lead into gold and open up the secrets of the cosmos. An ex-soldier with experience in making glass, Brandt began with old urine and boiled it up and heated the residue until glowing vapours – white phosphorous reacting with oxygen – filled his glassware. Within a few years, Brandt sold his secret and soon phosphorous was well enough known that the secretive alchemist Isaac Newton could begin a recipe for it with the instructions, "Take of urine one barrel." (Though I do wonder where one could easily procure a barrel of urine). From urine to art – another transformation –the moment of discovery was immortalized in the eighteenth century in a painting by Joseph



Wright of Derby, and recorded again as a mezzotint by William Pether in 1775 as “The Discovery of Phosphorous.” In this work, the alchemist kneels in awe before the glowing wonder in his alchemical laboratory. Many years later, in 1943, in another transformation, Brandt’s city burned when thousands of pounds of phosphorous fell in the form of bombs.

We turn clay into porcelain, urine into phosphorous, phosphorous into bombs, flour into bread, grapes into wine, minerals into pigments. There is almost no limit to the ways in which we transmute matter. Biological anthropologist, Richard Wrangham (United Kingdom), believes that it is cooking that made us human -- by making more energy available to feed our growing brains. If that is so, chemistry began the moment our ancestors became human. Homo chemicus—to be human is to transform matter. And the material transformations we –being human –make will reflect the best and the worst of us.

We cannot go back to that first chemical moment when raw food turned into cooked food, but we can go back to prehistoric humans and their desire for beauty. Philippe Walter, of the Centre de Recherche et de Restauration des Musées de France, studies chemical processes and substances in the ancient and prehistoric world. While he says these prehistoric peoples did not have an understanding of how or why processes worked, they still produced practical chemists who could mix natural ingredients to produce pigments – whether to adorn themselves or the walls of caves. Four

thousand years ago the ancient Egyptians, says Walter, synthesized new chemicals to treat eye diseases. Their lead-based cosmetics – think Cleopatra and her kohl eyeliner stimulated the wearer's immune system in an early health and beauty regimen.

In Hellenistic Egypt, the refining of metals was known as chemia. With the rise of early Islamic civilization, Muslim scholars translated many Greek texts, including ones on chemia, which they called al-kimia. How matter changed, how to purify substances, how to colour metals, all came under al-kimia. A side benefit of this new fascination was the refinement in practical knowledge such as distillation and crystallization, still important skills in twenty first century labs. On a more theoretical level, Muslim scholars built on earlier Greek understandings of matter – the four elements of air, earth, fire, and water – and its behaviour, including the transmutation of one metal into another. Al-kimia arrived in Europe in the twelfth century, along with some knowledge of al-iksir (elixir, which became known as the Philosopher's Stone).

Unsurprisingly, alchemy ran into the same kinds of problems that still occasionally plague medicine – hucksters hawking miracle cures and charlatans, etc. Even less surprising, this caught the attention of both rulers and the legal profession, if for different reasons. Later, in England, it became illegal to succeed in turning lead into gold, for this was considered as debasing the currency.

Some claimed that, since human manipulation of matter was essentially inferior to what nature does, naturally (an early version of the still running natural versus artificial debate – check back next century for an update) human attempts at transmuting metals were doomed. Despite such criticisms, there were those who believed that human art was powerful enough to transform the world. But these were discussions for the elites at universities. And matter in all its manifestations was on the move through all social strata. We don't know who first created kohl or a clay pot, who first tanned leather or brewed beer, and we don't know the names of the medieval artisans who mixed sand, wood ash, and metal salts to create the great stained-glass windows of medieval cathedrals. But these people all transformed matter and our lives.

By the early modern period, the status of painters, goldsmiths and artisans with an intimate association with matter, was on the rise. Science, long associated with understanding rather than doing, and with elites rather than common folk, was now turning to the practical makers of things for knowledge and power. Such an approach, where matter was central, found its expression in Sir Francis Bacon's 1620 manifesto *Novum Organum*, and the origins of modern science. Doing – poking, prodding, changing the material world – would now be allied with understanding, and our world of art, science, and the everyday, would never be the same. Robert Boyle (Ireland), of Boyle's Law fame – which connects the pressure, volume and temperature of a gas – epitomized this new

experimental approach. An inheritor of the alchemical tradition, (almost by definition, alchemists were experimentalists and careful measurers) and an aspiring alchemist, Boyle is considered a founding figure of modern chemistry, in the 17th century.

### A colourful science

Many chemists believe chemistry became a proper science in the eighteenth century. The investigation of air by Antoine Lavoisier (France), the discovery of oxygen by Joseph Priestly (England), and the new scientific language of chemistry, all played a part. But chemistry, or at least its results, could not be confined to the world of scientific research. The craze for hot-air and hydrogen ballooning in the late eighteenth century and the ballooning-related fashions in clothes, playing cards, and ceramics were only part of the story. Priestley's invention of carbonated water, as the poor man's alternative to the sickly rich drinking the waters at expensive spas, continued chemistry's association with health that had begun with alchemy. On the other hand, the Victorian craze for green coloured (courtesy of arsenic) wallpaper helped create what might be the worlds' first recognized (and reported as such) environmental hazard.

In 1856, an eighteen-year old Englishman, William Henry Perkin, tried to turn coal tar into the malaria-preventative quinine (a material transformation worthy of an alchemist). Like Böttger, he failed, and in his failure he launched a colour revolution and inadvertently

helped found the German dye and pharmaceutical industry. Perkin had created mauve, the first of the synthetic aniline dyes that brightened the world from the 1860s. Queen Victoria, before her black phase, wore the new chemistry and started a fashion for that shade of purple. A rapidly industrializing Germany adopted the colourful anilines and made them its own, incidentally creating the first strong link between chemistry as a modern science and industry. A German physician, Gerhard Domagk, working for I.G. Farben, found, in 1932, that a modified red dye killed bacteria and so the first true antibiotics, the sulfa drugs, came into use. The link between fashion and medicine remained, for the skin of patients sometimes turned red, an indication that the drug was working.

ry lie in fashion, but the same industry that began with the world's brightest colours went on to produce Zyklon B – the poison gas of choice in the Nazis' extermination plans. World War II is known as the physicists' war for the development of the atomic bomb, but every war has been a chemist's war from the time humans learned to smelt metal. Just before World War II, Lise Meitner (an Austrian-born, later Swedish physicist) showed that the alchemists were right -- we can transmute one metal into another, in this case via nuclear reaction, and, by the end of the war, uranium 238 was transmuted into plutonium.

The hallmarks of the old alchemists, the grandiose goals and sometimes secrecy, continue today in our chemical quests – the creation of synthetic life, a cure for aging. At the same time, every

time you boil an egg you change the very nature of matter, in this case the shape of the proteins in the egg.

The rise of modern science and its growing prestige, especially the professionalization of science in the nineteenth century, pushed out the non experts. We've lost that sense of chemistry as the art and science of the everyday, and of ordinary people. But we can get it back. Recently, as part of the Chemical Heritage Foundation's museum programme, I asked a glass artist to give a talk and presentation of her work. She was a little nervous at first, saying she had never studied chemistry and didn't know anything about it. But after speaking about what she did -- her tools, the furnace, how she pulled molten glass about, the metals she added, what happened to the glass at different temperatures – she turned to me in surprise and said, “I am a practical chemist.”

Near the beginning of this essay I wrote: “To be human is to transform matter.” I'd like to end it with a variation. To transform matter is to be.

### [Michal Meyer](#)

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## Chemistry: History of Chemistry

The earliest practical knowledge of chemistry was concerned with metallurgy, pottery, and dyes; these crafts were developed with considerable skill, but with no understanding of the principles involved, as early as 3500 BC in Egypt and Mesopotamia. The basic ideas of element and compound were first formulated by the Greek philosophers during the period from 500 to 300 BC. Opinion varied, but it was generally believed that four elements (fire, air, water, and earth) combined to form all things. Aristotle's definition of a simple body as one into which other bodies can be decomposed and which itself is not capable of being divided is close to the modern definition of element.

About the beginning of the Christian era in Alexandria, the ancient Egyptian industrial arts and Greek philosophical speculations were fused into a new science. The beginnings of chemistry, or alchemy, as it was first known, are mingled with occultism and magic. Interests of the period were the transmutation of base metals into gold, the imitation of precious gems, and the search for the elixir of life, thought to grant immortality. Muslim conquests in the 7th cent. AD diffused the remains of Hellenistic civilization to the Arab world. The first chemical treatises to become well known in Europe were Latin translations of Arabic works, made in Spain c.AD 1100; hence it is often erroneously supposed that chemistry originated among the Arabs. Alchemy developed extensively during the Middle Ages, cultivated largely by itinerant scholars who wandered over Europe looking for patrons.

In the hands of the Oxford Chemists (Robert Boyle, Robert Hooke, and John Mayow) chemistry began to emerge as distinct from the pseudoscience of alchemy. Boyle (1627–91) is often called the founder of modern chemistry (an honor sometimes also given Antoine Lavoisier, 1743–94). He performed experiments under reduced pressure, using an air pump, and discovered that volume and pressure are inversely related in gases (see [gas laws](#)). Hooke gave the first rational explanation of [combustion](#)—as combination with air—while Mayow studied animal respiration. Even as the English chemists were moving toward the correct theory of combustion, two Germans, J. J. Becher and G. E. Stahl, introduced the false phlogiston theory of combustion, which held that the substance phlogiston is contained in all combustible bodies and escapes when the bodies burn.

The discovery of various gases and the analysis of air as a mixture of gases occurred during the phlogiston period. Carbon dioxide, first described by J. B. van Helmont and rediscovered by Joseph Black in 1754, was originally called fixed air. Hydrogen, discovered by Boyle and carefully studied by Henry Cavendish, was called inflammable air and was sometimes identified with phlogiston itself. Cavendish also showed that the explosion of hydrogen and oxygen produces water. C. W. Scheele found that air is composed of two fluids, only one of which supports combustion. He was the first to obtain pure oxygen (1771–73), although he did not recognize it as an element. Joseph Priestley independently discovered oxygen by heating the red oxide of mercury with a burning glass; he was the last great defender of the phlogiston theory.



The work of Priestley, Black, and Cavendish was radically reinterpreted by Lavoisier, who did for chemistry what Newton had done for physics a century before. He made no important new discoveries of his own; rather, he was a theoretician. He recognized the true nature of combustion, introduced a new chemical nomenclature, and wrote the first modern chemistry textbook. He erroneously believed that all acids contain oxygen.

The assumption that compounds were of definite composition was implicit in 18th-century chemistry. J. L. Proust formally stated the law of constant proportions in 1797. C. L. Berthollet opposed this law, holding that composition depended on the method of preparation. The issue was resolved in favor of Proust by John Dalton's atomic theory (1808). The atomic theory goes back to the Greeks, but it did not prove fruitful in chemistry until Dalton ascribed relative weights to the atoms of chemical elements. Electrochemical theories of chemical combinations were developed by Humphry Davy and J. J. Berzelius. Davy discovered the alkali metals by passing an electric current through their molten oxides. Michael Faraday discovered that a definite quantity of charge must flow in order to deposit a given weight of material in solution. Amedeo Avogadro introduced the hypothesis that equal volumes of gases at the same pressure and temperature contain the same number of molecules.

William Prout suggested that as all elements seemed to have atomic weights that were multiples of the atomic weight of hydrogen, they could all be in some way different combinations of hydrogen atoms. This contributed to the concept of the [periodic table](#) of the elements, the culmination of a long effort to find regular, systematic properties among the

elements. [Periodic laws](#) were put forward almost simultaneously and independently by J. L. Meyer in Germany and D. I. Mendeleev in Russia (1869). An early triumph of the new theory was the discovery of new elements that fit the empty spaces in the table. William Ramsay's discovery, in collaboration with Lord Rayleigh, of argon and other inert gases in the atmosphere extended the periodic table

Organic chemistry developed extensively in the 19th cent., prompted in part by Friedrich Wohler's synthesis of urea (1828), which disproved the belief that only living organisms could produce organic molecules. Other important organic chemists include Justus von Liebig, C. A. Wurtz, and J. B. Dumas. In 1852 Edward Frankland introduced the idea of valency (see [valence](#)), and in 1858 F. A. Kekule showed that carbon atoms are tetravalent and are linked together in chains. Kekule's ring structure for benzene opened the way to modern theories of organic chemistry. Henri Louis Le Châtelier, J. H. van't Hoff, and Wilhelm Ostwald pioneered the application of thermodynamics to chemistry. Further contributions were the phase rule of J. W. Gibbs, the ionization equilibrium theory of S. A. Arrhenius, and the heat theorem of Walther Nernst. Ernst Fischer's work on the amino acids marks the beginning of molecular biology.

At the end of the 19th cent., the discovery of the [electron](#) by J. J. Thomson and of [radioactivity](#) by A. E. Becquerel revealed the close connection between chemistry and [physics](#). The work of Ernest Rutherford, H. G. J. Moseley, and Niels Bohr on atomic structure (see [atom](#)) was applied to molecular structures. G. N. Lewis, Irving Langmuir, and Linus Pauling developed the electronic theory of [chemical bonds](#), directed valency, and

molecular orbitals (see [molecular orbital theory](#)). Transmutation of the elements, first achieved by Rutherford, has led to the creation of elements not found in nature; in work pioneered by Glenn [Seaborg](#) elements heavier than uranium have been produced. With the rapid development of [polymer](#) chemistry after World War II a host of new synthetic fibers and materials have been added to the market. A fuller understanding of the relation between the structure of molecules and their properties has allowed chemists to tailor predictively new materials to meet specific needs.

### **Chemistry: Branches of Chemistry**

Chemistry can be divided into branches according to either the substances studied or the types of study conducted. The primary division of the first type is between [inorganic chemistry](#) and [organic chemistry](#). Divisions of the second type are physical chemistry and analytical chemistry.

The original distinction between organic and inorganic chemistry arose as chemists gradually realized that compounds of biological origin were quite different in their general properties from those of mineral origin; organic chemistry was defined as the study of substances produced by living organisms. However, when it was discovered in the 19th cent. that organic molecules can be produced artificially in the laboratory, this definition had to be abandoned. Organic chemistry is most simply defined as the study of the compounds of carbon. Inorganic chemistry is the study of chemical [elements](#) and their compounds (with the exception of carbon compounds).

Physical chemistry is concerned with the physical properties of materials, such as their electrical and magnetic behavior and their interaction with electromagnetic fields. Subcategories within physical chemistry are thermochemistry, [electrochemistry](#), and chemical kinetics. Thermochemistry is the investigation of the changes in [energy](#) and [entropy](#) that occur during chemical reactions and phase transformations (see [states of matter](#)). Electrochemistry concerns the effects of electricity on chemical changes and interconversions of electric and chemical energy such as that in a voltaic cell. Chemical kinetics is concerned with the details of chemical reactions and of how equilibrium is reached between the products and reactants.

Analytical chemistry is a collection of techniques that allows exact laboratory determination of the composition of a given sample of material. In qualitative analysis all the atoms and molecules present are identified, with particular attention to trace elements. In quantitative analysis the exact weight of each constituent is obtained as well. Stoichiometry is the branch of chemistry concerned with the weights of the chemicals participating in chemical reactions. See also [chemical analysis](#).

Where did chemistry come from? Early "chemists" focused on practical problems—how to make dyes and perfumes, soap manufacture, uses of metals, and glass production, among others. The goal was not to understand the physical world—that came later. People just wanted to make things that would improve their lives in some way.

## History of Chemistry

The **history** of chemistry is an interesting and challenging one. Very early chemists were often motivated mainly by the achievement of a specific goal or product. Making perfume and soaps did not require much **theory**, just a good recipe and careful attention to detail. There was no standard way of naming materials (and no periodic table that everyone could agree on). However, the science developed over the centuries.

Major progress was made in putting chemistry on a solid foundation when Robert Boyle (1637-1691) began his **research** in chemistry. He developed the basic ideas for the behavior of gases; gases could thereafter be described mathematically. Boyle also helped pioneer the idea that small particles could combine to form molecules. Many years later, John Dalton used these ideas to develop the atomic theory.

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The practical aspects of chemistry were not ignored. The work of Volta, Davy, and Faraday eventually led to the development of batteries that provided a source of electricity to power a number of devices.

Charles Goodyear (1800-1860) discovered the process of vulcanization, allowing a stable rubber product to be produced for the tires of all the vehicles that we have today. Louis Pasteur (1822-1895) pioneered the use of heat sterilization to eliminate unwanted microorganisms in wine and milk. Alfred Nobel (1833-1896) invented dynamite. After his death, the fortune he made from this product was used to fund the Nobel Prizes in science and the humanities. J.W. Hyatt (1837-1920) developed the first plastic. Leo Baekeland (1863-1944) developed the first synthetic resin, which is widely used for inexpensive and sturdy dinnerware.

## **Who is the Father of Chemistry?**

Who is the Father of Chemistry? Here is a look at the best answers to this question and the reasons why each of these people may be considered to be the Father of Chemistry.

Father of Chemistry: Most Common Answer If you are asked to identify the Father of Chemistry for a homework assignment, your best answer probably is Antoine Lavoisier. Lavoisier wrote the book Elements of

Chemistry (1787). He compiles the first complete (at that time) list of elements, discovered and named oxygen and hydrogen, helped develop the metric system, helped revise and standardize chemical nomenclature and discovered that matter retains its mass even when it changes forms.

Another popular choice for the title of Father of Chemistry is Jabir ibn Hayyan, a Persian alchemist living around 800AD who applied scientific principles to his studies.

Other people sometimes known as the Father of Modern Chemistry are Robert Boyle, Jöns Berzelius and John Dalton.

Other "Father of Chemistry" Scientists Other scientists are called the Father of Chemistry or are noted in specific fields of chemistry:

Subject	Name	Reason
Father of Early Chemistry Father of Chemistry	Jabir ibn Hayyan (Geber)	Introduced the experimental method to alchemy, circa 815.
Father of Modern Chemistry	Antoine Lavoisier	Book: Elements of Chemistry (1787)
Father of Modern Chemistry	Robert Boyle	Book: The Sceptical Chymist (1661)
Father of Modern Chemistry	Jöns Berzelius	developed chemical nomenclature in the 1800s
Father of Modern Chemistry	John Dalton	revived atomic theory

Father of Early Atomic Theory	Democritus	founded atomism in cosmology
Father of Atomic Theory Father of Modern Atomic Theory	John Dalton	first to propose the atom as a building block of matter
Father of Modern Atomic Theory	Father Roger Boscovich	described what came to be known as modern atomic theory, about a century before others formalized the theory
Father of Nuclear Chemistry	Otto Hahn	Book: Applied Radiochemistry (1936) first person to split the atom (1938) Nobel Prize in Chemistry for discovering nuclear fission (1944)
Father of the Periodic Table	Dmitri Mendeleev	arranged all the known elements in order of increasing atomic weight, according to periodic properties (1869)
Father of Physical Chemistry	Hermann von Helmholtz	for his theories on thermodynamics, conservation of energy and



		electrodynamics
Father of Physical Chemistry Founder of Chemical Thermodynamics	Willard Gibbs	published the first unified body of theorems describing thermodynamics

(Author: Dr. Murray Coombs, June 23, 2015)

## Why study Chemistry

Chemistry is an incredibly fascinating field of study. Because it is so fundamental to our world, chemistry plays a role in everyone's lives and touches almost every aspect of our existence in some way. Chemistry is essential for meeting our basic needs of food, clothing, shelter, health, energy, and clean air, water, and soil. Chemical technologies enrich our quality of life in numerous ways by providing new solutions to problems in health, materials, and energy usage. Thus, studying chemistry is useful in preparing us for the real world.

Chemistry is often referred to as the central science because it joins together physics and mathematics, biology and medicine, and the earth and environmental sciences. Knowledge of the nature of chemicals and chemical processes therefore provides insights into a variety of physical and biological phenomena. Knowing something about chemistry is worthwhile because it provides an excellent basis

for understanding the physical universe we live in. For better or for worse, everything is chemical!

### **The UW-La Crosse's**

**accredited Chemistry and Biochemistry programs blend technical, hands-on research experience with practical skill development.**

Studying chemistry also puts one in an excellent position to choose from a wide variety of useful, interesting and rewarding careers. A person with a bachelor's level education in chemistry is well prepared to assume professional positions in industry, education, or public service. A chemistry degree also serves as an excellent foundation for advanced study in a number of related areas. The list of career possibilities for people with training in chemistry is long and varied. Even in times when unemployment rates are high, the chemist remains one of the most highly sought after and employed scientists.

### **WHAT DO CHEMISTS DO?**

The behavior of atoms, molecules, and ions determines the sort of world we live in, our shapes and sizes, and even how we feel on a given day. Chemists who understand these phenomena are very well equipped to tackle problems faced by our modern society. On any given day, a chemist may be studying the mechanism of the recombination of DNA molecules, measuring the amount of insecticide in drinking water, comparing the protein content of meats, developing a new antibiotic, or analyzing a moon rock. To design a

synthetic fiber, a life-saving drug, or a space capsule requires a knowledge of chemistry. To understand why an autumn leaf turns red, or why a diamond is hard, or why soap gets us clean, requires, first, a basic understanding of chemistry.

It may be obvious to you that a chemistry background is important if you plan to teach chemistry or to work in the chemical industry developing chemical commodities such as polymeric materials, pharmaceuticals, flavorings, preservatives, dyestuffs, or fragrances. You may also be aware that chemists are frequently employed as environmental scientists, chemical oceanographers, chemical information specialists, chemical engineers, and chemical salespersons. However, it may be less obvious to you that a significant knowledge of chemistry is often required in a number of related professions including medicine, pharmacy, medical technology, nuclear medicine, molecular biology, biotechnology, pharmacology, toxicology, paper science, pharmaceutical science, hazardous waste management, art conservation, forensic science and patent law. Thus, a chemistry degree can be effectively combined with advanced work in other fields which may lead, for example, to work in higher management (sometimes with an M.B.A.), the medical field (with a medical degree), or in the patent field (possibly with a law degree).

It is often observed that today's graduate, unlike the graduate of a generation ago, should anticipate not a single position with one

employer or in one industry, but rather many careers. You will be well prepared for this future if, in your college years, you take advantage of the opportunity to become broadly educated, to learn to be flexible and to be a creative problem solver. Knowledge and skills gained in your college courses may be directly applicable in your first job, but science and technology change at a rapid pace. You will keep up and stay ahead if you graduate with the skills and self-discipline to pursue a lifetime of learning. Since chemistry provides many of these skills and is a fundamental driver in the business and commerce sector of our society, chemists and biochemists are likely to remain in continual demand.

A bachelor's degree in chemistry is also an ideal pre-medicine degree. Medical schools do not require a particular college major, but a chemistry background will be helpful in the advanced study of biochemistry, endocrinology, physiology, microbiology, and pharmacology. Chemistry is also an excellent major for students planning careers in other health professions such as pharmacy, dentistry, optometry and veterinary medicine. All of these professional programs require chemistry for admission. Most require at least one year of general chemistry and one year of organic chemistry, both with laboratories. Many students have found that having a chemical background gives them a distinct advantage in these professional programs.

Whether your goal is to become a surgeon or a research scientist, a teacher or an information specialist, you should examine chemistry as a college major. It isn't for everyone; but those students who do choose chemistry usually find it as interesting as it is challenging, and they always take great pride in the degree they earn as undergraduates.

Studying chemistry is very important - this type of scientific study may open up a career path that leads to important scientific research that will help humanity. Chemistry is used in many different fields of industry - however, every chemist must start out by learning the basics during high school. Without credits in chemistry, a student may not be able to get into certain college and university programs, such as medicine or science. Therefore, it's always best to prepare for a bright future by learning chemistry in high school. Some students who avoid chemistry courses end up regretting it, as they are locked out of certain post-secondary education programs, unless they go back to high school to get the credits.

In general, a good understanding of chemistry will help student to understand more about the world around them. Chemicals appear in liquids, solids, and gases; they are also main components of many products we use every day, such as:

- plastics
- cosmetics
- cleaning agents

Without a good understanding of chemistry, it's difficult to create new formulas or invent new products. While chemistry may feel challenging to many students, those with less scientific aptitude can help themselves learn more effectively by hiring tutors, speaking with chemistry teachers about their difficulties in learning required coursework, and increasing their study time. Student who thinks they will fail chemistry may only be psyching themselves out, and depriving themselves of valuable knowledge that might lead to a fulfilling career.

Chemistry is usually taken alongside biology and physics; usually, people with good math skills and logic skills will excel at this subject. Sometimes, people who are more artistic and literary may not have such an easy grasp of chemistry, and they may decide to take other courses instead. In general, chemistry is viewed as being more difficult than biology, and about as difficult as physics.

There are many reasons why the study of chemistry is important. We have outlined some of them here:

- To Have Better Understanding of Our World

Everything around us from the air we breathe, the soil we grow our plants, the food we eat, to the water we drink is a chemical

substance. From the striking of a match to make fire, to the cooking of our foods, and to the digestion of food in our bodies to provide us energy is a chemical reaction. Without being chemists, we are always initiating chemical reactions as we carry out daily activities without even knowing it.

Studying chemistry gives us the knowledge of the composition and properties of the substances in our world and the understanding of the changes that they undergo. This knowledge enables us to use them well and to manipulate and derive greater value from them.

- To Research and Create Useful Products

The study of chemistry enables us to perform researches and develop great products for human use, and also to improve on existing ones. Lots of household products, medicines, beauty products, building and house maintenance products, educational, insecticides, fertilizers, preservatives, and many more products have been developed with the knowledge of chemistry.

- Proper Handling and Usage of Household Products

All the products we use at home for various application, including tooth paste, soaps and detergents, body lotion and creams, and disinfectants are chemicals. Studying chemistry enables you to read product labels and understand their compositions. That understanding allows you to make informed purchasing decisions.

It also guides you in the way you handle and use them. Some products are corrosive and inflammable, and will need to be handled with care.

- To Produce Simple Household Product

Knowledge of chemistry can enable you to produce certain usable products from home, thereby saving you money. Some of the products can be made from waste such as egg shell, which can be used to make face mask, paints and crafting.

You can also go ahead with some knowledge of chemistry to make for yourself some fragrances that suit your taste.

- Can Make You a Better Cook

The study of chemistry can actually make you a better cook because cooking itself is a chemical reaction. The ingredients are substances which are composed of certain chemical materials, which will combine with themselves in the process of the cooking to produce the food. The understanding of what the ingredients are composed of, which you get from studying chemistry will enable you to carry out your cooking in a way that will produce a great taste.

- Helps to Develop Analytical Reasoning and Problem Solving Skills

As a science, the study of chemistry involves lots of analytical reasoning as chemists try to determine the kind of chemical



reactions that are taking place under their observation, or to predict the reactions that may occur when certain conditions are prevalent. It also involves solving problems and being exact. Therefore, the individual who studies chemistry will develop analytical reasoning and problem solving skills.

- Understanding of Current Affairs

If you studied chemistry you will not be confused when news relating to environmental pollution, ozone layer depletion, green house effect, petroleum, nuclear waste, bio-fuel, and other chemistry based phenomenon come up. Instead, you will be able to meaningfully contribute to such discussions.

- Diverse Job Opportunities

The study of chemistry opens up lots of areas one can work. You can work in the food processing, pharmaceutical, petrochemical, and chemical industries. You can also work in the product research and development department of manufacturing companies, as well as in research institutes.

Aside from the normal career areas, chemistry graduates, due to the immense analytical and problem solving skills they have developed in the course of their studies can do virtually all kinds of jobs, be it in journalism, banking, sales and marketing, human relation, customer service, art, and fashion.









# **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.<sup>1</sup>

### **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. Falsifiability 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 fiscal limitations. Anything that

cannot be observed or measured or shown to be false is not amenable to scientific 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 verified; 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

### **3 The Nature of Science and the Scientific Method**

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 verifiability. 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 defined 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 difficult 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 specific physical predictions

## **The Nature of Science and the Scientific Method 4**

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 waged 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

**Nature of Science  
(NOS)**

Methods  
of Science  
(MOS)

Psychology  
of Science  
(POS)

History  
of Science  
(HOS)

Global Context

## **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
- 
- 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

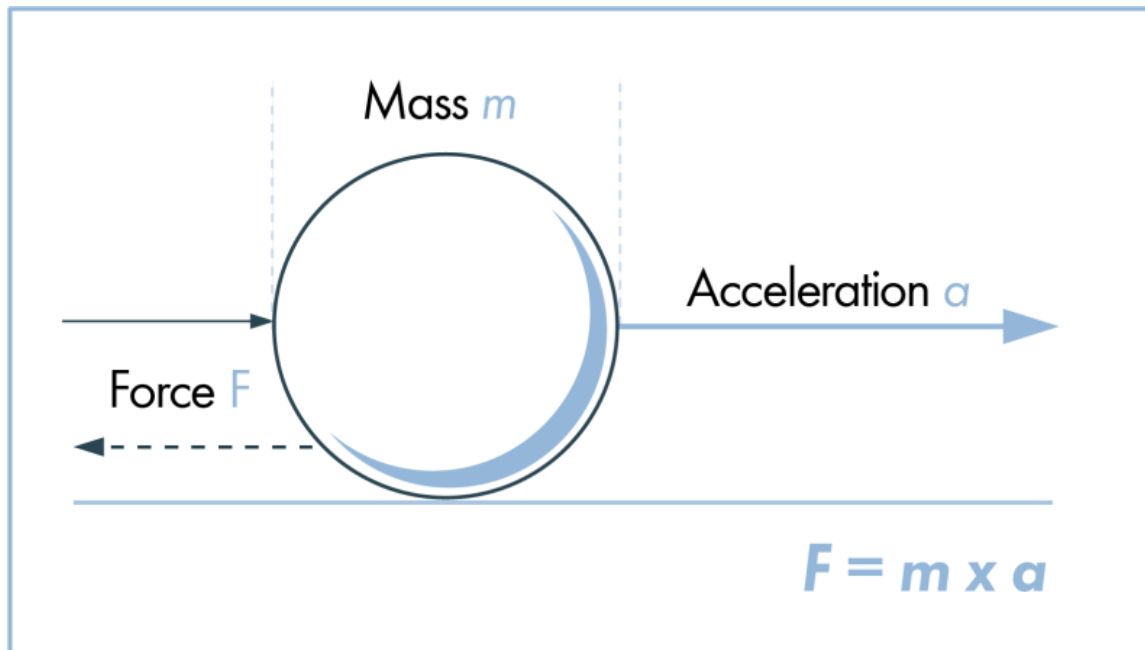
- Generalization can apply to all similar situations in all places and all times and here we call it the Principle. Example: Archimedes' Principle "If an object is submerged in a liquid, it is thrown from the bottom up. The amount of this thrust is equivalent to the weight of the displaced fluid, whose 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



— 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:  $c = t \times m$  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

—

***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

— \_\_\_\_\_  
<https://www.youtube.com/watch?v=TkvjDZseD4k>

[https://www.youtube.com/watch?v=ui8X\\_TTFizI](https://www.youtube.com/watch?v=ui8X_TTFizI)

— <https://www.youtube.com/watch?v=dgvOL6ZELuc>

























**CHAPTER 3**

**Objective of Teaching**

**Chemistry**



### **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 instructional objectives in the cognitive domain. Arranged from lowest to the highest level, they are as follows:

**Knowledge or recall** – knowledge of terminology and conventions, 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 of 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** – putting parts 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**

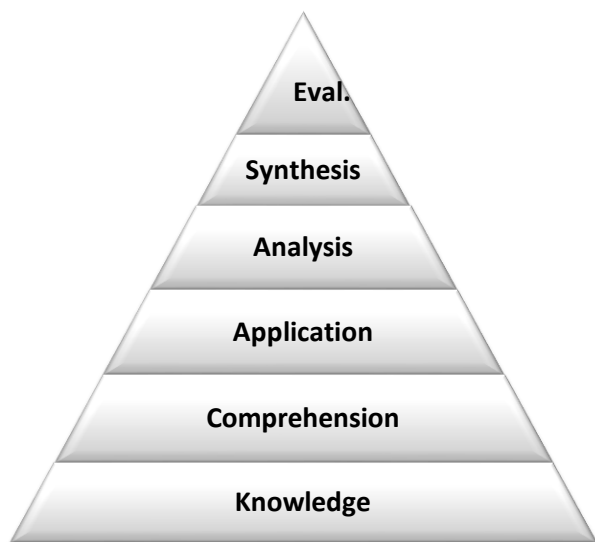


Figure 3-a

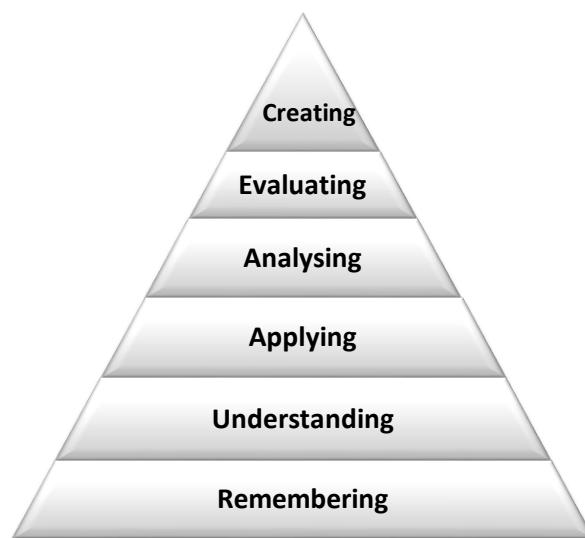


Figure 3-b

**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, differentiate, discriminate, distinguish,

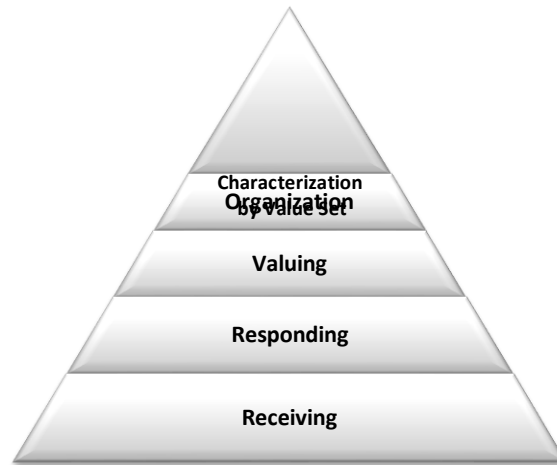
parts?	examine, experiment, question, test
Evaluating: Can the student justify a stand or decision?	Appraise, argue, defend, judge, select, support, value, evaluate
Creating: Can the student create new product or point of view?	Assemble, construct, create, develop, formulate, write

Schultz, L. (2005). Bloom's Taxonomy. Accessed on September, 2006.

[http://www.odu.edu/educ/llschult/blooms\\_taxonomy.htm](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

	<p>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.</p>	<p>outcomes in this area range from the simple awareness that a thing exists to selective attention on the part of the learner</p>	<p>accepts, listens (for), to reponds to. asks, chooses, identifies, locates, points to, sits erect, etc.</p>	<p>attentively, shows sensitivity to social problems.</p>
<p>Reponding</p>	<p>Is not only being aware of the stimulus but reacting and responding to the stimulus.</p>		<p>Answers, assists, complies, discusses, helps, performs, practices, presents, reads, reports, writes, etc.</p>	<p>Examples of objectives in the responding level e.g. to contribute to group discussions by asking questions, to listen attentively during group</p>

				<p>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.</p>
Valuing	<p>Is concerned with the worth or value of a student attaches to a particular object, phenomenon, or behavior.</p> <p>Willing to be perceived by others as valuing certain</p>	<p>This ranges in degree from the simpler acceptance of a value to the more complex level of commitment</p>		<p>Desire to improve group skills</p> <p>Assumes responsibility for the effective functioning of the group</p> <p>Appreciates the role of science in the</p>

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



	<p>or philosophy.</p> <p>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.</p>			<p>systematic planning in solving problems, accepts responsibility for own behavior.</p>
Characterization	<p>At this level, the person has held a value system that</p>			<p>Displays self reliance in working independently,</p>

	<p>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.</p>			<p>cooperates in group activities, maintains good health habits,</p> <p>Uses an objective approach in problem solving,</p> <p>Displays a professional commitment to ethical practice on a daily basis</p> <p>Revises judgments and changes</p>
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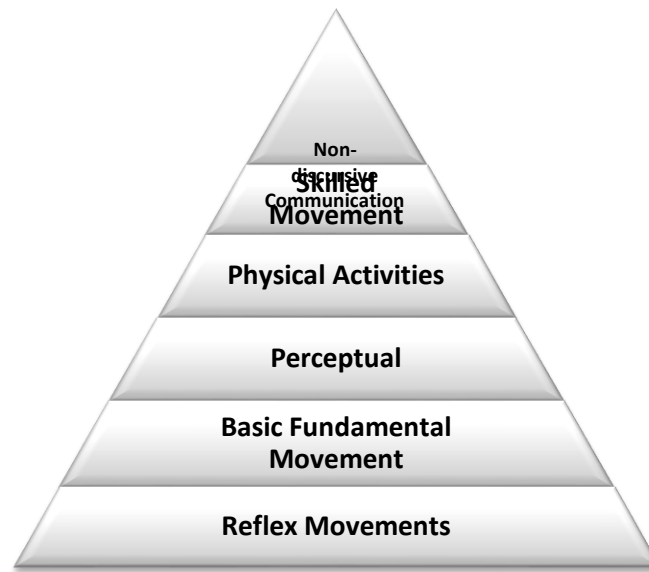
Source: **Krathwohl, D.r., Bloom, B.S., and Masia, B.B.** (1964).

*Taxonomy of Educational Objectives: Handbook II”:*  
*Affective Domain.* New York: David McKay Co.

**Anita Harlow’s taxonomy of the psychomotor domain.**

**Figure 5**  
**Domain**

**Harlows's Taxonomy of Objectives in the Psychomotor**

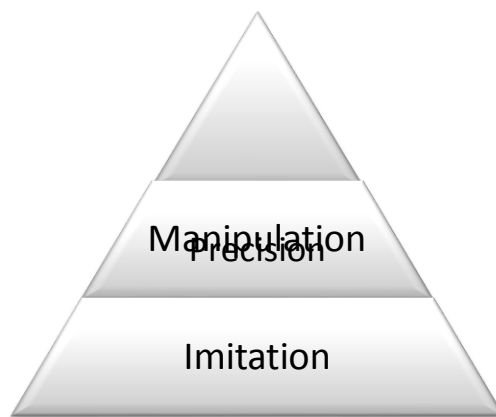


<b>Level</b>	<b>Description</b>	<b>Examples</b>
Reflex Movement Actions elicited without	Learning in response to some stimuli.	Flexion, extension, stretch, postural adjustments
Basic fundamental	Inherent movement	Pushing, pulling,

movement	patterns which are formed by combining of reflex	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, kinesthetic, or tactile discrimination. Suggests cognitive as well as psychomotor behavior.	Coordinated movements such as jumping ope, punting, or catching.
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	Is communication	Examples include: body

communication	through bodily movements ranging from posture to gestures, creative movements facial expression, act a part in a play through sophisticated choreographics. (Harlow, 1972)	postures, gestures, and facial expressions efficiently executed in skilled dance movement and choreographics.
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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:**

<b>Cognitive Domain Taxonomy Classification</b>	<b>Examples of infinitives</b>	<b>Examples of direct objects</b>
<b>1.0 Knowledge</b>		
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,	Forms, conventions, uses, usage, rules, ways, devices, symbols, representaions,

<p>1.3 Knowledge of universals and abstractions in a field</p>	<p>sequences, causes, relationships, forces, influences, areas, types, features, classes, sets, divisions, arrangements, classifications, categories, criteria, basics, elements, methods, techniques, approaches, uses, procedures, treatments</p>	<p>Principles, generalizations, propositions, fundamentals, laws, principal elements,</p>
<p><b>2.0 Comprehension</b></p>	<p>To acquire, to identify, to recall, to recognize Implications, theories, bases, interrelations, structures,</p>	<p></p>
<p>2.1 Translation</p> <p>Transform, to give in own words, to illustrate, to prepare, to read, to represent, to change, to rephrase, to restate</p>	<p>formulations</p> <p>To translate, to transform, to abstractions, representations, words, phrases</p>	<p>Meanings, samples, definitions,</p>
<p>2.2 Interpretation</p> <p>Rearrange, to</p>	<p></p>	<p>Relevancies, relationships,</p>

<p>differentiate, to distinguish, to make, to draw, to explain, to demonstrate</p>	<p>To interpret, to reorder, to essentials, aspects, new views, qualifications, conclusions, methods, theories, abstractions</p>	<p>Consequences, implications</p>
<p><b>2.3 Extrapolation</b> To conclude, to predict, to differentiate, to determine, to extend, to interpolate</p>	<p>to write, to tell, to relate, to produce, to constitute, to transmit, to originate, to modify, to document</p>	<p>Principles, laws, conclusions, effects, methods, theories, abstractions, situations, generalizations, processes, phenomena, procedures</p>
<p><b>3.0 Application</b></p>	<p>to propose, to plan, to product/to design, to modify, to specify</p>	<p>Elements, hypotheses, conclusions, assumptions, statements of fact, statements of intents, arguments, particulars</p>
<p><b>4.0 Analysis</b></p>	<p>To estimate, to infer, conclusions, factors,</p>	<p>Elements, hypotheses, conclusions, assumptions, statements of fact, statements of intents, arguments, particulars</p>
<p>4.1 Analysis of elements</p>	<p>To estimate, to infer, conclusions, factors,</p>	<p>Elements, hypotheses, conclusions, assumptions, statements of fact, statements of intents, arguments, particulars</p>



<p>4.2 Analysis of relationships</p>	<p>ramifications, meanings, corollaries, effects, possibilities</p>	<p>relationships, interrelations, relevance, relevances, themes, evidences, fallacies, arguments, cause-effects, consistency, consistencies, parts, ideas, assumptions,</p>
<p>4.3 Analysis of organizational principles</p>	<p>to apply, to generalize, to relate, to choose, to develop, to organize, to use, to employ, to transfer, to restructure, to classify</p>	<p>forms, patterns, purposes, points of view, techniques, biases, structures, themes, arrangements, organizations,</p>
<p><b>5.0 Synthesis</b></p>	<p>to distinguish, to detect, to identify, to classify, to discriminate, to</p>	<p>recognize, to categorize</p>
<p>5.1 Production of a unique communication</p>	<p>to analyze, to contrast, to compare, to distinguish, to deduce</p>	<p>structures, patterns, products, performances, designs, works, communications, efforts, specifics, compositions</p>
<p>5.2 Production of a plan or proposed set of operations</p>	<p>to analyze, to distinguish, to detect, to deduce</p>	<p>Plans, objectives</p>
<p>5.3 Derivation of a set of abstract relations</p>	<p>to analyze, to distinguish, to detect, to deduce</p>	<p>Plans, objectives</p>

<p><b>6.0 Evaluation</b></p>		<p>specifications, schematics, operations, ways, solutions, means</p>
<p>6.1 Judgment in terms of internal evidence</p>	<p>to produce, to derive, to develop, to combine, to organize, to synthesize, to classify, to deduce, to develop, to formulate, to modify</p>	<p>Phenomena, taxonomies, concepts, schemes, theories, relationships, abstractions, generalizations, hypotheses, perceptions, ways, discoveries</p>
<p>6.2 Judgments in terms of external criteria</p>	<p>to judge, to argue, to validate, to assess, to decide</p>	
	<p>To judge, to argue, to consider, to compare, to contrast, to standardize, to appraise</p>	<p>Accuracies, consistencies, fallacies, reliability, flaws, errors, precision, exactness</p>
		<p>Ends, means, efficiency, economies, utility, alternatives, courses of action, standards, theories, generalizations</p>

Source: Newton D. Metfessel, William B. Michael, and Donald A. Kersner, "Instrumentation of Bloom's and Krathwohl'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

<b>Taxonomy Classification</b>	<b>Examples of infinitives</b>	<b>Examples of direct objects</b>
<b>1.0 Reflex Movements</b>	To flex, to stretch, to straighten, to extend, to inhibit, to lengthen, to shorten, to tense, to stiffen, to relax	reflexes
<b>2.0 Fundamental Movements</b>	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
<b>3.0 Perceptual Abilities</b>	To catch, to bounce, to eat, to write, to balance, to bend, to draw from memory, to distinguish by	Discrimination visually, discriminates auditory, discriminates kinesthetically, discriminates tactually,

<p><b>4.0 Physical Abilities</b></p>	<p>touching, to explore</p>	<p>coordinates two or more perceptual abilities</p>
<p><b>5.0 Skilled</b></p>	<p>To endure, to improve, to increase, to stop, to start, to move precisely, to touch, to bend</p>	<p>Exerts tension, moves quickly, stops immediately, endures fatigue</p>
<p><b>6.0 Nondiscursive Communication</b></p>	<p>To waltz, to type, to play the piano, to file, to skate, to juggle, to paint, to dive, to fence, to golf, to change</p> <p>To gesture, to stand, to sit, to express facially, to dance skillfully, to perform skillfully, to paint skillfully, to play skillfully</p>	<p>Changes or modifies basic body movement patterns, uses a tool or implement in adaptive or skilled manner</p> <p>Moves expressively, moves interpretatively, communicates emotions, communicates esthetically, expresses joy</p>

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 Department 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 subjects.”*

**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 employed 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 Learning competencies (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 classroom, ultimately depends on you. Below are some principles 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 students – through the things we say, the assignments we give, and the criteria we use to evaluate learning – 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 facts and concepts.
- d. Hypotheses 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?

## Guiding Principles in the Selection and Use of teaching Strategies

Here are some guiding principles in the selection and use of appropriate teaching 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

<b>Intelligence</b>	<b>Example of Classroom Activities</b>	<b>Examples from My Classroom</b>
Verbal-Linguistic	Discussions, debates, journal writing, conferences, essays, stories, poems, storytelling, listening activities, reading	
Logical-Mathematical	Calculations, experimentations, comparison, 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	
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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

<b>Learning Style</b>	<b>Examples of Classroom Activities</b>	<b>Examples of My Classroom</b>
Mastery Exercise – practice	Direct instruction Drill and repetition Demonstrations Competitions Activities that focus on: <ul style="list-style-type: none"> <li>• Organizing and managing information</li> <li>• Practicing a skill</li> <li>• Observing</li> <li>• Describing</li> <li>• Memorizing</li> <li>• Categorizing</li> </ul>	
Interpersonal Experience – personalize	Team games Learning circles Role playing Group investigation Peer tutoring Activities that focus on: <ul style="list-style-type: none"> <li>• Describing feelings</li> </ul>	

	<ul style="list-style-type: none"> <li>• Emphathizing</li> <li>• Responding</li> <li>• Valuing</li> </ul>	
<p>Understanfing Explain – prove</p>	<p>Inquiry Concept formation Debate Problem solving Independent study Essays Logic problems Activities that focus on:</p> <ul style="list-style-type: none"> <li>• Classifying</li> <li>• Analyzing</li> <li>• Using evidence</li> <li>• Applying</li> <li>• Comparing and contrasting</li> <li>• Evaluating</li> </ul>	
<p>Self-Expressive Explore – produce</p>	<p>Divergent thinking Mataphors Creative art avtivities Imaging Open-ended discussion Imagery Creative problem solving Activities that focus on:</p> <ul style="list-style-type: none"> <li>• Hypothesizing</li> </ul>	

	<ul style="list-style-type: none"> <li>• Synthesizing</li> <li>• Symbolizing</li> <li>• Creating</li> <li>• Metaphorical expression</li> <li>• Self-expression</li> </ul>	
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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):**

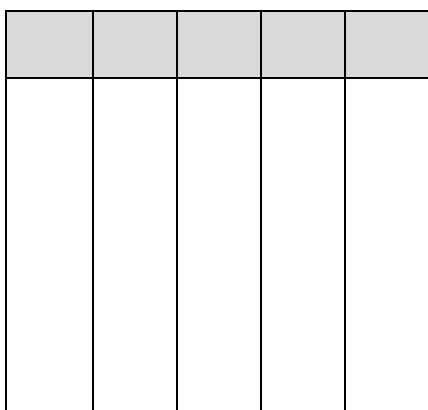
1. Without rehearsal or constant attention, information remains in working memory for only about 15 to 20 seconds. This implies the need for memory aids.
2. Learning is a process of building neural networks. This network is formed through concrete experience, representational or symbolic learning, and 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

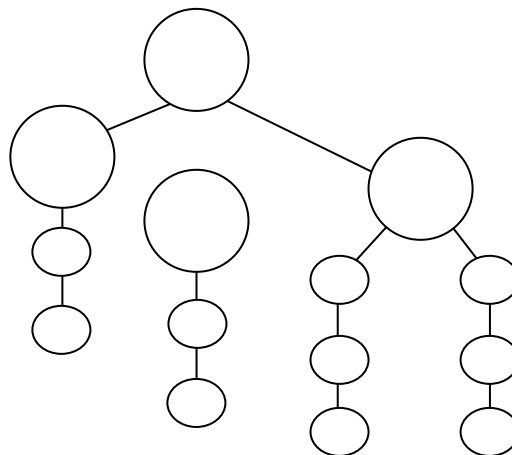
## GRAPHIC ORGANIZERS FOR CLASSIFICATION

**Figure 9**

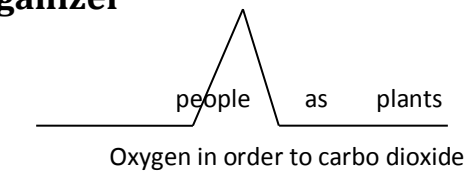


**Figure 10**

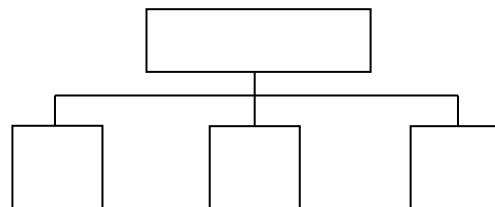
Categories



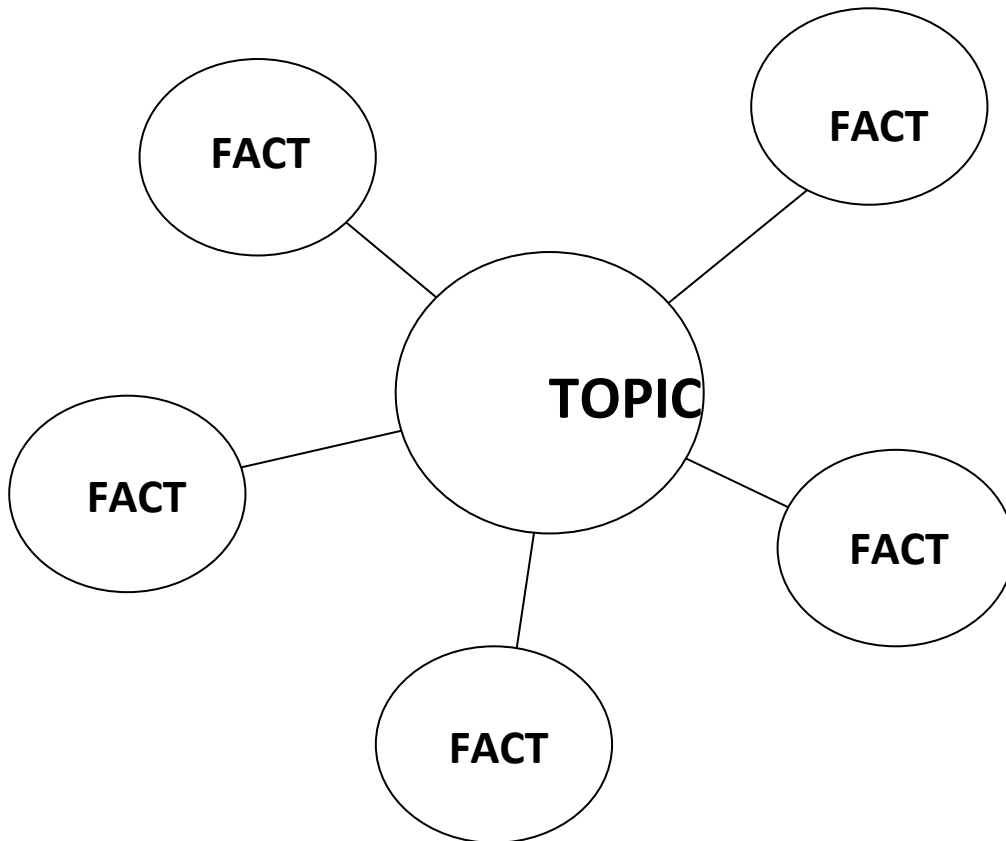
**Figure 11 For Analogy  
organizer**



**Figure 12 Hierarchical topical**

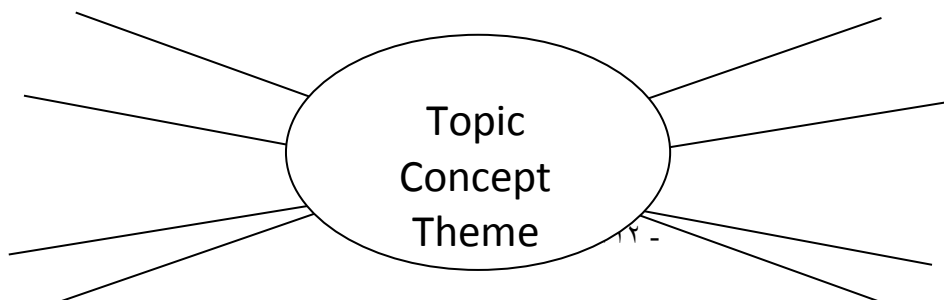


**Figure 13**



**Figure 14**

**Web**





Songs, jingles, and raps

5. Mnemonic strategies
6. Writing strategies
7. Active review
8. Hands-on activities

**An integrated approach is also interdisciplinary and multidisciplinary.**

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

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













**CHAPTER 4**

**PREPARATION FOR chemistry**

**TEACHING**



# **PREPARATION FOR chemistry 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
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## 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 1<sup>st</sup> 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 assess 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 seen 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 advise 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 is 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 is 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 content is presented in the form of teaching points. The learning activities are 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 (Herbartian 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 is 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 checks 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. It induces confidence among teachers.
4. Lesson planning makes 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://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 times 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 encourages 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 rote 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 tests 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, the 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 entails 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 from 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 with 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, is the experiment which is a 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, principles 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**

**SCIENCE 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 activity 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.

#### **3.2.1 Course 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 rationale, 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 have achieved his/her goal of teaching the skills. These learning outcomes are derived from the needs 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 possess in finding solution to the question given to him. It is an instrument that assesses the performance of the teacher.

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

- i. What is castration?
- ii. The importance of castration
- iii. How do you castrate an animal?

#### **5.2.4 The 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 tertiary 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 “Facts, 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 re-validated. 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 it 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.

<b>UNIT</b>	<b>MEANING AND</b>	<b>LESSON MEANING</b>	<b>OF</b>
<b>CLASSIFICATION</b>			
1:	CLASSIFICATION OF	1:	CLASSIFICATION
	PLANT		OF
	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

### 5.4.1 COGNITIVE

**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 originality and creativity. It involves bringing facts, ideas, elements, 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 to 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 definition 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 a criterion 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 for 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 the 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.

### **6.3.2 Audio Materials**

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

### **6.3.3 Audio-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.

### **6.4.1 Teacher-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

### **6.5.1 Instructional 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.

### **6.5.2 Relevance**

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.

### **6.5.3 Learner'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.

#### **6.5.4 The 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 format of the material selected should match the subject matter and the topic.

#### **6.5.5 Economic 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.

#### **6.5.6 Teacher'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 and 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 thought 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**

### **7.2.1 Set 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 to 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 to 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 in.

### **7.2.1.2 Transition Set**

This process has 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 into 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 not paying attention to the lesson can be of great significance in encouraging the pupil or catching the attention of the latter 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-teachers to avoid teaching styles 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 an 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.

#### **7.2.4 Closure**

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 is however very important to keep in mind that a method is not an end in itself but is used to achieve the set aims of teaching. You should also keep in mind that, same method should not be used at all times but there should be flexibility in using it as for as situations circumstances, and condition in a particular case. You should use various 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 is 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 by observing the experiments. As young children do it by themselves, the experience is impressed more firmly in their minds. Thus this method is 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 aim.

#### **PRINCIPLES OF LABORATORY METHOD:-**

1. It follows the principle of learning by doing.
2. It follows psychological principle, where students' age, level 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 instructions 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 spirit of enquiring.
8. It helps in developing higher order this kind 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.

# **TEACHING GENERAL SCIENCE**

## **UNIT-III**

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3.0 Objectives.

3.1 Introduction.

3.2 Formulation of Instructional Objectives.

3.3 Unit Planning.

3.4 Lesson Planning.

3.5 Improvisation of teaching aids in general science.

3.6 Let us sum up.

### **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 if the objectives are clearly defined, then students know which activities are relevant for success of the teaching learning process.

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

#### **According to B.S. Bloom**

“Educational objectives are not only the goals towards which curriculum is shaped and towards which instruction is 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 detects 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 is 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 lenses, propagation of lights etc.

vii) The pupil predicts various applicability of laws.

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

ix) The pupil interprets various graphs, charts etc.

x) The pupil translates statements into symbols.

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

**Specifications: -**

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

- ii) The pupil rectifies the defects in the instruments e.g. the presence of air bubble in the burette during titration.
- iii) The pupil sets up appropriate apparatus for perform different experiment.
- iv) The pupil measures with reasonable accuracy the length of pendulum and period of oscillations.
- v) The pupil reads the log table, mathematical symbol, 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 new 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 are 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 avoided. 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 form 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](https://www.youtube.com/watch?v=4YG5d8xL_hw)

## **CHAPTER 9**

# **Assessment in Chemistry 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.

How would you like to assess your students? ✕

**Plans keep students within an expectation**  
Students will work through the skills within a selected expectation at their own pace and will drop back to pre-requisites when necessary.

**Assignments quiz students on a set of skills**  
Students will receive a fixed amount of skills that you choose. This is great for doing diagnostic or summative assessments!  
You can now assign it as homework

**Prepare students for EQAO**  
Students will practice the specific skills that are assessed by your region's standardized test, as your dashboard tracks their results!

[Continue](#)

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 teacher improve his/her questioning skills?
- What are some effective reacting techniques?

### **Types of Questions according to Purpose**

For Assessing Cognition

For Verification

For Creative 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 comprehension
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 questioning 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:**

**Design Exercise:**

**Tell us in one page Why Is Assessment Important?**

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## Reverence

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