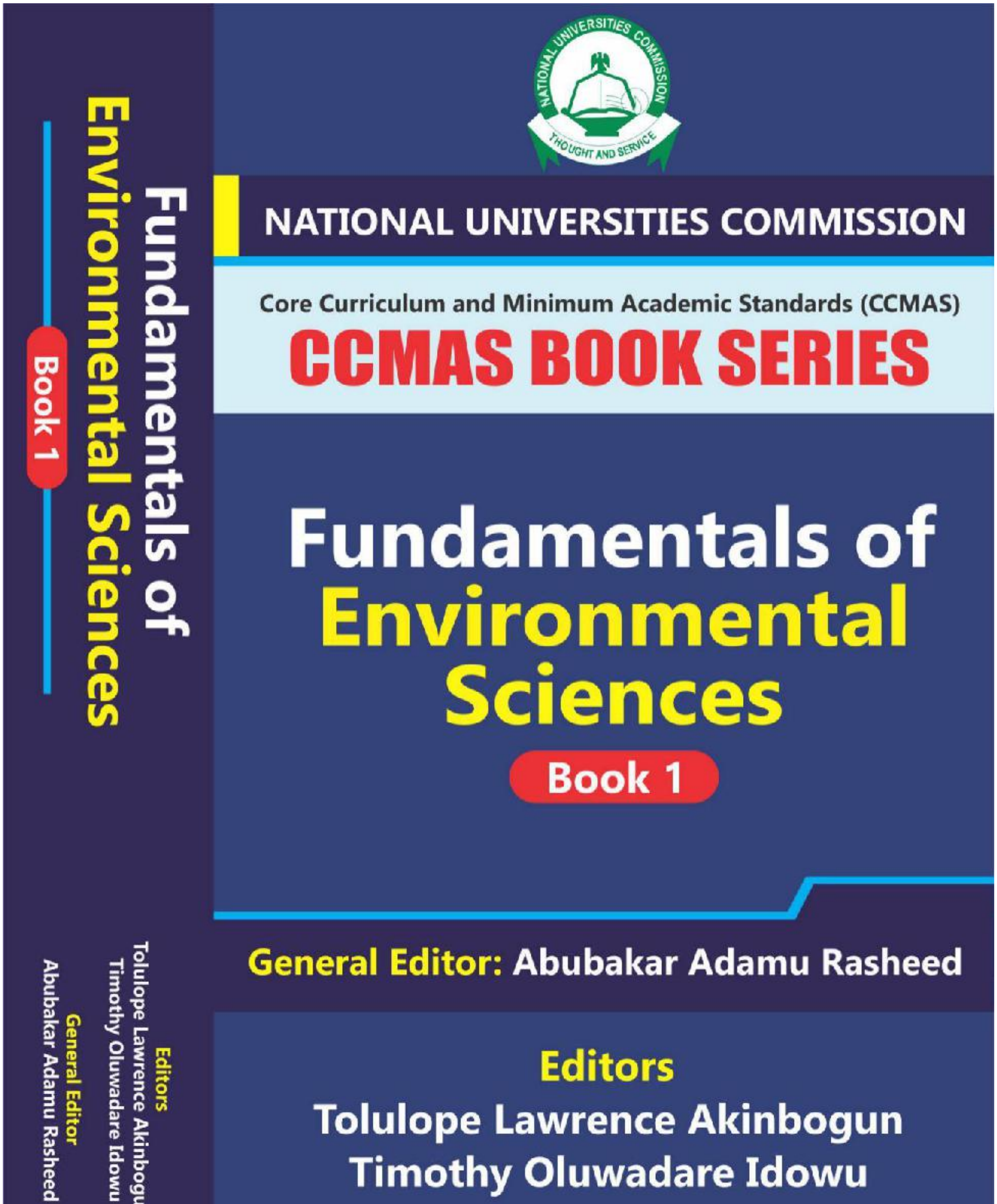
NATIONAL UNIVERSITIES COMMISSION
THOUGHT AND SERVICE
NATIONAL UNIVERSITIES COMMISSION
Core Curriculum and Minimum Academic Standards (CCMAS)
CCMAS BOOK SERIES
Fundamentals of Environmental Sciences
Book 1
General Editor: Abubakar Adamu Rasheed
Editors
Tolulope Lawrence Akinbogun
Timothy Oluwadare Idowu
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Abubakar Adamu Rasheed
General Editor

Professor Abubakar Adamu Rasheed, mni, MFR, FNAL, HLR is a distinguished and globally acclaimed Professor of English, He was Vice-Chancellor of one of Nigeria's foremost universities, Bayero University, Kano where he raised to higher heights, the tradition of exemplary leadership. He was editor of the New Nigerian Newspapers. He now serves as the Executive Secretary of the National Universities Commission. He is the recipient of GUNI-Africa Award for the Best Executive Secretary of NUC.

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Foreword

The National Universities Commission is empowered by the Education (National Minimum Standards and Establishment of Institutions) Act, CAP E3, Laws of the Federation of Nigeria, 2004, to lay down minimum academic standards in Nigerian Universities and to accredit the degrees therefrom. According to this and in its sustained commitment to the revitalization of the Nigerian University System, the Commission launched the “Core Curriculum and Minimum Academic Standards (CCMAS)”, in December, 2022. The document has been adjudged by both internationally and locally revered scholars, as a standard and fit-for- purpose, designed to meet the demands of the 21st Century.

To ensure the efficient delivery of the CCMAS, it has become fitting and necessary to develop a reference document that would contain innovative and simple topics for all disciplines/programmes to serve as a guide for students and lecturers. This novel idea informs the development of the CCMAS Book Series, which presents to Nigerian universities the fundamentals of each discipline, aimed at deepening the understanding of the CCMAS, for the overall improvement in teaching and learning, and ultimately, for the production of nationally relevant and globally competitive graduates from the System.

The excitement and wide acceptance of the Book Series stems from the fact that several scholars in their respective disciplines sent in their contributions, which are rated topnotch in all ramifications. There is no gainsaying that the Book Series is a welcome masterpiece as it expounds what the CCMAS offers and the many lessons and motivations to draw from its optimal implementation, for the overall good of society.

The effort of the National Universities Commission in the development of the CCMAS and following up with associated innovative initiatives like the CCMAS book series is commendable. Consequently, I congratulate the Executive Secretary, National Universities Commission, Professor Abubakar Adamu Rasheed *mni, MFR, FNAL* for adding another feather to his feather-filled cap within his reltively short period in NUC. Kudos must be given to the Distinguished Emeritus Professor Okebukola led NUC Strategy and Advisory Committee (STRADVCOM) and staff of the National Universities Commission for driving this process to fruition. There is no way this initiative can become a reality without the contributions of the scholars who developed the texual materials. Consequently, I laud the erudite scholars of Nigerian universities, who have demonstrated their love for academic excellence in sharing their knowledge with humanity through the instrumentality of this project.

I commend the CCMAS Book Series to staff and students of Nigerian universities and indeed to scholars all over the globe as the contribution of the Nigerian University System to academic development and excellence.

Happy reading.
Malam Adamu Adamu
Honourable Minister of Education

Preface

In keeping with its mandate of making university education in Nigeria more responsive to the needs of the society, the National Universities Commission commenced the journey to restructure the BMAS in 2018, introducing in its place, the Core Curriculum and Minimum Academic Standards (CCMAS), to reflect the 21st Century realities, in the existing and new disciplines and programmes in the Nigerian University System. The arduous process, which was birthed through continued stakeholder interactions over the course of four years, produced seventeen documents to cater for each of the disciplines in the Nigerian University System. A key feature of the CCMAS document is the unique structure that provides for 70% of core courses for each programme, while allowing universities to utilise the remaining 30% for other innovative courses in their peculiar areas of focus.

Following the conclusion of the development and review process as well as a series of editing, the CCMAS documents were launched in a grand ceremony on the 5th of December 2022. With the launch, the job of the Commission was far from over as this was only the beginning of a three-phase process in the development/review and implementation of the CCMAS document. Having completed phase one, which is the launching of the CCMAS, NUC proceeded to phase two, which involves the development of the 30% CCMAS by the universities. At the same time, the plan for capacity building for effective implementation of the CCMAS as well as the development of textual materials to support the implementation of the CCMAS were taken on board.

The need to have customised (bespoke) texts to support the implementation of the CCMAS was pointed out by an erudite Professor (President of the Nigerian academy of Education) during one of the General Assemblies and was processed through the NUC Strategy and Advisory Committee (STRADVCOM). Emeritus Professor Nimi Briggs was unanimously nominated as the Project Coordinator. The series of textual materials are called the *CCMAS Book Series* and titled *Fundamentals Series* in the first project.

The contributors across the 17 disciplines have been drawn from the six geopolitical zones and proprietorship of universities such that there is collective ownership. The major denominator for selection was scholarship in the discipline, which was reflected in the narrative of each book. The various chapters showcase and give examples from local published research so that visibility can be given to ideas from Nigeria and Africa on the topics. While definitions and models from "western" scholars are mentioned, these are de-emphasised as much as possible. The time is ripe to show the world, through this book, that Nigerian scholars, over the last 70 years at least, have been in the frontline of research in the published topics and now able to provide generic and contextual definitions, models and examples in the respective disciplines for scholarly work the world over.

The contents target the compulsory courses in the CCMAS and will be published in a series. As much as possible, the books attempt to sync with the levels of delivery of the curriculum that is 100 level; 200 level and so on. The books are written in very simple English, well-illustrated and rendered in the typical course-material format of objectives, content to be learned, summary, evaluation, exercises and references.

The Commission is optimistic that these series will serve as a guide to support the implementation of the CCMAS documents in the Nigerian University System and beyond and adequately equip the trainers and students in making university education more responsive to the needs of society.

Professor Abubakar Adamu Rasheed, *mni, MFR, FNAL, HLR*

Executive Secretary

Message from the Project Coordinator

Emeritus Professor Nimi Briggs (RIP)

With the launching of the 17 documents of the new Core Curriculum and Minimum Academic Standards (CCMAS) on Monday 5th December 2022 by Vice- President Professor Yemi Osinbajo, *GCON,* Nigeria's National Universities Commission (NUC) accomplished a major feat in its quest to rapidly revitalise the nation's university system.[1] In this regard, the Commission working though its *Strategy Advisory Committee (STRADVCOM),* had, in 2019, identified 10 priority areas that needed urgent attention, one of which is, the introduction of a reengineered curriculum that addresses 21st century challenges. Such a curriculum, it was envisaged, should lay emphasis on skills acquisition and learning outcomes and should be able to stand side by side with those from the World's best universities in the quality of its content as well as being relevant on issues affecting the local communities in which individual universities are located. Thus, CCMAS documents were developed to provide 70% of the contextual materials and compulsory credit units required for graduation at the bachelor's level across the entire chain of degree courses offered by all universities in the country.

That done, attention shifted towards enabling individual universities to develop the additional 30% of the curriculum from issues that are peculiar and relevant to their core mission and local circumstances, as approved by Senates of their individual universities, capacity building and training of staff on the delivery of the CCMAS and the production of books that would cover the contextual materials of the CCMAS.

It is expected that utilisation of the CCMAS series in the Nigerian Universities System will commence in the 2023/2024 academic session. Stringent efforts were therefore made to conclude the production of the series of books, the first in the series, well in advance of that period.

Nimi D. Briggs
February 2023

Note: Sadly, Emeritus Professor Nimi Briggs passed on April 10, 2023. He is resting in the realisation that this project is "safely delivered", he being a globally renowned scholar in obstetrics and gynecology.

Editors' Note

It is a privilege for us to serve as Editors of this important Book project being the first in the series of books on the Core Curriculum and Minimum Academic Standards (CCMAS) for the Environmental Sciences Discipline. Book 1 of Fundamentals of Environmental Sciences focuses on the contents of the compulsory courses for 100 and 200 level students. The book chapters were contributed by volunteer academics who have taught the courses for significant period of time and have therefore been seasoned to know the nitty gritty of the courses. The Contributors cut across universities in all the six geopolitical zones in Nigeria.

The development of the book went through a 12-step process. These are:

Sequence	Activity
Step 1	• Set up Editorial Committee • Layout of chapters
Step 2	• Call for Expression of Interest (EoI) with the chapter layout advertised from which potential authors willselect.
Step 3	• Selection of contributors based on geographical spread and expertise in having taught the top for at least five years. As much as possible, each chapter should be co-authored by scholars from different universities. • Submission of signed Acceptance Form
Step 4	• Development of first draft (Version 1.0)
Step 5	• Collation of first draft by Editorial Team
Step 6	• Plagiarism check
Step 7	Three-way review by • Scholars external to the writing team • Internal to the writing team: exchange of chapters for review among the contributors • Final-year students selected across universities in the Nigerian university system
Step 8	• Revision of Version 1.0 based on feedback from the three clusters of reviewers. Product is Version 2.0
Step 9	• Check by Editorial Technical Team for compliance with suggestions for improvement made by the three

	clusters of reviewers. This can be done at plenary withall contributors present.
Step 10	• Second revision by authors based on the feedback at plenary/by the editorial technical team review of Version 2.0. Product is version 3.0
Step 11	• Professional editing/copy editing of Version 3.0. Product is Version 4.0.
Step 12	• Printing/publication of Version 4.0.

We assure all students of Environmental Sciences discipline in our universities that the book will provide the necessary exposure for them in all the courses that are focused on in the book.

Tolulope L Akinbogun
Timothy I Idowu
Editors

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Contents

CHAPTER 1
Environmental Problems
By
OKOYE Anthony Chukwudi

Overview

Our life on planet earth is highly influenced by and is indeed dependent on the welfare and wellbeing of our environment. It becomes obvious that man should have it as a duty to keep his environment healthy and conducive. Incidentally, the world is overwhelmed by various environmental problems, mostly caused by man. This chapter explains the concept of environment and environmental problems. It introduced the essential aspects that a beginner needs to know about the basic causes of environmental problems, some of the effects of resultant pollution; and some measures to reduce the menace. This chapter provides questions to test cognition, as well as the affective and psychomotor domains of the educational objectives.

Objectives

By the end of this chapter, students should be able to:

1) describe the concept of environment and environmental problems
2) make their own definition of environment
3) state and explain the components of the environment
4) write and explain the basic causes of environmental problems
5) explain various types of pollution
6) understand methods of how to reduce various types of pollution and come up with their own way of reducing pollution
7) know the Stakeholders in the solution of environmental problems

What is environment?

A comprehensive dictionary of Environmental Studies defines Environment as "The sum of all external conditions affecting the life, development and survival of an organism."

Webster's Collegiate Dictionary defines Environment as**"** the complex of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determines its form and survival***"***.

Therefore, the term "environment" refers to anything that directly surrounds an object and has an impact on it. In other words, the things, places, people and nature that surround any living thing are its environment. The environment provides the air we breathe, the water we drink, the food we eat, and the land we cultivate our crops. It consists of four major components namely:

- The Atmosphere
- The Hydrosphere
- The lithosphere
- The biosphere

The Atmosphere
The atmosphere is the layer of gas that surrounds the Earth often called air. It consists of several gases like Nitrogen, and argon, including oxygen that we breathe and the carbon dioxide needed by plants for growth.

The Hydrosphere
Hydrosphere is the water environment of the earth which comprises all water resources including surface waters (oceans, lakes, rivers, swamps), underground water (locked in soil); frozen water in form of ice, snow and water vapour in the atmosphere.

The Lithosphere
Lithosphere is the solid outermost shell of the earth. It is made up of rocks from two of the Earth's major layers namely the thin shell of the planet, called the crust, and the uppermost part of the next-lower layer, the mantle. It consists of solid rock (100-150km thick), soil and other minerals.

The Biosphere
The biosphere is the biological part of the earth that is occupied by living organisms, and this includes part of the atmosphere, hydrosphere and lithosphere. The collection of living things in the biosphere is called the biota. It is the sector of the earth where land, water and air interact with each other to support life.

Human beings should naturally care for the environment as keepers of our common home as biblically provided in Gen 2:15, but over time, instead of man protecting the earth from danger, he is putting it in danger. This has caused serious environmental problems.

What is an environmental Problem?
Environmental problems are interruptions in ecosystems' regular functioning due to the decline in environmental quality as a consequence of pollution. This is evidenced by loss of vegetation, biological diversity, excessive amounts of harmful chemicals in the ambient atmosphere and in food chains, and threats to life support systems. This may be brought on by human beings or may occur naturally.

What is Environmental Pollution?
The altering of the physical, chemical, and biological properties of the air, land, and water in a way that has a detrimental impact is referred to as environmental pollution. The substance that brings the alteration in those aforementioned properties is a pollutant.

Basic Causes of Environmental Problems
The basic causes of environmental problems could be explained under the following headings:

- Population growth
- Poverty
- Urbanization
- Economic growth

The other two are inclusive for most developing countries

- Poor environmental awareness
- Poor funding and enforcement of environmental laws

Population Growth
According to the world population review, the population in Nigeria grew from 95,214,257 in 1990 to 218,541,212 in 2022 which is more than a 200% increase. The natural environment has some capacity to resist pollution created by humans, but as soon as the pollution load exceeds this capacity, the environmental quality starts deteriorating. Since the resources are not increasing at the same rate as the population, it simply implies that the population would continuously impact the environment more severely through the competitive use of the limited natural resources, a tremendous increase of wastes and other pollutants, loss of biodiversity, increased pressure on arable land and other environmental stresses. There has been a serious population increase in most cities in Nigeria as depicted in Fig. 1.

Fig 1 Overpopulation in Lagos.
Source:https://www.google.com/search?q=over+population+in+Nigeria+cities&source=lnms&tbm=isch&sa=X&ved=2ahUKEwj-087qzNH-

Poverty
The link between poverty and the environment is an extremely complex phenomenon. Naturally, poverty reduces people's capacity to use resources sustainably because they must survive at all costs. They rely on natural resources more than the rich; deplete natural resources faster as they have no real prospects of gaining access to other types of resources. This however intensifies pressure on the environment because of the numerical strength of people that are poor globally, especially in developing countries (Okoye, 2022). In urban areas, slums and pavement dwellings, unsanitary conditions, shortage of food, increased demand for coal, firewood and kerosene, shelter and energy are intimately connected with poverty leading to environmental degradation and human health problem.

Urbanization
Urbanization has made environmental issues worse, particularly in poorer nations. Due to the large amount of waste produced by homes, businesses, hospitals, markets, and other locations, as well as the high demand for housing, electricity, transportation, and other amenities, the migration of people from villages to towns from various cultural backgrounds has had an impact on the environment of the cities. These reduce the precious environmental resources available in the cities. In most developing countries like Nigeria, the urban population is growing faster than the urban authorities' ability to manage waste, a condition which has caused poor waste management.

Economic Growth

The effect of economic growth on the environment at low levels of economic development is small, but at this current rate of development, industrialization has caused a lot of environmental problems, especially through intensive resource and energy use (fuel, timber, water etc) and generation of different kinds of wastes leading to contamination of water, air and land. These cause health hazards and the degradation of natural ecosystems.

Poor Environmental Awareness

People's behaviours and the standard of responses and reactions to environmental problems are influenced by their knowledge and understanding of the need to safeguard the environment. High levels of public interest and awareness about environmental issues in industrialized nations encourage participation in environmental legislation that limits environmental destruction. But because environmental knowledge and literacy are low, it is difficult to control the problems with the environment in some nations. In most of these countries, political leaders are more concerned about economic achievements and short-term gains and consider environmental conservation as a wasteful expenditure. They do not carry out serious public awareness programmes that can inform the people about the dangers of environmental problems to encourage appropriate attitudes to them and thereby minimize the impact on the environment. Government needs to embark on serious environmental awareness programme.

Poor funding and enforcement of environmental laws

The environment cannot speak for itself. People are affected when the environment is destroyed. For people to be protected when their environment is polluted, laws must be made. Most developing countries have some environmental laws and regulations that are aimed at protecting the environment. The enforcement of these laws is important but is not yet effective in many developing countries. In Nigeria, when the law is violated, the organizations meant to enforce the law always complain about equipment and other things necessary to enforce the law. Since laws are ineffective if not enforced, pollution of the environment continues uncontrolled. Hence, there is need for funding of the environmental sector and ensuring that the funds are used for what they are meant for.

All these lead to different types of pollution which are discussed below.

Types of Pollution

Air Pollution

Air pollution occurs when gases, dust particles, smoke or any odour are introduced into the atmosphere in a way that makes it harmful to humans, animals and plants. Therefore, all substances changing the natural composition of the air are called pollutants and are said to cause air pollution. The sources of air pollution could be classified into natural and man-made sources. The natural sources may include those generated from the following:

- Volcanic eruptions release huge quantities of ash, chlorine, sulphur dioxide and other chemicals
- Dust storms pollute the environment
- Forest fires which generate various gases and smoke

While man-made sources include those that are generated from man's activities like industrialization, transportation, agriculture, military operations and others. For instance, when cars or other vehicles are moving, they release gases that pollute the environment. Similarly, industries, slaughterhouses, hotels and other sources generate gases which pollute the air.

Air pollution can also make people sick. It can make it difficult to breathe and cause diseases such as lung cancer, heart disease and other sicknesses. There are several reports about the death of a whole family because they brought a generator inside their house at the night because of thieves and the carbon monoxide that was produced by the generator killed them before morning.

Some other types of air pollutants include:

- Sulfur dioxide (SO_2) - can be generated by burning coal or oil (fuel or gas). It can cause respiratory illnesses like asthma.
- Carbon dioxide - can be produced in the same process as Sulfur dioxide (SO_2).
- Chlorofluorocarbons - These chemicals are also called CFCs. They were used in producing refrigerators and form of spray cans.
- Particulate matter - These are tiny particles like dust that get into the atmosphere and make the air we breathe dirty. They are linked to diseases like lung cancer

How to Reduce Air Pollution

1. Government should make sure that the environmental protection agencies are well funded and the right people are selected and trained to work there.

2. We are enjoined to maintained our vehicles and keep them in good running condition to avoid smoke emissions.

3. There should be adequate awareness creation at all levels by everybody.

4. Instead of driving the children to and from school, parents should use school buses as this would reduce the amount of polluting gases released into the atmosphere.
5. People are advised to share a ride or engage in carpooling. Use a bicycle or walk whenever possible to reduce air pollution

6. Avoid burning leaves, trash, and other materials. Mulch or compost leaves and yard waste.

7. Dispose of your waste in the right way

8. Conserve energy everywhere because the device that generates the energy pollutes the environment.

9. Plant trees at any slightest opportunity

Water Pollution

Water pollution is any change in the quality of water that harms living organisms or makes water unsuitable for certain use. Water pollutants could be classified into the following major categories namely:

a) Organic waste/materials (Wastes/materials that can decay),
b) Nutrients,
c) Germs
d) Suspended Matter,
e) Thermal (Heat) Pollution.
f) Chemical water pollution

Organic Wastes/materials

Wastes from various sources get into the rivers, streams and other water bodies. The microorganisms in the bid to decay them reduce the oxygen in the water. This is a serious problem as a lack of oxygen harms aquatic life, encourages more microorganism growth and produces harmful chemicals such as ammonia and sulphides.

Nutrients

Wastewater from various sources like agricultural run-off, fertilizer, industries and sewage that contain a high amount of these nutrients, end up in the water bodies. This increases the nutrient load of our water bodies causing excessive growth of algae and plants in the water body. When these plants die and decay, the available dissolved oxygen in the water body is seriously reduced as the micro-organisms use it for the decay. This leads to the suffocation and death of the aquatic habitats that depend on oxygen for survival.

Oil

Oil enters the water through oil spills, leaks from oil pipes, and wastewater from industries and refineries and spreads over the surface of the water because it is lighter. The oil can cause the death of many fish and get stuck to the feathers of seabirds causing them to lose their ability to fly. It also affects coastal plants due to the coating of oils and also results in the reduction of light transmission through surface waters.

Fig.2 Oil spillage in Nigeria.
Source: https://www.premiumtimesng.com/news/headlines/471901-nigeria-records-4919-oil-spills-in-6-years-4-5trn-barrels-stolen-in-4-years-minister.html?tztc=1

Germs

The sources of germs (small living things that cause disease) in the water body are mainly waste materials like urine and faeces that are discharged into the water and dirty water that enter the water body during the rainfall. Viruses and bacteria can cause water-borne diseases, such as cholera, typhoid, dysentery, polio and infectious hepatitis in humans.

Suspended Matter

Some pollutants (substances, particles and chemicals) do not easily dissolve in water. Some suspended pollutants later settle under the water body. They block the sunlight penetration in the water, which is required for photosynthesis by bottom vegetation. This can harm and even kill aquatic organisms that live at the bottom of water bodies.

Thermal (Heat) Pollution

When industries and other sources discharge their wastewater into the water body, it increases the temperature of the water body. The high temperature of this discharged wastewater lowers the dissolved oxygen content of the river because heat reduces the oxygen content of water. This causes breathing problems for aquatic organisms and also increases their chances of getting infected by diseases. Fish and other organisms used to a particular range of temperature may suffer thermal shock arising from unsteady temperature changes.

Chemical Water Pollution

Chemicals primarily enter water when it rains because runoff transports them from the land into the river. Farmers employ chemicals like fertilizer, pesticides, and other chemicals used to control weeds, insects, and pests, and many industries directly discharge their wastewater into rivers. These substances get into the water and can contaminate water sources. Many aquatic living forms are poisoned by these substances, which can also cause them to die or develop slowly or become infertile.

How to Reduce Water Pollution

*Dispose of chemicals properly***:** Do not dispose of pesticides, herbicides, motor oil, or other automotive fluids into the sanitary sewer or storm sewer systems. Both of them end at the river where they cause problems because they are not biodegradable (they cannot be broken down into less harmful substances by living organisms).

Conserve as much water as possible: Conservation is an important way to help preserve water as a resource. Pumping water into the house requires a lot of energy, so it's important to conserve as much as possible. Adopt the following habits to conserve more water around your house:

- Take showers, if possible, instead of baths, since baths require more water.
- Turn off your taps when you aren't using water, such as when you're brushing your teeth.

Reduce the use of plastics: Plastics do not decay: They often end up collecting in rivers, lakes, and oceans when it has nowhere else to go. This trash endangers marine life and affects humans as well. Whenever possible, use cartons, glass or cloth containers instead of plastic.

Avoid direct dumping into water systems: By all means possible, we should desist from disposing of waste in water bodies like lakes, rivers, streams or oceans to reduce the depletion of dissolved oxygen in the water by the microorganisms which decay the wastes.

Land Pollution

The term "land pollution" refers to the depositing of solid, particle, or liquid pollutants on or beneath the surface of the land in a way that could contaminate the soil and groundwater, endanger public health, or cause any annoyance. Numerous activities cause land pollution. Land contamination can be caused by both natural and artificial factors. The natural causes may include;

- Volcanic eruption
- Earthquake and
- Chemical decomposition due to biological activities.

Some of the man-made causes include

- Agricultural activities
- Deforestation
- Poor waste disposal
- Mining

In this chapter, only man-made causes shall be discussed.

Agricultural activities

The chemicals like pesticides and fertilizers used in farming pollute the land. They change the nature of the soil and kill some organisms living in the soil. Fertilizer is important for plant growth, but too much of it affects the plant. Generally, these chemicals present in the soil are toxic and can decrease the fertility of the soil, thereby decreasing the soil yield

Deforestation

Deforestation is the conversion of forest for other land use such as agriculture, grazing or urban development. Forests capture carbon dioxide and release oxygen but deforestation increases the concentration of carbon dioxide in the atmosphere. Ordinarily, carbon dioxide absorbs radiation (heat) from the atmosphere which causes global warming. This implies that a decrease in the forest would lead to an abundance of carbon dioxide which in turn worsens global warming and climate change.

Poor waste disposal

When wastes are disposed of poorly, it destroys the quality of the environment and makes it less habitable for man's living. Faecal sludge in most cases is disposed of on land where they decay on the surface of the land causing health problems. On the same note, most industries release their wastewater through their pipes or drainage systems, especially in developing countries which ends up on land, especially during the dry season. These pollutants contain heavy metal pollutants which reduce the quality of the land.

Mining

Minerals such as coal, gold and others are taken from the ground by digging pits or tunnels. The process of doing this is called mining. Mining affects the environment in many ways which include erosion, formation of sinkholes and contamination of soil, groundwater and surface water by chemicals used in mining. Surface mining (sometimes called quarrying or opencast mining) requires the removal of topsoil (the fertile layer of soil and organic matter that is used for agriculture) to get at the valuable rocks below. All these affect the soil quality.

Things that reduce land/soil pollution

The actions that can reduce land pollution include the following:

a) People should practice proper waste disposal that focuses on treating waste and disposing of it in the safest manner possible.

b) People are enjoined to reduce the usage of non-biodegradable materials such as plastic shopping bags, used empty sachet water, etc, because they pollute the land and disturb farmers during soil tilling.

c) The misuse of agrochemicals, such as excessive fertilization and uncontrolled pesticide application, are the main sources of pollution in agricultural fields. Thus, they should be used with caution to reduce soil pollution. Organic gardening can reduce the usage of pesticides and insecticides. Non-gardeners

can help by buying organic food.
d) Planting trees increases biodiversity, stops soil erosion, reduces carbon monoxide build-up, and adds aesthetic value to the area. You can plant trees in your community or work with worldwide organizations to plant trees in deforested areas

Stakeholders in the Solution of Environmental Problems

The Government

The government of every federation has an Environmental Protection Agency (EPA) that supports and conducts research, safeguards people and the environment from serious health threats, and creates and upholds environmental laws in the country. In Nigeria, NESREA (National Environmental Standard and Regulation Enforcement Agency) is the national environmental watchdog (the principal agency that attends to the protection of the environment). Each state in the nation has its independent agencies, whose purview is limited to that particular state. For instance, whereas Anambra State replaced Anambra State Environmental Protection Agency (ANSEPA) with Anambra State Waste Management Authority (ASWAMA), Lagos State still has the Lagos State Environmental Protection Agency (LASEPA) and the Lagos Waste Management Authority (LAWMA). Government should ensure that they have a strong political will to guarantee that the mission of the protection agencies is upheld.

The Citizens

According to Prince Charles, we must sustain the world if it is going to sustain us. Our lives are not sustainable if the world in which we live is not sustained by us. The protection of our environment is not only the duty of the government but equally of the governed. In Nigeria, the general public attitude towards environmental protection is very poor. Ignorance, materialistic tendency and apathy have often prevented people from adopting good environmental practices.
Most people find it difficult to cooperate with their co-tenants in either keeping their surroundings clean or paying sanitation levies. People in some cases dump waste at any vacant plot, or public space or even burn it in their houses thereby polluting the air. During rainfall, people dispose of their wastes into the drain which blocks the drains, makes the roads and pollutes the receiving water body. Street trading and hawking pollute the environment. It makes people in most cases throw the waste from moving vehicles thereby keeping the highways untidy. At times people cut down trees without planting any back. All these lead to unsustainable living. People are enjoined to do the following:

- keep their surroundings clean
- pay their sanitation levies
- Dispose of their waste properly
- Avoid burning their waste to reduce air pollution
- People should join the government in creating environmental awareness in society.
- Parents should ensure that they compel the government to let them participate in taking environmental decisions.
- Endeavour to plant trees at any given opportunity

The Clergies

God has placed humans in a position of responsibility over creation. In the bible, Christians are mandated in Genesis 2:15 "to cultivate and guard the earth". According to Oxford Advanced Learner's Dictionary, to guard is "to watch or protect something/somebody from danger". Then the big question is "Are we protecting the earth from danger or are we putting it in danger?" If we look at the way we indiscriminately dispose of our waste and pollute the air by burning our waste most times, destroying our forests, polluting our water bodies with industrial effluents, unsustainably exploiting our natural resources that lead to land pollution, using chemicals in fishing, refusing to pay sanitation levy etc, the answer becomes obviously NO.

The church has to manage and protect the environment in which human beings and other creatures thrive. Church leaders have been placed by God in strategic positions of leadership and influence in their various ministries, and they can use this to move people towards God's environmental agenda through their teachings, motivation and exemplary actions. It is, therefore, imperative that Church leaders should be sensitized about their roles in this context to help them to fulfil this God-given mandate. Church leaders are expected to address current environmental threats but inaction on the part of church leaders who most of the time do not even teach or preach about bible-based environmental protection has also led to a corresponding lack of action by Christians; who generally, have not engaged in practical bible-based stewardship of the environment.

The Church leaders can augment government efforts in protecting the environment by doing the following:

1) Enlightening the congregation on the need to respect and protect the environment
2) Appealing to their conscience to comply with the environmental laws of the state
3) Revealing to them the implications of their unfriendly environmental behaviours on their health and wellbeing
4) Informing them of their roles as Christians in environmental protection
5) Relating with and appealing to the government on some vital environmental issues

National and State Assemblies

Legislators make changes to existing laws or pass new legislation based on their constituents' needs. They also create policies, budgets and programs and participate in debates on proposed legislation. We have legislators at all tiers of the government namely the Federal government, the State government and the Local government.

The National Assembly is comprised of the House of Representatives and the Senate. Usually, members are assigned to topical committees. The House and Senate committees on the Environment are given primary responsibilities for the review and oversight of the existing environmental legislation, the collection and analysis of the relevant information, and the development of draft legislation on environmental matters. The committees comprise other sub-committees. It is generally their function to ensure that environmental matters are presented and handled thoroughly.

Unlike the National Assembly which is comprised of two units as earlier mentioned, the State has only the House of Assembly headed by the Speaker. They also have a house committee on the environment. Just like in the national assembly, they move motions on environmental problems arising from their constituencies, pass the budget and increase funding where the ones voted for are inappropriate and then visit Ministries, Departments and Agencies (MDAs) for supervision and ensure the release of funds for the effective completion of jobs.

Nigeria has 774 Local Government Areas (LGA). The local Government legislative arm is the legislative council. Unlike their federal and state counterparts, local governments are not empowered to make, repeal or revise legislation including environmental issues, rather they make recommendations to the State government.

The Media

The environment cannot speak for itself. The media is a powerful tool for drawing attention to environmental issues and increasing public awareness of environmental issues. The media focus on three key issues: to inform, educate and entertain. The different types of media can be categorized as

- Print Media which includes newspapers, Magazines and advertisements;
- Broadcast Media which includes television and Radio;
- Social Media (New Media) which includes social media and the internet

Radio, television and newspapers have been used in spreading important news about environmental protection at a faster rate. This has been enriched by the production and distribution of printed materials such as books magazines and brochures which has helped in the transfer of news on global environmental problems like climate change. Environmental reporting can contribute a lot to awareness. A few print and broadcast media had offered columns and feature programs on the environment. This has been very helpful in environmental protection

Environmental Organizations

Environmental organizations are mainly non-governmental organizations and comprise any non-profit, voluntary citizen groups which are organized on a local, national and international level to protect the environment. They help in framing the environmental policy, mobilizing public support for environmental conservation and protecting the endangered species of forests and animals.

Environmental organizations also help in doing the following:

- Creating awareness among the public on current environmental issues and solutions.
- Assisting different stakeholder groups in participating in the discussion of environmental issues.
- Protecting natural resources and entrusting the equitable use of resources.
- Being active in defending people's rights to a clean environment.
- Analysis and monitoring of environmental quality.
- Organizing lectures, seminars, and focus groups to spread environmental awareness.

Fig 3: UMOFC organizations working in Africa environmental cleanup - AHGINGOS
Source:https://www.google.com/search?q=Environmental+organizations+in+africa&tbm=isch&ved=2ahUKEwiovt_L19H-AhUymCcCHff4BXQQ2

Summary

This chapter has defined environment, environmental problems, environmental pollution in such a way that students can attempt to give their own definition of the concepts. The four major components of the environment namely atmosphere, hydrosphere, lithosphere and biosphere which has been polluted by mainly unsustainable human activities were highlighted. The six basic causes of the environmental problems namely population growth, poverty, urbanization, economic growth, poor environmental awareness and poor funding and enforcement of environmental were explained. The various types of pollution which were categorized as air pollution, water pollution and land pollution and the ways that they could be reduced were thoroughly explained. The chapter rounded up with explanation of the roles of various stakeholders in the solution of the environmental problems.

Exercise

1. What do you understand by the term environment?
2. Define environmental problems.
3. What are the four components of the environment?
4. State the basic causes of environmental problems.
5. List 3 types of pollution you know.
6. List 3 ways you can reduce air, water and land pollution.
7. Suggest any four stakeholders in environmental protection you know in Nigeria

References

Norah, B.D. (2010) A comprehensive Dictionary of Environmental Studies, Abhishek Publications, India

Okoye, A.C. (2019) Basic Environmental Education for Junior Secondary Schools, SCOA Heritage Nigeria Ltd, Awka

Okoye A.C. (2022) Fundamentals of Environmental Studies for fresh undergraduates, SCOA Heritage Nigeria Ltd, Awka

World Population Review (2023) https://worldpopulationreview.com/countries/nigeria-population retrieved on 21/3/23

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CHAPTER 2

Causes, Consequences and Management of Environmental Problems

By

DAURA Mala Mohammed and DAWHA Emmanuel Daniel

Overview

This chapter guides and provides students the opportunity to have an in-depth exploration of environmental problems, including their meaning, recognition, nature, magnitude, severity, causes, and sources. Students will also examine the barriers to solving these problems and learn how to deal with and solve environmental problems using both preventive and remedial measures. Through case studies and real-world examples, students will gain a comprehensive understanding of the challenges facing our planet and the strategies that can be employed to address them. By the end of the course, students will be equipped with the knowledge and skills necessary to engage in meaningful environmental advocacy and contribute to the global effort to preserve and protect our natural resources.

Objectives

By the end of this chapter, students should be able to:

1. define the concept of environmental problems and their significance in today's world.
2. recognize and identify various types of environmental problems, and their causes and consequences.
3. explain the nature, magnitude, and severity of different environmental problems and how they impact the ecosystems and human wellbeing.
4. identify and explain the underlying causes and sources of environmental problems.
5. discuss barriers to solving environmental problems, such as political, economic, social, and technological factors.
6. demonstrate skills and strategies of dealing with and solving environmental problems using both preventive and remedial measures.
7. demonstrate a sense of environmental responsibility and awareness and contribute to efforts to preserve and protect natural resources for future generations

What is “Environment”?

The environment is defined as the sum total of the circumstances, objects (biotic and abiotic) or conditions surrounding an individual. In other words, it is the sum total of components of the ecosystem, and their interactions and relationships among themselves. In environmental studies, the term "environment" typically refers to the physical, biological, and social surroundings in which living organisms, including humans, interact with their surroundings. It encompasses the natural and built environments. It comprises everything in the individual’s surroundings including the ecosystems, landforms, air, water, soil, climate, biodiversity, and the human societies, and the way they interact between and with each other. Federal Ministry of Environment. (n.d.).

What is the meaning of the term "Environmental Problem"?

The term "environmental problem" refers to a situation where human activities or natural events result in negative impacts on the ecosystems, natural resources, and human well-being, resulting in different types of pollution, habitat destruction, draught, deforestation, climate change, biodiversity loss, water scarcity, soil degradation, waste accumulation and anything that negatively impacts the environment. Most of these problems arise from the interactions between human activities and the natural environment. Addressing environmental problems requires taking proactive measures to prevent or mitigate their impacts, which can be achieved through promoting sustainable use and management of natural resources to ensure the long-term health and well-being of both people and the environment that sustains them (NESREA, n.d.).

How to recognize environmental problems

In order to recognize an issue that is becoming an environmental problem first, one needs to be aware of what environmental problems are (as defined in the previous section) If you notice any unusual changes in the natural environment or increase in waste or pollution, decline in biodiversity, Legal or regulatory violations or Inefficient use of resources then it is important to make observation of its impacts on human health, natural resources, and the ecosystems. If it is observed to have a negative impact on the environment then it is an environmental problem and is important to investigate and take action to address the underlying causes in order to mitigate and reverse its impact on the environmental. (Mooney, L. A., Clever, M., & Van Willigen, M. (2021).

Nature of Environmental problems

Agro Environ Media (2020) explains that Environmental problems are complex, interconnected, and global in nature, with long-term consequences, when they happen, they require sustainable solutions and urgent action to overcome them. Addressing environmental problems often times requires collaborative efforts from diverse stakeholders, including governments, businesses, communities, and individuals, to engender responsible environmental stewardship and ensure a sustainable future for generations to come.

Environmental problems can result from both natural and human phenomena. Natural phenomena such as volcanic eruptions, earthquakes, tsunamis, storms, droughts, and wildfires can have significant environmental impacts, often on a large scale

Human factors, on the other hand, are largely responsible for environmental problems such as deforestation, pollution, and climate change. Human activities often have a significant impact on the environment at a global scale. For example, greenhouse gas emissions from human activities are causing global climate change, which has far-reaching ecological, social, and economic consequences (Isife, 2012).

Whichever is the origin of the problem, they generally share some of these characteristics.

1. **Interconnectedness:** This is the fact that most Environmental problems are often interconnected and can have a cascading effect. For example, deforestation can lead to loss of habitat for wildlife, soil erosion, disrupted water cycles, and increased greenhouse gas emissions, which in turn can contribute to climate change and further environmental degradation.
2. **Global scope**: Many environmental problems especially the natural ones transcend national boundaries and have a global impact. For example, climate change, ocean pollution, and

biodiversity loss are not generally confined to specific regions or countries, but rather spread across countries and have far-reaching consequences on the planet and its inhabitants.

3. **Long-term impact:** Environmental problems can have long-term consequences that may persist for generations. For instance, pollution of air, water, and soil can have detrimental effects on human health, wildlife populations, and ecosystems for years to come.
4. **Complex and multidimensional**: Environmental problems are often complex and multifaceted, it often times involves wide range of factors and stakeholders. Mitigating environmental problems often times require interdisciplinary approaches and solutions that take into account social, economic, cultural, and political aspects, in addition to ecological considerations.
5. **Disproportionate impact:** The impact of environmental problems is more on the less fortunate and vulnerable communities than those with access to resources. Low-income groups, who may have limited access to resources, often times suffer from environmental injustices, and face disproportionate health and social impacts resulting from environment problems.
6. **Urgency**: Environmental problems when they occur often require urgent action to prevent irreversible damage to ecosystems, loss of biodiversity, and catastrophic impacts on human health and well-being. Immediate and proactive measures are necessary to mitigate the causes and effects of environmental problems.

Magnitude and severity of environmental problems

Environmental problems can vary in their magnitude, from local and regional issues to global crises that affect the entire planet. The severity of environmental problems on the other hand refers to the seriousness and extent of the impacts that these problems have on the environment, human health, and socio-economic systems. It can range from minor to severe.

The magnitude and severity of environmental problems, differs depending on various factors such as the type of problem, its size, extent, or scale, duration, and geographic location. For example, pollution from a single factory may have a local magnitude, affecting the air and water quality of the surrounding area, while climate change resulting from global greenhouse gas emissions has a global magnitude, affecting the entire planet. Natural environmental problems, such as volcanic eruptions, earthquakes, tsunamis, storms, droughts, and wildfires, can also vary in magnitude and severity. For example, a small-scale earthquake in a sparsely populated area may have relatively minor consequences, while a large-scale earthquake in a densely populated area can result in extensive damage, loss of life, and long-term environmental and social impacts.

It's important to note that the magnitude and severity of environmental problems can be influenced by human factors, such as population density, vulnerability of communities, level of development, and resource management practices. Human activities can exacerbate natural environmental problems and contribute to man-made environmental problems, influencing their magnitude and severity.

Causes of environmental problems

Environmental problems can arise from both human and natural causes and the combinations of both. Some of the common causes of environmental problems include:

a. Examples of anthropogenic factors that can cause environmental problems include:

1. **Human activities**: Human activities like industrial and agricultural practices, deforestation, urbanization, transportation, energy production, and waste generation are to blame for many environmental issues. These activities frequently involve the exploitation and utilization of

natural resources, contamination of the air, water, and soil, destruction of habitats, and change of ecosystems, all of which can have negative environmental effects.

2. **Overconsumption and unsustainable production patterns**: Overconsumption is a major cause of environmental problems especially when the consumer behaviour drives the production to be done in an unsustainable way putting pressure and Demand for natural resources, such as water, minerals, and fossil fuels, to outpaces natures capacity to replenish them sustainably, resulting in resource depletion, pollution, and ecological deterioration.
3. **Population growth and urbanization**: The growth of human populations, particularly in urban areas, can lead to increased demand for resources, such as land, water, and energy, and can cause environmental problems such as air and water pollution, waste disposal issues, forest and wildlife habitat destruction.
4. **Lack of awareness and education**: Environmental problems may be exacerbated by a lack of knowledge and instruction about environmental issues. Many people lack the information and skills necessary to adopt sustainable behaviours, or they may not be completely aware of how their actions affect the environment. Promoting environmentally conscious behaviour and tackling environmental problems require education and awareness.
5. **Economic and policy factors**: Economic and policy factors can also contribute to environmental problems. Economic activities that prioritize short-term gains over long-term sustainability can lead to overexploitation of natural resources, pollution, and environmental degradation. Weak or inadequate environmental policies, regulations, and enforcement can also contribute to environmental problems by allowing unsustainable practices to continue unchecked.
6. **Unsustainable use of natural resources**: The unsustainable use of natural resources, such as overfishing, overgrazing which leads to soil erosion, can cause environmental problems such as the loss of biodiversity, soil degradation, and desertification. (AESA (2020)

b. Natural causes of environmental problems:

Natural causes of environmental problems are those phenomena that arise from natural processes and events, such as weather patterns, geological processes, and biological phenomena. Some examples of natural causes of environmental problems include:

1. **Natural disasters**: Natural catastrophes like hurricanes, floods, wildfires, earthquakes, and volcanic eruptions can cause significant environmental damage leading to significant negative influence on the environment and on natural ecosystems. For example, desertification in northern Nigeria that is encroaching on arable lands of the Sahel savannah. Daura, M. M. *et al* (2001)

Plate 1. Migrating sands of the desert encroaching on the Sahel Savannah in Tulutuluwa; Yobe State Nigeria.
Source: https://i.pinimg.com/originals/

2. **Climate change**: Natural forces like fluctuations in the Earth's orbit and solar radiation are what drive climate change, but human actions have significantly sped up the rate of change in recent decades. Sea-level rise, an increase in the frequency and severity of extreme weather events, and changes to natural ecosystems are just a few of the environmental issues that climate change can bring about.

Plates 2 (a) and (b) impact of a thunder strike on the environment (a) the tremendous energy released in a thunderbolt. Source https://web.facebook.com/avantgardens.org/photos/a.573121939368238/8239873952692960 and (b) the enormous destructive power of a thunder strike. Source: David P Howard and licensed for **reuse** under this **Creative Commons Licence**. https://www.geograph.org.uk/photo/4084083

3. **Soil erosion**: The natural process of soil erosion happens when wind and water wash away soil particles. But human activities like deforestation, excessive grazing, and unsustainable farming methods can significantly speed up soil erosion and cause environmental issues like soil degradation and decreased agricultural productivity.
4. **Biological phenomena:** Natural biological processes such as disease outbreaks, insect infestations, and algal blooms can also cause environmental problems. For example, the covid19 outbreak, locust infestations and Lassa fever are all biological phenomenon that are related to the environment
5. **Geological processes**: Geological processes such as rock weathering that leads to rock fall and erosion, volcanic activity, and tectonic plate movements that leads to earthquakes can also cause environmental problems. For example, volcanic eruptions can release harmful gases and particles into the atmosphere, while earthquakes can cause landslides and if it happens under the ocean it can lead to tsunamis. It's important to note that while natural causes of environmental problems exist, human activities often exacerbate these problems and create new ones. https://www.nytimes.com/2018

A  B

Plates 3 (a) and (b) environmental problems of endogenic origin (a) An ash plume at the Kilauea volcano Hawaii authorities warned of something unseen but no less dangerous: high levels of sulfur dioxide gas. Credit...U.S. Geological Survey, via Getty Images
https://www.nytimes.com/2018/05/05/us/Hawaii-volcano-eruption.html
and (b) a devastating aftermath of earthquake that happened in Turkey. Source:
https://www.bbc.com/news/world

Sources of environmental problems

Sources of environmental problems refer to the specific activities, processes, or factors that contribute to environmental degradation or pollution. Generally environmental problems owe their sources to either anthropogenic or natural sources.

Anthropogenic sources of environmental problems:

Examples of anthropogenic sources of environmental problems include:

1. **Industrial activities:** Industrial activities, such as those involved in manufacturing, energy generation, and mining, have the potential to discharge pollutants into the air, water, and soil, causing pollution of those areas as well as other environmental issues. Deforestation, habitat degradation, and biodiversity loss are all problems that can be exacerbated by industrial emissions, waste disposal, and resource extraction.
2. **Agricultural practices**: Agricultural activities, such as the use of fertilizers, pesticides, and herbicides, as well as livestock production, can lead to soil erosion, water pollution from runoff, and degradation of soil and water quality. Intensive agricultural practices can also contribute to deforestation, habitat destruction, and loss of biodiversity.
3. **Transportation:** substantial source of air pollution and especially emissions of greenhouse gases like carbon dioxide and nitrogen oxides that are contributing to climate change is transportation by cars, airplanes, and ships. Transportation can also result in noise pollution, habitat fragmentation due to infrastructure expansion, and accidents on routes can cause spills of hazardous substances leading to environmental problems.

Plate 4: Fire Ignited by cell phone spark razes filling station in Badagry. Source: https://www.premiumtimesng.com/news/top-news/550135-fire-ignited-by-cell-phone-spark-razes-filling-station-in-badagry.html?tztc

4. **Waste generation and disposal**: Improper waste generation, treatment, and disposal can lead to environmental problems, including pollution of air, water, and soil. Landfills, incineration, and inadequate waste management practices can release pollutants, greenhouse gases, and toxic substances into the environment, posing risks to human health, wildlife, and ecosystems. (Isife, 2012)

Plate 5: indiscriminate dumping of refuse in Edo state Nigeria.
Source: https://sunnewsonline.com/edo-residents-indiscriminate-dumping-refuse/

5. **Extraction and use of natural resources**: The extraction and use of natural resources, including fossil fuels, minerals, water, and timber, can lead to environmental problems, such as deforestation, habitat destruction, pollution, and land degradation. Unsustainable extraction practices, such as overfishing, illegal logging, and mining without proper environmental safeguards, can have long-term negative impacts on ecosystems and natural resource availability (AESA, 2020).

Plate 6 Illegal mining activity in Osun (Sept 30 2021).
Source: https://businesspost.ng/economy/reps-to-investigate-illegal-mining-activities-in-osun/

6. **Urbanization and infrastructure development:** Urbanization, including the expansion of cities and infrastructure development, can result in land conversion, loss of natural habitats, and increased demand for resources, energy, and water. Urbanization also contributes to air and water pollution, waste generation, and greenhouse gas emissions (Isife, 2012)

Plate 7: Flood disaster attributed to poor planning and blockages of drainages and building in water ways.
Source:https://gazettengr.com/experts-demand-enforcement-of-relevant-laws-to-check-incessant-flooding/

Natural sources of environmental problems on the other hand include:

1. **Weather and climate-related disasters**: These disasters are caused by atmospheric conditions and climate patterns. Examples include:

- Hurricanes and tropical storms
- Tornadoes and thunderstorms
- Ozone layer depletion
- Heat waves and droughts
- Floods and flash floods and
- Wildfires

2. **Geological disasters:** These disasters are caused by geological processes within the Earth's crust. Examples include:

- Earthquakes which sometimes leads to tsunamis
- Volcanic eruptions
- Landslides and mudslides or mudflow

3. **Water-related disasters:** These disasters are caused by water-related processes, such as floods or tsunamis. Examples include:

- Coastal floods and storm surges
- Flash floods
- Tsunamis and
- Water-logging of environments.
- Acid rains

Plate 8: the Great East Japan Earthquake and Tsunami, which occurred on March 11, 2011. Japan leaders warns of earthquake that can produce 34 meter tsunami waves.
Source: **https://www.theguardian.com/world/2012/apr/01/japan-earthquake-tsunami-wave-risk**

4. **Biological disasters:** These disasters are caused by biological agents, such as viruses or bacteria. Examples include:

- Pandemics and epidemics and e.g., Covid 19
- Insect infestations e.g., Locust infestation

Plate 9: Locust infestation: *Locusts invade Mwingi North, Kituicounty*

- *Image:* https://www.the-star.co.ke/opinion/columnists/2020-01-28-locust-invasion-early-warning-did-not-lead-to-action/ Retrieved 3 may 2023

5. **Climate change:** Climate change itself is also a source of environmental problems, as it can cause a range of impacts, including sea level rise, ocean acidification, extreme weather events, and loss of biodiversity.

It is important to remember that a number of elements may combine to generate a particular natural disaster. For instance, a hurricane's heavy rain and powerful gusts can result in landslides (a geological disaster) and flooding (a disaster involving water). In addition, some natural disasters can cause additional calamities or cascading effects, for example earthquake can also trigger landslides.

Barriers to solving environmental problems

There are several barriers that can hinder the effective resolution of environmental problems. Omofonmwan, &Osa-Edoh, (2008) observed that these barriers may arise from various sources, including societal, economic, political, technological, and behavioural factors. Some common barriers to solving environmental problems according to them may include:

1. **Lack of political will**: Environmental policies and regulations require political will and support from government leaders. However, politicians may prioritize short-term economic gains over long-term environmental concerns, resulting in weak environmental policies and regulations.
2. **Limited resources**: Resources like money, technology, and knowledge may be needed in large amounts to address environmental issues. Organizations and governments could be unable to adopt practical environmental remedies due to a lack of funding.
3. **Technological limitations**: Technological advancements can offer innovative solutions to environmental problems. However, limitations in existing technologies or a lack of access to new technologies can hinder progress towards environmental sustainability.
4. **Lack of public awareness and education**: Many people may not be aware of environmental issues or understand the impact of their daily activities on the environment. Lack of public awareness and education can lead to a lack of interest and support for environmental solutions.
5. **Conflicting interests**: Environmental solutions may conflict with other interests, such as economic interests or political agendas. For example, industries that rely on fossil fuels may resist transitioning to clean energy sources due to concerns about profitability.
6. **International cooperation/conflicts:** Environmental issues often cross borders, and international cooperation is required to address them effectively. However, conflicts between nations or lack of cooperation can hinder progress towards finding solutions to environmental problems. A typical example is the shrinking Lake Chad which depends on cooperation between Nigeria, Cameroon, Chad and Niger for any meaningful remediation to take place
7. **International dependencies and external pressures**: Developing nations generally rely on foreign trade, investment, and aid, which may limit their capacity to solve environmental issues. Environmental policy-making and implementation in these countries may be impacted by external pressures from international entities, such as trade partners based on trade agreements and their investment preferences, or geopolitical interests.
8. **Limited institutional capacity:** Inadequate institutional capacity, such as a lack of skilled personal, technical know-how, and efficient governance frameworks, may make it difficult for developing nations to address their environmental issues. Effective attempts to solve environmental concerns may be hampered by insufficient capacity for policy development, implementation, and enforcement.
9. **Poverty and economic challenges**: Environmental issues in developing nations can be exacerbated by poverty and economic hardship. Lack of access to necessities like clean water, sanitary facilities, and energy sources can lead to unsustainably destructive behaviours like relying on polluting technologies or destroying forests for fuel. Poverty can restrict a

community's or government's ability to invest in environmentally friendly activities or technologies. (Omofonmwan & Osa-Edoh, 2008)

How to deal with environmental problems

Hardoy *et al.* (2013). Observed that dealing with environmental problems can be a complex and multifaceted task. However, the following strategies can help in curbing the menace of environmental problems:

1. **Identify and understand the problem:** Understanding the root causes and scope of the environmental problem is the first step towards finding a solution. This requires collecting data, analysing trends, and evaluating the impact of the problem on the environment and human health.
2. **Collaborate with others**: Solving environmental problems requires a collaborative effort involving individuals, communities, governments, and organizations. Collaboration can help pool resources, share knowledge, and build consensus on solutions.
3. **Develop a plan of action**: Developing a comprehensive plan of action is essential for tackling environmental problems. This includes setting goals, identifying strategies, and establishing timelines for implementation.
4. **Implement the plan**: Once a plan of action has been developed, it is important to implement it effectively. This may involve deploying technology, changing policies, educating the public, or engaging in community-based initiatives.
5. **Monitor progress**: Monitoring progress is critical for evaluating the effectiveness of solutions and making adjustments as needed. This requires measuring indicators, tracking outcomes, and making data-driven decisions.
6. **Evaluate outcomes**: Evaluating outcomes can help determine the success of environmental interventions and provide insights into areas for improvement. This requires assessing impacts on the environment, human health, and economic sustainability.
7. **Maintain momentum**: Environmental problems can be persistent and complex, and solving them requires ongoing effort and commitment. It is important to maintain momentum and continue to work towards sustainable solutions over the long term.

How to solve human induced environmental problems

Ekpo and Olatunde-Aiyedun (2019) and Ndubuisi-Okolo *et al.* (2020). Observed that there are many ways in which environmental problems can be solved, and some of these solutions include:

1. **Behavioural change**: Promoting sustainable behaviours among individuals and communities, such as reducing waste, conserving energy and water, and adopting eco-friendly practices in daily life, can contribute to solving environmental problems.
2. **Reducing, reusing, and recycling (the RRR method):** One of the most effective ways to solve environmental problems is to 1. Reduce waste generation 2. Reusing and 3. Recycling used materials. This helps to conserve natural resources and reduce pollution and waste.

Plate 10: The **RRR** logo (reduce reuse and recycle)
Source: *https://www.google.com/search?q=reduce+reuse+recycle+logo&tbm*)

3. **Conservation and protection of natural resources:** Natural resource preservation and protection can help to maintain ecosystem health and lessen the effects of environmental problems. Examples of these resources to be conserved include forests, water bodies, and biodiversity.
4. **Transition to renewable energy sources:** Transitioning to renewable energy sources, such as solar, wind, and hydropower, can help to reduce greenhouse gas emissions and mitigate climate change.
5. **Promotion of sustainable agriculture**: Sustainable agriculture practices, such as organic farming and agroforestry, can help to reduce soil erosion, conserve water resources, and preserve biodiversity.
6. **Implementation of green technologies and practices:** Ekpo and Olatunde-Aiyedun (2019). Advises that green technologies and practices, such as energy-efficient appliances, green building design, and low-emission transportation, can help to reduce pollution and conserve natural resources.

Plate 11: Green technology solutions to environmental problems.
Source: https://earth.org/renewable-energy-facts/

7. **Strengthening environmental governance and regulation**: Environmental problems can be effectively addressed by strengthening environmental governance and regulation, including enforcement of environmental laws and regulations.

8. **Education and awareness-raising:** Campaigns to raise awareness and encourage people to adopt sustainable behaviours can help to foster an environment of environmental responsibility.
9. **Collaboration and partnerships:** Collaboration and partnerships among governments, civil society organizations, and the private sector can help to mobilize resources and expertise to address environmental problems effectively.
10. **Innovative financing mechanisms:** Innovative financing mechanisms, such as carbon taxes, green bonds, and public-private partnerships, can help to mobilize resources and incentivize investment in sustainable projects.
11. **International cooperation**: International cooperation and collaboration can help to address environmental problems that cross borders, such as climate change, biodiversity loss, ocean pollutions, and epidemics.

How to mitigate nature induced environmental problems.
It might be difficult to reduce or eliminate environmental issues brought about by natural forces because they frequently occur outside of human control. However, both Hardoy, *et al* (2013) and AESA (2020) say, to lessen their effects on the environment and human societies, a number of steps can be taken. Some of these steps may include:

1. **Early warning systems:** Developing and implementing early warning systems can help to provide advance notice of impending natural disasters, allowing people to evacuate or take other precautionary measures.
2. **Infrastructure design:** Building infrastructure that is resilient to natural disasters can help to reduce the risk of damage or destruction. For example, constructing buildings that are earthquake-resistant or designing drainage systems that can handle heavy rainfall can help to mitigate the impacts of natural disasters.
3. **Land-use planning**: Planning for land use appropriately can lower the likelihood of suffering harm from natural disaster. For instance, avoiding development in landslide-prone or flood-prone areas can help to lower the danger of property damage or loss of lives from such events.
4. **Ecosystem-based development plan**: Ecosystem preservation and restoration can lessen the effects of natural disasters. Restoration of wetlands or mangroves, for instance, can lessen the effects of storm surges and coastal floods.
5. **Emergency preparedness and response**: Effects of natural disasters can be lessened by creating emergency preparations and response systems. For instance, setting up emergency response teams and gathering emergency supplies helps reduce casualties and property damage.

Measures than can prevent or reduce environmental problems
Preventive measures are proactive steps that can be taken to avoid or minimize the occurrence of environmental problems. Mba (2004), Ndubuisi-Okolo, *et al* (2020), and Omofonmwan and Osa-Edoh (2008). Agree with the following as preventive measures that can be implemented to address and mitigate environmental problems:

1. **Conservation and sustainable management of natural resources**: This includes protecting and conserving natural resources such as forests, freshwater sources, marine ecosystems,

and biodiversity through sustainable management practices. This includes measures such as reforestation, sustainable fishing practices, and protected area management.

2. **Pollution prevention**: Environmental problems can be avoided by putting pollution control measures in place to reduce the release of dangerous compounds into the environment. This entails minimizing or completely ceasing the use of hazardous substances, putting in place sound waste management procedures, and encouraging cleaner production methods.
3. **Energy conservation and efficiency**: Reducing greenhouse gas emissions and increasing energy efficiency can assist to lessen the effects of climate change. This entails boosting renewable energy sources, bettering building design and insulation, and promoting energy-efficient technologies.
4. **Waste reduction through recycling and reusing of used materials**: Reducing waste generation, encouraging recycling, and putting in place good waste management methods can help avoid pollution, save resources, and lessen the negative effects of waste on the environment. This includes encouraging the concepts of the circular economy, separating recyclable goods, and reducing waste at the source.
5. **Environmental education and awareness**: It are possible to encourage ethical behaviour among people, communities, and organizations by educating people about environmental issues, conservation, and sustainable practices. This includes attempts to increase capacity as well as environmental education programs in schools and awareness campaigns.
6. **Sustainable agriculture and food production**: Promoting sustainable agricultural methods can help stop the soil erosion, water pollution, and biodiversity loss that are caused by traditional agriculture. These methods include organic farming, agroforestry, and integrated pest management.
7. **Environmental regulations and policies**: At the national, regional, and international levels, the implementation and enforcement of environmental legislation and policies can offer a legal foundation for averting environmental issues. This covers regulations for managing resources, preventing pollution, and conducting environmental impact analyses.
8. **Ecosystem restoration and conservation**: It is possible to stop biodiversity loss, soil erosion, and other environmental issues by restoring damaged ecosystems and preserving essential habitats. This covers efforts for conservation as well as projects like habitat restoration and ecological restoration.
9. **Sustainable urban planning and design**: Planning and designing cities and urban areas in a sustainable manner can help prevent environmental problems associated with urbanization, such as air pollution, water pollution, and loss of green spaces. This includes measures such as compact city planning, green infrastructure, and sustainable transportation systems.
10. **Corporate social responsibility and sustainable business practices**: Encouraging businesses to adopt sustainable practices, such as reducing carbon emissions, minimizing waste generation, and promoting responsible supply chain management, can contribute to preventing environmental problems.

Remedial measures to environmental problems

Remedial steps are actions taken to mitigate or address existing environmental problems. AESA (2020) agrees with the following idea as some remedial steps that can be taken to tackle environmental problems:

1. **Cleanup and remediation of problems that have occurred**: This involves the physical cleanup and remediation of polluted sites, such as contaminated land, water bodies, and air

pollution hotspots. This can include measures such as soil and water remediation, pollution control devices installation, and cleanup efforts through technologies like bioremediation or phytoremediation.

Plate 12: Oil Spill in Eleme, Tai, Gokana and Khana councils of Ogoni Land. Source: https://guardian.ng/news/ogoni-communities-lack-water-health-facilities-1000-days-into-cleanup/

2. **Restoration and rehabilitation of ecosystems**: Ecological functions and services provided by degraded ecosystems, such as forests, wetlands, and coral reefs, can be restored. Examples of these include initiatives for reforestation, habitat restoration, and ecological restoration.
3. **Pollution control and management:** By putting pollution control mechanisms in place, such as emission controls, waste treatment technologies, and monitoring and reporting systems, it is possible to lessen the discharge of dangerous compounds into the environment and lessen the effects of pollution.
4. **Environmental monitoring and assessment**: In order to identify environmental issues and direct corrective action, monitoring and assessment programs should be established to evaluate the state of the environment, including air quality, water quality, biodiversity, and ecosystem health.
5. **Environmental regulations and enforcemen**t: Environmental rules and regulations, such as emissions requirements, water quality standards, and waste disposal regulations, can be strengthened and enforced to assure compliance and stop more environmental problems.
6. **Public participation and engagement**: Engaging local stakeholders, communities, and the general public in decision-making processes pertaining to environmental issues can aid in increasing awareness, gathering local knowledge, and fostering group action for finding solutions.
7. **Sustainable resource management**: The overuse and degradation of natural resources can be avoided by putting into practice sustainable resource management techniques including sustainable logging, fisheries management, and water resource management.
8. **Climate change mitigation and adaptation:** One of the most urgent environmental problems of our day can be solved by putting into practice steps to reduce climate change, such as lowering greenhouse gas emissions, and adapting to its effects, such as sea level rise and extreme weather.
9. **Environmental education and capacity building**: Long-term solutions to environmental issues can be achieved through implementing environmental education and capacity-building

efforts to increase awareness, develop knowledge and skills, and promote sustainable behaviours among people, communities, and stakeholders

10. **International cooperation and collaboration:** Transboundary environmental issues including air and water pollution, climate change, and biodiversity loss can be addressed through fostering international cooperation and collaboration among nations, organizations, and stakeholders.

    Remedial steps require careful planning, coordination, and implementation to effectively address existing environmental problems. They may involve a combination of technological, regulatory, social, and behavioural measures, and may vary depending on the specific environmental problem, its severity, and the context in which it occurs.

Examples of Man-made environmental problems that have occurred in Nigeria:

1. Oil spills in the Niger Delta region due to oil exploration and production activities, leading to widespread pollution of waterways, farmland, and fishing grounds. - UNEP Environmental Assessment of Ogoniland (2011), Amnesty International Report on Oil Spills in the Niger Delta (2013)
2. Air pollution in major cities like Lagos and Port Harcourt due to high levels of vehicular traffic, industrial emissions, and burning of waste. - Nigerian Urban Reproductive Health Initiative Report on Air Pollution in Lagos (2018), Port Harcourt Air Quality Monitoring Project Report (2019)
3. Deforestation and desertification due to human activities such as logging, clearing land for agriculture, and unsustainable fuelwood harvesting. - Nigerian Conservation Foundation Report on Deforestation (2018), Nigerian Environmental Study/Action Team Report on Desertification (2017)
4. Soil degradation and erosion due to poor land use practices such as overgrazing, improper irrigation, and slash-and-burn agriculture. - Food and Agriculture Organization Report on Soil Degradation in Nigeria (2018), Nigerian Institute of Soil Science Report on Soil Erosion (2019)
5. Water scarcity and poor water quality due to overuse, pollution, and poor management of water resources. quality - United Nations World Water Development Report on Nigeria (2019), WaterAid Nigeria Report on Water Scarcity (2018)
6. Waste management problems due to inadequate waste collection and disposal infrastructure, leading to littering, illegal dumping, and open burning of waste. - United Nations Environmental Programme Report on Solid Waste Management in Nigeria (2012), Federal Ministry of Environment Report on the National Environmental Sanitation Policy (2005)
7. Climate change impacts such as flooding, droughts, and heatwaves due to greenhouse gas emissions from human activities. - Nigerian Climate Change Policy Response and Strategy Report (2012), Nigerian Meteorological Agency Report on Climate Change Trends (2019)

Examples of natural environmental problems that have occurred in Nigeria:

1. "Nigeria: Over 500,000 Affected by Floods in Benue State," United Nations Office for the Coordination of Humanitarian Affairs (OCHA), 5 September 2017. Available online: https://reliefweb.int/report/nigeria/nigeria-over-500000-affected-floods-benue-state
2. "Nigeria: Floods - Aug 2017," International Disaster Database (EM-DAT). Available online: https://www.emdat.be/disaster-list/field_emdat_event_type/flood-24239
3. "Benue Floods: Over 110,000 Displaced as Death Toll Rises," Vanguard News Nigeria, 15 September 2017. Available online: https://www.vanguardngr.com/2017/09/benue-floods-110000-displaced-death-toll-rises/
4. Lassa fever outbreak in Nigeria: In 2020, there was a Lassa fever outbreak in Nigeria, with over 1,000 confirmed cases and 200 deaths reported across 27 states, including Lagos, Ondo, and Edo. The outbreak was linked to the consumption of contaminated food and contact with infected rodents. Akhuemokhan, O. C., Erameh, C. O., Iruolagbe, C. O., Adeghe, A. J.,

Okonofua, M. O., Dawodu, S. O., ... & Obi, R. K. (2021). Epidemiology of Lassa Fever Outbreaks in Nigeria Between 2016 and 2020: A Retrospective Study. Tropical Medicine and Infectious Disease, 6(1), 37. https://doi.org/10.3390/tropicalmed6010037

5. Epidemics and disease outbreaks due to natural factors such as insect vectors and animal hosts, leading to public health emergencies. - World Health Organization Report on Cholera Outbreaks in Nigeria (2018), Nigerian Centre for Disease Control Report on Lassa Fever Outbreaks (2019)
6. Desertification in Nigeria: Nigeria is experiencing desertification, particularly in the northern part of the country. The Sahara Desert is advancing southwards at a rate of about 0.6 km per year. As a result, large areas of land in the northern states, including Kano, Sokoto, and Jigawa, have been lost to desertification, leading to soil erosion, loss of vegetation cover, and reduced agricultural productivity. "Assessment of Desertification in Nigeria: Causes, Effects and Mitigation Strategies" by A. O. Adetunji and O. O. Amusat, published in the Journal of Environmental Protection, Vol. 10, No. 1, 2019.
7. Desertification due to natural factors such as drought and soil erosion, leading to loss of vegetation cover and agricultural productivity. - Nigerian Environmental Study/Action Team Report on Desertification (2017), United Nations Convention to Combat Desertification Report on Nigeria (2018)
8. Lead poisoning in Zamfara State: In 2010, there was a lead poisoning outbreak in Zamfara State, located in the North-West region of Nigeria. The outbreak was caused by the informal and unsafe mining of gold in the state, which resulted in the release of lead into the environment. The outbreak affected over 10,000 people, with at least 400 deaths reported. Dooyema, C.A., Neri, A., Lo, Y.C., Durant, J., Dargan, P.I., Swarthout, T., . . . Brown, M.J. (2012). Outbreak of fatal childhood lead poisoning related to artisanal gold mining in northwestern Nigeria, 2010. Environmental Health Perspectives, 120(4), 601-607.
9. Coastal erosion in Lagos: Lagos, the commercial capital of Nigeria, is experiencing coastal erosion, which is causing the loss of land and infrastructure in the area. It is estimated that about 3,000 square meters of land are lost to erosion each year. This has led to the displacement of coastal communities and the loss of properties worth billions of naira. Oyedepo, J. A., &Abimbola, A. F. (2018). Coastal erosion and its implications for sustainable development in Lagos State, Nigeria. International Journal of Environment and Sustainable Development, 17(4), 383-399.
10. Ocean surges due to natural factors such as storms and tidal waves, causing damage to coastal communities and infrastructure. - United Nations Development Programme Report on Coastal Erosion in Nigeria (2018), National Emergency Management Agency Report on Coastal Flooding (2017)
11. Landslides due to soil instability in hilly areas, causing loss of life and property damage. Landslides - Nigerian Geological Survey Agency Report on Landslide Occurrence in Nigeria (2018), Nigerian Conservation Foundation Report on Soil Erosion (2018)
12. Forest fires due to natural factors such as lightning strikes and dry conditions, causing loss of forest cover and wildlife habitats. - Nigerian Conservation Foundation Report on Forest Fires (2017), Nigerian National Park Service Report on Forest Fire Management (2019)

Summary

The nature of environmental problems, their potential scope and severity, their causes and origins, the challenges associated with resolving them, preventive measures to address them, corrective actions to address them, and potential solutions for environmental issues in Nigeria are just a few of the topics that have been covered so far.

The nature of environmental problems encompasses issues such as pollution, climate change, deforestation, loss of biodiversity, and resource depletion. These problems have wide-ranging impacts on human health, economies, and ecosystems. The magnitude and severity of environmental problems vary, with some issues posing immediate and severe threats, while others may have long-term and cumulative impacts.

The causes of environmental problems include human activities such as industrialization, deforestation, agriculture, and pollution, as well as socio-economic factors, population growth, and unsustainable consumption patterns. The sources of environmental problems include point sources such as factories and industries, non-point sources such as agricultural runoff and urban runoff, and global sources such as greenhouse gas emissions.

Barriers to solving environmental problems include inadequate policies and regulations, lack of enforcement mechanisms, economic and social challenges, technological limitations, and lack of public awareness and engagement. Preventive measures to address environmental problems involve proactive strategies such as sustainable resource management, pollution prevention, conservation, and sustainable consumption patterns.

Remedial steps to tackle environmental problems include strategies such as pollution control, ecosystem restoration, waste management, and renewable energy adoption. Potential solutions for environmental problems in Nigeria may involve strengthening environmental regulations and enforcement, promoting sustainable resource management, investing in renewable energy and clean technologies, enhancing waste management practices, restoring and protecting ecosystems, promoting environmental education and awareness, encouraging community participation and engagement, fostering international cooperation and collaboration, strengthening environmental impact assessment and monitoring, and promoting sustainable urban planning and development. Achieving meaningful and long-lasting solutions to environmental problems requires concerted efforts from various stakeholders and a multi-faceted approach that encompasses regulatory measures, sustainable practices, public awareness, and community engagement.

Exercise

1. What are some examples of natural disasters that cause environmental problems, and how do they contribute to the problem?
2. Can you give examples of environmental policies or initiatives that have been implemented in Nigeria to address environmental problems?
3. How can sustainable agriculture practices help mitigate environmental problems in Nigeria?
4. What are the main natural causes of environmental problems, and how can we mitigate or solve these problems?
5. What are some of the most pressing environmental problems in Nigeria, and what are the causes of these problems?
6. How do human activities contribute to environmental problems, and what are some potential solutions to these problems?
7. What is the role of policy in addressing environmental problems, and what are some of the key environmental policies in Nigeria?
8. How can individuals and communities take action to address environmental problems in Nigeria, and what are some examples of successful environmental activism in the country?

Hands on class exercises

1. Conduct a case study on a local environmental problem, like air pollution or deforestation, and create a thorough action plan to solve the problem that involves stakeholder engagement and sustainable solutions.
2. Go on a field excursion to a nearby ecosystem, like a forest, wetland, or coastal region, and take notes on its biological characteristics, environmental problems, and suggest methods for preserving or restoring it.
3. Organize a tree planting event in your campus to promote reforestation and raise awareness about the importance of trees in mitigating climate change, conserving biodiversity, and improving air and water quality.

4. Develop a campus-based plan to reduce plastic waste and promote sustainable consumption patterns
5. Conduct a water quality study of a local river or stream and assess the impacts of pollution on aquatic life and human health.
6. Organize a Campus cleanup and raise awareness about the impact of marine debris on coastal ecosystems.
7. Research and evaluate the effectiveness of environmental policies and regulations in Nigeria or a particular state of your choice.

References

Daura, M.M., Gisilanbe, A.M. and Waziri, M. (2001) Flood Plain Encroachment and Hazard Awareness in Urbanized Catchments: A Study of Ngadda Flood Plain in Maiduguri. In: Daura, M.M., Ogunnika, O., Irefin, D. and Balami, D., Eds., Environment and Development Issues in Sub-Saharan African, Seminar Series, Vol. 1. Faculty of Social and Management Sciences, University of Maiduguri, Maiduguri, 50-60. https://scirp.org/reference/referencespapers.aspx?referenceid=1687835 Retrieved 4 may 2023

Ekpo, C.G. & Aiyedun, T.G. (2019). Environmental Education: A tool for creation of awareness on adaptation to climate change in Nigeria. IOSR Journal of Research & Method in Education (IOSR-JRME), 9 (6) 12-21. http://iosrjournals.org/iosr-jrme/papers/Vol-9%20Issue-6/Series-5/C0906051221.pdf Retrieved 2 may 2023

Environmental Degradation: Causes and Remediation Strategies. (2020). Agro Environ Media, Publication Cell of AESA, Agriculture and Environmental Science Academy DOI:10.26832/aesa-2020-edcrsHaridwar, India ISBN: 978-81-942017-2-4

Federal Ministry of Environment. (n.d.). Definition of environment. http://environment.gov.ng/ Retrieved 4 may 2023

Hardoy, J. E., Mitlin, D., &Satterthwaite, D. (2013). Environmental problems in an urbanizing world: finding solutions in cities in Africa, Asia and Latin America. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9781315071732/ Retrieved on 29 April 2023

Isife, C. (2012). Environmental problems in Nigeria-A review. Sustainable Human Development Review, 4(1&2), 21-38. http://www.wiprointernational.org/shdrv4n1-2.pdf#page=27

Mba, H. C. (2004). Management of environmental problems and hazards in Nigeria. Aldershot: Ashgate. https://www.researchgate.net/publication/316441235Retrieved on 1 may 2023

Mooney, L. A., Clever, M., & Van Willigen, M. (2021). Understanding social problems. Cengage learning. https://www.cengage.uk/

National Environmental Standards and Regulations Enforcement Agency (NESREA), Retrieved from http://nesrea.gov.ng/environmental-issues/ Retrieved on 4 may 2023

Ndubuisi-Okolo, P., Ifeoma, R., &Adaeze, E. (2020). Environmental Sustainability and Sustainable Development in Nigeria: Problems and Prospects. International Journal of Accounting and Finance. 4. 6-11.https://www.researchgate.net/publication/341194279Retrieved on 1 may 2023

Obroh, Oveka & Sambo, Garba. (2022). Flood Vulnerability Mapping of River Ngadda Using Geospatial and Remote Sensing Techniques Maiduguri Metropolis, Borno State. 10.21203/rs.3.rs-1274069/v1.

Omofonmwan, S. I., & Osa-Edoh, G. I. (2008). The challenges of environmental problems in Nigeria. Journal of human Ecology, 23(1), 53-57.
https://scirp.org/reference/referencespapers.aspx?referenceid=1610236 Retrieved on 28 April 2023

Omofonmwan, S & Osa-Edoh, G. (2008). The Challenges of Environmental Problems in Nigeria. Journal of Human Ecology. 23. 10.1080/09709274.2008.11906054.
https://www.researchgate.net/publication/265748767Retrieved on 4 May 2023

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Plate 3B: https://www.bbc.com/news/world
Plate 4: https://www.premiumtimesng.com/news/top-news/550135-fire-ignited-by-cell-phone-spark-razes-filling-station-in-badagry.html?tztc
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Plate 6: https://businesspost.ng/economy/reps-to-investigate-illegal-mining-activities-in-osun/
Plate 7: https://gazettengr.com/experts-demand-enforcement-of-relevant-laws-to-check-incessant-flooding/
Plate 8: https://www.theguardian.com/world/2012/apr/01/japan-earthquake-tsunami-wave-risk
Plate 9: https://www.the-star.co.ke/opinion/columnists/2020-01-28-locust-invasion-early-warning-did-not-lead-to-action/
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Plate 12: https://guardian.ng/news/ogoni-communities-lack-water-health-facilities-1000-days-into-cleanup/

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CHAPTER 3

Elements of Environmental Management

By
IBRAHIM Ahmed Maigari

Overview

The place of environmental management to the service of humanity cannot be over emphasized. As it could be argued that it is a single roadmap, with no alternative, for man's successful stewardship of the planet earth. In the first instance, generally, it enables man to understand the structure and function of the earth system, as well as the ways in which humans relate to their environment (Laurila-Panta et al, 2015). It promotes safe keeping of soil, water, and air for humans and wildlife (Mattheus, 2012 and Michael, 2014). It also enables man to rationally adjust with nature - judiciously exploits and utilizes natural resources without disturbing the ecosystem balance and ecosystem equilibrium (Kumar, 2016).

At the end of this course, students should be able to:
1. explain the elements of environmental management.
2. describe the types and causes of major environmental issues.
3. explain how to reduce and prevent occurrences of pollution in air, water and land

Introduction

The place of environmental management to the service of humanity cannot be over emphasized. As it could be argued that it is a single roadmap, with no alternative, for mans' successful stewardship of the planet earth. In the first instance, generally, it enables man to understand the structure and function of the earth system, as well as the ways in which humans relate to their environment (Laurila-Panta et al, 2015). It promotes safe keeping of soil, water, and air for humans and wildlife (Mattheus, 2012 and Michael, 2014). It also enables man to rationally adjust with nature - judiciously exploits and utilizes natural resources without disturbing the ecosystem balance and ecosystem equilibrium (Kumar, 2016). In the same vein, environmental management facilitates socioeconomic developments on one hand and maintenance of environmental quality on other hand (Kaushik and kaushik, 2010). While at a micro level or corporate entities, environmental management promotes optimal allocation of scanty resources in the economy; ensures health and safety within workplace; serves as an index for pollution control in corporate bodies; helpful in discharging organizational accountability and increasing environmental transparency (Christiansen, 2004 and Beder, 2006). Others are: supports green reporting to combat effectively all negative public opinions in the global economy; improves performance through better management of environmental cost and thus, benefits the natural and human environments; forces corporate sectors to fulfill their commitments towards introduction and change, and thus appears to be responsive to new factors; and reflects unsound production and consumption patterns, misuse and scanty use of resources and assets, among others (Eresi, 1996; Jain, 2000; Chong, 2008). Intellectually, also, political economists and environmentalists used it as an index in measuring a nation's economic development, social welfare, industrial development, pollution control and in fulfilling the needs of government (Chong, 2008).

Evolution of Environmental Management

Quite contrary to the claims by nonprofessionals that environmental management is a recent discipline, a byproduct of the 1970s and 1980s earth summits (Colby, 1991), it is not an accidental carrier, profession or discipline but rather a strategy or technique that goes with time. Its philosophy dates back to the evolution of man on the planet earth. In real sense, however, the history of Environmental management is a very long one and can be divided into three major developmental periods; namely ancient, classical and modern history (Ereky, 1919; Hughes, 1975; Kolk and Mauser, 2001; Weler, 2018). The ancient history dated hundreds of centuries ago suggesting that humans have used environmental management principles for development almost throughout human history. During that period, strategies and techniques that today formed the background of environmental management were developed, although the word environmental management was not used to describe any of the techniques. Discovery of nature, protection and caring were the centre pits of ancient environmental management that later gave rise to the conglomerations concept of agriculture (Dauvergne, 2009).

The classical environmental management evolved from 1700 to almost the middle of the twentieth century. Thus environmental management in the classical phase centred on exploration of determinant factors and description of environmental features in relation to space, location and place. Further development of these, gave rise to the development of associated theories, concepts, and disciplines, such as Adam Smith (1776) and Thomas Malthus (1798) theories on population-resources relationship, Ellsworth Huntington (1876 - 1947) concept of environmental determinism, classical geography (Charles and Withers, 2013), economics, environmental biotechnology, ecology, and environmental health and engineering, among others. It is on this background that most environmental, technical and social sciences cloned themselves with environmental management principles.

Owing to the inability of most of the environmental sciences and techniques to completely handled the problems associated with industrial revolution, high population growth, modernization and globalization, the modern environmental management emerges in order to rescue the situation and promote safe living heaven and best keeping culture of the natural and built environment. Indeed, this development can be associated with the 1972 Stockholm Conference on the Human Environment, which was the landmark for the major changes in the way societies think about the management of the relationship between nature and human activity in the future (Kaushik and kaushik, 2004, and 2010). Since then, the nomenclature of modern environmental management began and the discipline develops and subsumes other applied and social sciences into one integrated discipline (Lochner, et al, 2004 and Michael, 2014). Thus, in addition to going in conformity with the ancient and classical principles, the modern environmental management also avails itself with control of environmental quality and sustainable resource management (Raven, Berg, and Hassenzahl, 2010) through five basic operations. These are: Manipulation, Accounting, Monitoring, Auditing, and Legislation; which in acronyms is denoted as MAMAL.

Definition of Environmental Management

Irrespective of the controversy involved among scholars on a unifying definition of environmental management, here it can be defined, based on practical application, as the scientific study of the strategies and techniques of monitoring and manipulation of physical, chemical, and non-human biological system in order to preserve and maintain their natural qualities (after, Heer and Hagerty, 1977). Thus, from this brief definition, it can be deduced that environmental management is a broad field of study that includes the natural environment, built environment and the sets of relation between them (Ormazabal et al, 2014; Speight and Singh, 2014; and Theodore and Theodore, 2010). Therefore, in other words, Environmental management is concerned with the description and monitoring of environmental changes, with predicting future changes and with attempts to maximise human benefit and to minimise environmental degradation due to human activities (Park, 1981 and Colby, 1991). Brown, (2005) added that 'Environmental management is the process we use to reduce risk and keep harmful substances away from humans or down to levels that will not cause harm… as risk is manage in the financial world through insurance, so also Environmental management too is a form of insurance'.

To sum up, NEC (2011) described Environmental management as a subject that combines science, policy, and socioeconomic applications. It primarily stresses on finding solution to practical problems that people face in cohabitation with nature, resource exploitation, and waste production. In a purely anthropocentric sense, environmental management is all about dealing with the fundamental issue of how to innovate technology to evolve continuously while limiting the degree to which this process alters natural environment. Thus, Environmental management is closely linked with issues regarding sustainable economic growth, ensuring fair and equitable distribution of resources, and conserving natural resources for future generations Paul, et al, 2016).

Based on this practical multidimensional definition, the scope of environmental management has encompasses large number of areas and aspects, which can be summarized into five broad areas. These are: i. Natural resources, their conservation and management; ii. Ecology and biodiversity; iii. Environmental pollution and control; iv. Social issues in relation to development and environment; and v. Human population, environment and climate change. Indeed, these are the basic aspects of environmental management studies which have a direct relevance to every section of the society (Kumar, 2016). It is in line with this broad scope that, Brown (2005 in Kumar, 2016) identified the objectives of environmental management to include the following:

i. Identify the environmental problem and find its solution;
ii. Restrict and regulate the exploitation and utilization of natural resources;
iii. Regenerate degraded environment and renew natural resources (renewable)
iv. Control environmental pollution and degradation;
v. Reduce the impacts of extreme events and natural disaster;
vi. Make optimum utilization of natural resources;
vii. Assess the impacts of proposed projects and activities on environment; review and revise the existing technologies and make them eco-friendly; and
viii. Formulate laws for the implementation of environmental protection and conservation programmes.

As a field of study as well as a professional carrier, environmental management has basic distinctive features that differentiate it from other disciplines and related applied sciences. Some of these include the following:

i. It is a strategy that centered on "sustainable development" (i.e. the ability of present generation to meet their need without compromising the ability of future generations to meet their own needs). It emphasizes utilitarianism (a belief in protecting resources for the "greatest good" for the greatest number and for the longest time) and disregards anthropocentrism (a belief in humans as master of the world with a unique set of right and values) (Mattheus, 2012).
ii. It is multi disciplinary in nature, because it cut across many disciplines which include Agriculture, Architecture, Biology, Chemistry, Economics, Ecology, Engineering, Ergonomics, Estate management Geography, Geology, Physics, Psychology, etc (Louis, 2016).

iii. It is a vision of the nature, evolves on the basis of righteous practice and resolves the conflict between man and nature (Hussein, 2005).
iv. It awaken man to be environmentally conscious and to be proactive than reactive to environmental problems. It has positioned man as a caretaker and steward of resources working together with the rest of nature to sustain life and make the world a better place.
v. It rejected the views of the nihilist (the view that there is no reason to behave morally, only power, strength and shear survival matter “might is right eat or be eaten”) instead, it accept the views of biocentrism (the view that all living things are held to be worthy of respect).
vi. It opposes environmental possibilism (a belief that humans can shape the environment), environmental racism (inequitable distribution of environmental hazard) and supports environmental determinism (the belief that the environment determines what man can do) and environmental justice (which combine civil right with environmental protection to demand a safe, healthy and life giving environment for every one) (Guha, 2000).

Approaches of Environmental Management

There are several approaches of environmental management; however, the best approach to environmental management is an integrated approach in which all the components of the environment are taken into consideration and its proper management, as a whole is achieved. For an introductory study the following can be presented.

Ad hoc Approach:

This approach is developed in reaction to a specific situation. It does not have an already packaged approach but develops to suit a specific situation when the need arises .For example , Environmental Management Accounting(EMA); it highlights the past /future and short/longterm time dimension of the different tools and the regularity of information generation, before concluding with a brief discussion about the choice of the most important EMA tools.

Problem –Solving Approach

This approach is for the identification of problems and needs and also to implement solutions. It is used where a perceived problem is solved through controlling devices such as laws, threats, contracts and and/agreements.It is used across many disciplines and works best with problems that are restively simple. For example, the use of herbicides and pesticides to safeguard crops in order to harvest more product, the culling of predators in order to obtain larger more reliable game species and safe guarding of timber supply by suppressing forest fires.

Specialist Discipline Approach

This approach is often adopted by professionals for air, water and land management, urban management, tourism management and environmental health.

System Approach

This approach include ecosystem, agro-ecosystem. The eco-system concept has become a widely used conceptual tool for research after 1945 (Smith,1972).These days, ecologists often adopt an ecosystem approach when seeking to understand and monitor a given situation. The ecosystem concept allows the environmental managers to look at portions of complex nature as an integrated system. It may be applied to cities or agriculture (urban ecosystems and agro –ecosystems respectively).

Human Ecology Approach

Human ecology is the study of relations between humans or society and nature, through a multidisciplinary approach (Valerie and Dyball, 2005).Similar to that of ecosystem approach, the main emphasis in this approach is on social relationship with environment which is a primary aspect of any management for planning and development. The scale of approach may be local to global, and it supports holistic study. The approach can be used as a solution for better management of deteriorating ecological and hydrological areas.

Political Ecology Approach

Political ecology also studies relationships between society and nature. It holds that radical changes in human habits required in order to counter environmental degradation and achieves sustainable development. There are likely to be different perceptions of environmental needs and problems between planners, policy makers, ministries, various departments of government, etc. All this can be effectively done by adopting political ecological approach of environment management. It focuses on the decision making environment of land users and managers and on the great variety of management and degradation problems through time and space. A methodology is introduced for analyzing the problems of land management and degradation in detailed local studies. It takes into account the views of both social and natural science.

Commercial Approach

In recent times, there has been an increasing emphasis on environmental management for business and the role of business houses in environmental protection. The emphasis is on:

i. Green corporate environmental management
ii. Green business ethics
iii. Eco- Auditing
iv. Impact assessment, hazard and risk assessment.
v. Green marketing, labeling
vi. Recycling and waste disposal
vii. Environmentally sound investment and funding
viii. Total quality management.

The commercial approach involves corporate priority, employee education, customer advice, transfer of technology, prior assessment, facilities and operations, research and compliance and reporting.

Environmental Management System

Aside the above approaches; an environmental management system (EMS) approach has been developed as an integrated and proactive approach to environmental issues. It helps industry or other bodies, and is designed to ensure that an environmental policy and environmental objectives are adopted and followed (Hunt and Johnson, 1995) The EMS system approach, also helps to develop a proactive environmental approach, ensure a balanced view across all functions, enable effective, directed environmental goal setting, and make the environmental auditing process effective.

Other Worldwide Environmental Management Approaches include:

i. Eco-mapping – It is a worldwide environmental management approach which allows an organization to easily visualize the origins of environmental impacts at its premises. It can provide a base upon which to seek other environmental standards such as ISO 14000 and EMAS - the Eco Management and Audit Scheme regulation or other environmental management system. It is a toolbox for different eco–maps, checklists, working methods and forms especially for small companies (Buckley, 1999). The limitations if this approach is that it focuses on site premises and so may be difficult for multiple sites or in more diverse set of places. It deals with environment impact assessment only with experts that concerned directly with the environment.

ii. Eco-profit - The main idea is using systematic environmental protection to create a ''win-win'' model especially for SMEs. It is implemented as regional or local initiatives/project with group of companies. License is necessary to implement eco-profit projects.
iii. Profitable Environmental Management (PRUMA): It focus on organizational development and environmental accounting. It was developed for German international technical co- operation.

Elements of Environmental Management

Environmental management as a discipline and a carrier profession has several components as a whole entity (elements), but for academic pedagogy, they can be categorized into two groups, these are: i. Conceptual Elements and ii. Operational Elements. Namely, the conceptual elements include: environmental issues; causes, consequences, and remediation measures, while the operational elements are manipulation, accounting, monitoring, auditing, and legislation.

Definition of Environmental Issues

By definition Environmental Issues are problems or issues related to human impact on the living environment, habitats, land use and natural resources (Felicity, 2012). UNEP (2018), defined Environmental issues as harmful effects to Earth and its natural systems due to the actions of humans. On a more elaborate term, however, Environmental Issues are problems or challenges that result from human activities on, or interaction with the biophysical environment that if unchecked or not adequately managed could result to severe environmental degradation, economic crises and social illness.

Types of Environmental Issues

Basically, Environmental Issues can be classified into three. These are: i. Air Quality Issues, which include: air pollution, ozone depletion, global warming, drought, and climate change; ii. Ecosystem Issues: these include - depletion of genetic resources, biodiversity loss, species extinction, high prevalence of pest and diseases, salinity, soil erosion, desertification, bioaccumulation and poisoning; and iii. Built Environment Issues which consist; land and water pollution, flooding, noise pollution, scenic and aesthetic nuisance, urban heat-island, urban sprawl and decay, conflict, destitution and social problems, among others.

The most disastrous side of these issues or problems, is that, their repercussions are not area specific or limited to a particular place, they can cut across boundaries, have long term effects, and difficult to overcome. Although, their causative, associated, or attributable factors could be different and varied, but their consequences are almost the same, wherever they occur, ecological disaster and human sufferings are the actual outcomes. Ecosystem restorations and improving the wellbeing of humanity are the top contemporary priorities of human endeavor on the planate earth (UNEP, 2020). Thus, by analogy, the impending increase (growth) of global environmental issues if not mitigated would go along in negating the United Nations Agenda of Sustainable Development Goals. However, on the other hand, appropriate and adequate responses (best environmental practices) are catalyst to achieving global ecosystem restoration and improvement of human wellbeing.

Consequences of Environmental Issues

Based on their causative agents, the consequences of environmental issues can be presented in three from, those associated with air quality, ecosystem services and built environment.

Air Quality

Air pollution and urban heat island (UHI) are the immediate repercussion of environmental issues associated with ambient air quality to man and his immediate surroundings. The daily nature of socioeconomic activities going on in urban centre, in particular, in terms of urban commuting (vehicular movement), domestic energy consumption, industrial production, and waste disposal practice, is responsible for the vehement poor air condition in developing countries in general. These activities to say the least, daily produced huge amount of greenhouse gasses such as carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S), methane (CH_4) and ammonia (NH_3), among others, with the consequences of adverse effect on human health and ecosystem.

Ecosystem Services

Increasing high population pressure, massive urbanization and pollution have been mutilating the efficiency and quality of ecosystem services in most developing countries thereby concomitantly result in evolving ecological issues such as biodiversity loss, depletion of genetic resources, species extinction, high prevalence of pest and diseases, soil erosion, and bioaccumulation and poisoning. These to say the least exact a serious repercussion on human health and ecosystem

Built Environment Issues

Waste disposal, traffic flow and congestion, housing demand and quality, industries, water supply, energy consumption, emergency facilities, health and social illness, among others have concomitantly result in other kind of environmental issues, such as water (surface and ground), soil, air, and noise pollution, urban decay, public health issues, and social illness in urbanized area of the world.

Conventional Response and Adjustment to Environmental Issues

The ongoing threat posed the consequences of environmental issues human civilization and survival on the planate earth called for remediation measures. The following are some of the most common solutions or response to the repercussion of environmental issue:

i. Replacing of disposal items with reusable items.
ii. Conservation of water and electricity.
iii. Supporting of environmental friendly practices.
iv. Recycling waste to conserve natural resources.
v. Sustainable waste management (Reduce, reuse, repair, recover, and recycle).
vi. Environmental Education and public awareness.
vii. Aforestation.
viii. Environmental legislation
ix. Green economy

Environmental Risks

Environmental risks are activities, events or phenomenon that are Likely to negate environmental quality and cause injury, disease, or death resulting from their exposure. Examples of environmental risk factors include chemical pollution, air pollution, climate change, disease-causing microbes, lack of access to health care, poor infrastructure, and poor water quality. The followings are the ways of identifying or assessing environmental risks:

i. Identifying any hazards, ie possible sources of harm.
ii. Describing the harm they might cause.
iii. Evaluating the risk of occurrence and identify precautions.
iv. Recording the results of the assessment and implement precautions.
v. Reviewing the assessment at regular intervals

The followings are the conventional ways of managing environmental risk

i. Better identifying, assessing and controlling of risks that could impact air, land, water and groundwater, as well as harm caused by noise.
ii. Prevention of harm to human health and the environment.
iii. Complying with your environmental duties and obligations.
iv. Meeting community expectations.

Environmental Risk Assessment

Environmental risk assessment (ERA) is the process of identifying potential environmental hazards caused by a business and determines its likelihood or probability to negatively affect various aspects of the environment such as living organisms, natural habitats, and ecosystems. The followings are some of the steps of carrying out an environmental risk assessment:

i. problem identification;
ii. hazard characterization;
iii. exposure characterization;
iv. risk characterization;
v. documenting the assessment and implementing precautions; and
vi. monitoring at regular intervals

Operational Elements of Environmental Management

As mentioned earlier, the operational elements of environmental management involve five basic activities which are explained below.

Environmental Manipulation

Environmental manipulation is the scientific way of managing environmental variables in order to improve or protect their natural well-being or quality. Unlike environmental modification, the measures put in place in environmental manipulation results in or have a temporary effect and need to be repeated. While on the other hand If such measures result in long-lasting or permanent changes in land, water or vegetation, they are often referred to as environmental modification. Environmental manipulation is usually achieved through four basic methods as follows:

i. Natural surveillance,
ii. Access control,
iii. Territorial reinforcement, and
iv. Target hardening.

Environmental Accounting

Environmental accounting is an environmental management tool that involves quantifying environmental impact on monetary form. It is a vital tool that assists in the management of environmental and operational costs of natural resources. Its main goal is to help companies understand how their actions affect the environment and find ways to be more sustainable. Environmental Conservation Cost (monetary value), Environmental Conservation Benefits (physical units), and the Economic Benefit associated with environmental conservation activities (monetary value) are the key facets of Environmental accounting. , is composed of three key facets:

Environmental Monitoring
Environmental monitoring is the continuous, automated observation of changes in the environment. Wiersma, (2004) defined Environmental monitoring as a systematic sampling of air, water, soil, and biota in order to observe and study the environment, as well as to derive knowledge from this process In other words Environmental monitoring is the systematic approach to observing and studying conditions of the environment. Monitoring typically involves collecting samples and specimens from the air, water, and land to determine if any physical or biological factors are negatively impacting natural ecosystems and habitats (USEPA, 2010).

Environmental Auditing
Environmental Audit is an environmental management tool that comprises a systematic, documented, periodic and objective evaluation of how well environmental organization, management and equipment are performing on environmental terms. Its main aim is to help in safeguarding the environment through facilitating management and control of environmental practices and assessing compliance with company policies, which includes meeting regulatory requirements. Basically there are three main types of environmental audit; these are as follows:

i. Environmental System Audit
ii. Regulatory Compliance Audit
iii. Other Specific Audits, such as health and safety audit, energy audit, due diligence audit, waste protocol audit etc.

Conceptually, there are three major steps in environmental audit activities. These are as follows:

i. Pre-audit activities
ii. Activities at site (Actual Auditing)
iii. Post-audit activities.

Environmental Legislation
Environmental legislation is a collection of laws and regulations pertaining to air quality, water quality, the wilderness, endangered wildlife and other environmental factors. The main objectives of Environmental legislation, among others, are to prohibit, restrict, regulate environmentally harmful practices, to work as incentives for activities that benefit the environment, and to discourage negative externalities by encouraging positive externalities.
Environmental Legislation takes several forms, among which are:

i. Regulation of emissions that may cause environmental pollution,
ii. Taxation of environment and health damaging activities, and
iii. Establishing the legal framework for trading schemes (e.g. for carbon emissions).
iv. Voluntary agreements,
v. Environmental permitting,
vi. Mandating environment and health impact assessments.

Summary

The chapter dwells on the evolution of environmental management as a discipline; its meaning; basic approaches and components. Global environmental issues such as ecological degradation, pollution,

and public health and socioeconomic challenges are explained along with their respective management strategies. How environmental risks are perceived and communicated, and how individuals can be educated about them, are also explained.

Exercise

i. Define Environmental Management and trace its historical development
ii. List and explain the basic approaches of environmental management
iii. Distinguish between Conceptual and Operational Elements of Environmental Management
iv. List and explain the operational elements of Environmental management
v. Define Environmental Issues and explain the three main types of environmental issues
vi. Explain the causes and consequences of environmental issues
vii. State and explain major forms of environmental legislations
viii. List and explain the conventional response to environmental issues
ix. Describe how environmental risks are perceived and communicated.

References

Adam Smith (1776) The Wealth of Nations. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. All rights reserved.

Beder, S. (2006) Environmental Principles and Policies: An Interdisciplinary Approach. University of New South Wales Press Ltd Sydney NSW 2052 Australia www.unswpress.com.au

Charles W. and Withers, J. (2013) Geography and the Classical World: Unearthing Historical Geography's Forgotten Past, The AAG Review of Books, 1:3, 116-117, DOI: Taylor & Francis, LLC Association of American Geographers 10.1080/2325548X.2013.850348

Chong, H. G., (2008), "The Environmental Management System as a Competitive Advantage Tool for Organizations", The Journal of Accounting and Finance, The Research Development Association, Jaipur, October-March, Vol.22, No. 1, pp. 71-78.

Christiansen H. (2004) An Overview of Corporate Environmental Management Practices: Directorate for Financial, Fiscal and Enterprise Affairs; Joint Study by the OECD Secretariat and EIRIS International Investment and Services Division, OECD, and Esther Garcia, EIRIS Research Department.

Colby, M. E. (1991) Environmental Management in Development: the Evolution of Paradigms - Ecological Economics, - Elsevier Ecological Economics, 3 (1991) 193-213 Elsevier Science Publishers B.V., Amsterdam

Eresi, D. K., (1996), "Environment- Information Disclosure in Annual Reports", The Chartered Accountants, ICAI, New Delhi, Vol. XI, No. 7, pp. 45-48

Guha, R. (2000) *Environmentalism: A Global History*, the European Society for Environmental History: ESEH.org, Environmental History, Oxford Journals

Heer, J. E. and Hagerty, D. J. (1977). Environmental Assessments and Statements. Van Nostrand Reinhold, USA.

Hussein, A. M. (2005) Principles of Environmental Economics: Economics, Ecology and Public Policy. 2nd Edition 11 New Fetter Lane, London EC4P 4EE www.eBookstore.tandf.co.uk."

Jain, T.K., (2000), "Social and Environmental Accounting and Auditing", Rao & Rao, P. Sasi Bhushana & P. Mohana, edt. Environment Management and Audit, Deep and Deep Publications Pvt. Ltd., New Delhi, p. 226.

Kaushik, A. and kaushik, C. P. (2004) Perspectives in Environmental Studies: 2nd Edition. ISBN (13) : 978-81-224-2345-7 NEW Age International (P) Limited, Publishers 4835/24, Ansari Road, Daryaganj, New Delhi - 110002 www.newagepublishers.com

Kolk, A. and Mauser, A. (2001). The Evolution of Environmental Management: from Stage Models to Performance Evaluation, John Wiley & Sons, Ltd. and ERP Environment.

Kumar, A., (2016). An Introduction to Environmental Management: Concept, Scope and Aspects of Environmental Management. New Age International (P) Limited, 4835/24, Ansari Road, Daryaganj, New Delhi - 110002 www.newagepublishers.com

Laurila-Panta, M, Lehikoinenb, A., Laura Uusitaloc, L. and Venesjärvib, R. (2015) How to Value Biodiversity in Environmental Management? Elsevier Journal of Ecological Indicators 55 1-11 2015 Journal of Global Resources Volume 2 Page 62-67 ISSN: 2395-3160 (Print), 2455-2445 (Online)

Lochner, P., Weaver, A., Naidu, S. and Will, C. (2004). Overview of Integrated Environmental Management. Integrated Environmental Management Information Series – O, Department of Environmental Affairs and Tourism (CSIR)

Louis, K. (2016). Environmental Management: An Introduction. ResearchGate. Northwest University, South Africa

Malthus T. R., (1798) Essay on the Principle of Population. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. All rights reserved

Mattheus F. A. Goosen (2012) Environmental Management and Sustainable Development. Alfaisal University, Riyadh, 11533, Kingdom of Saudi Arabia, Elsevier Ltd. ISWEE'11

Michael, G. (2014). The Environmental Management Theories Evolution and their Role in the System of Renewable Natural Resources Usage, Economic Annals-XXI . 2014, Issue 9/10, p57-60. 4p.

National Environment Commission (NEC) (2011). Environmental Management Tools and Techniques: A Learning Material – National Capacity Self Assessment Project, National Environment Commission Secretariat (United Nation Development Programme) Royal Government of Bhutan, Thimphu, www.nec.gov.bt Phama Printers

Nel, J. G. and Kotze, L. J. (2016), Environmental Management: An Introduction. ResearchGate

Neuman, W.L. (2014). *Social Research Methods: Qualitative and Quantitative Approaches*. 7th Edition, New International Edition. Pearson Educational Limited.

Ormazabal, M., Rich, E, Sarriegi, J. M., and Viles, E (2014) Environmental Management Evolution Framework: Maturity Stages and Causal Loops. Springer

Paul J. Gertler, Sebastian Martinez, Patrick Premand, Laura B. Rawlings, and Christel M. J. Vermeersch (2016). Impact Evaluation in Practice Second Edition, International Bank for Reconstruction and Development / The World Bank 1818 H Street NW, Washington, DC 20433 Telephone: 202-473-1000; Internet: www.worldbank.org

Peter M. Groffman, Jill S. Baron, Tamara Blett, Arthur J. Gold, Iris Goodman, Lance H. Gunderson, Barbara M. Levinson, Margaret A. Palmer, Hans W. Paerl, Garry D. Peterson, N. LeRoy Poff, David W. Rejeski, James F. Reynolds, Monica G. Turner, Kathleen C. Weathers and John Wiens (2006) Ecological Thresholds: The Key to Successful Environmental Management or an Important Concept with No Practical Application? Ecosystems, Vol. 9, No. 1 (Feb., 2006), pp. 1-13 Published by: Springer Stable URL: http://www.jstor.org/stable/25470313

Raven, P. H., Berg, L. R. and Hassenzahl, D. M. (2010) Environment. 7th Edition, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030-5774, ISBN-13 978-0470-11857-3 ISBN-13 978-0470-55658-0 United States of America

Speight, J. G. and Singh, K. (2014). Environmental Management

Tibor, T. and Feldman, I., (1996). ISO 14000. A Guide to the New Environmental Management Standards. Irwin, Chicago.
Theodore, M. K. and Theodore, L., (2010) Introduction to Environmental Management. CRC Press, Taylor and Francis Group, London and New York.

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CHAPTER 4

Natural Ecosystems

By

SABO Ahmed

Overview

Ecosystem as a concept, is often referred to as the basic unit of ecology. The concept of an ecosystem is essential as it assists in understanding the intricate relationships between the living and non-living components of the environment and how the impacts of human activities affect the environment and significantly influence the lives of other organisms. The ecosystem as a concept is widely applied in different spheres of life including resources conservation, urban planning, pollution control, feasibility study for construction of roads, dams etc. This chapters discusses the types, structure and functions of natural ecosystems. It also explains the materials and energy flow and its importance for sustenance of life within an ecosystem.

Objectives

By the end of this chapter, the students should be able to:

- explain the concept of ecosystem and differentiate between natural and artificial ecosystems
- explain the six attributes of the ecosystem
- explain based on feeding habits of the biotic components of an ecosystem
- explain how different abiotic factors affect the survival of organisms within an ecosystem
- explain importance of energy flow in ecosystem
- illustrate the ecological pyramids
- explain the different types of aquatic and terrestrial ecosystem
- define a biogeochemical cycle and explain the carbon, nitrogen and phosphorous cycles

What is an ecosystem?

An ecosystem is defined as the collection of living organisms within a geographic area that interact with each other and their physical environment to form a stable and self-sustaining system. An ecosystem could be natural or artificial.

Natural Ecosystems

These are ecosystems that naturally thrive on their own without human intervention. They are fully self-sustaining and subject to constant change based on the dynamics of the species that live within the systems. Examples of natural ecosystems are natural forests, rivers, etc

Artificial Ecosystems

These are ecosystems have been created by man to imitate the natural habitats. They are created to meet some specific needs of humankind. Such ecosystems are not self-supporting and require continuous monitoring and maintenance. Some examples of man-made ecosystems include botanical gardens, zoos, crop fields, aquariums, etc.

Table 1: Differences between Natural and Artificial ecosystems

S/N	Natural ecosystem	Artificial ecosystem
1	Exist naturally	Created by man
2	Self-sustaining	Requires human assistance

3	Wide range of genetic variation	Low genetic variation
4	Contains many species	Contains few species
5	Long and complex food chain	Simple and disorganized food chain
6	Ecological succession is possible	Ecological succession impossible

Attributes of Ecosystems
The ecosystem as a concept has six major attributes
Structure Attribute
Ecosystems consist of biotic and abiotic components. At a minimum, a terrestrial ecosystem must have green plants, a substrate, and an atmosphere. An ecosystem can only function when it has appropriate mixture of plants, animals and microbes. A typical ecosystem consists of a complex community of soil and atmosphere, an energy source, and a water supply.
Attribute of Function
The functional attributes show the continuous exchange of matter and energy between the different components of the ecosystem. An ecosystem can be categorized into its abiotic component, including minerals, water, sun, climate, and its biotic components, made up of all of its living members. These components are linked together by two main forces: the flow of energy through the ecosystem and the cycling of nutrients within the ecosystem.
Attribute of Complexity
The complexity attribute of an ecosystem refers to the complex interplay between all living systems and their environment, and the properties arising from such intricate interplay. The attribute of complexity emphasizes the richness of ecosystem and its ability to adapt to changes and sustain itself.
Attributes of Interdependence and complexity
This attribute explains the interconnectedness of the various components of ecosystems. In a functioning ecosystem, all organisms depend on one another. Very small changes in ecosystems often have large consequences that can be difficult to predict. This means that all organisms in an ecosystem are interdependent.
Temporal Changes
In addition to the continuous flow of energy and nutrient cycling within the ecosystem, the structure and function of an ecosystem are dynamic and change over time.

Ecosystem structure and function
An ecosystem is made up of both biotic and abiotic components. The structure of an ecosystem is characterized by the organization of these intricately related biotic and abiotic components. The function of any ecosystem involves variety of cycles and processes. The cycles results in the flow of energy and nutrients in order for life to continue within the ecosystem.
Structure of the Ecosystem
The structure of an ecosystem is characterized by the organization of both biotic and abiotic components and the distribution of nutrients and energy within a particular habitat. This also includes the climatic conditions that prevail in that particular environment.

Ecosystem Component
Based on its structure, an ecosystem has two main components, namely:
- Biotic components
- Abiotic components

Both the biotic and abiotic components are interconnected in an ecosystem. It is an open system in which energy and other material components can flow throughout the boundaries.

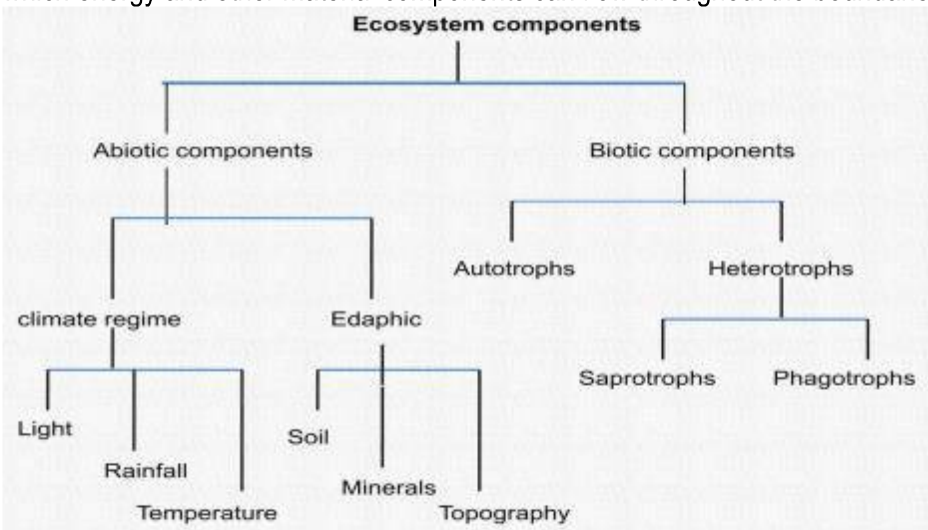

Figure 1. Showing the components of an ecosystem

Biotic Component

The biotic component comprises of all the living things within the ecosystem. Based on their functions within the ecosystem, the biotic community can be divided into two major classes viz: Autotrophs and Heterotrophs.

Autotrophs

Autotrophs are organisms capable of synthesizing their own food from simple inorganic substances (H_2O and CO_2) and the radiant energy absorbed by chlorophyll or other pigments. In terrestrial ecosystems, the autotrophs are mostly grasses, shrubs and tree rooted in the soil. In aquatic ecosystems (rivers, streams, lakes etc.), however, algae and phytoplankton are the major autotrophs. The process through which the autotrophs produce their own food from simple inorganic chemicals with the aid of radiant energy is called photosynthesis and the process is mainly represented by the following equation

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

In the above equation, six molecules of carbon dioxide ($6CO_2$) react with six molecules of water ($6H_2O$) to produce a sugar molecule ($C_6H_{12}O_6$) and six molecules of oxygen ($6O_2$). The sugar is a form of chemical stored and used by the organism while the oxygen is given up as a bi-product.

In some special circumstances where the organisms lack chlorophyll and therefore cannot absorb the radiant energy to activate the process, a different source of energy in the form of chemical elements are used. This process is called chemosynthesis.

During chemosynthesis, the bacteria and other organisms use energy derived from inorganic chemical reactions to produce their food. A typical example of chemosynthetic process is that found in vent bacteria at the hydrothermal vents which oxidize hydrogen sulphide to generate the energy needed for the conversion of the carbon dioxide to sugar, sulphur and water as shown in the following equation

$$CO_2 + 4H_2S + O_2 \text{->} CH_20 + 4S + 3H_2O$$

Heterotrophs

These are organisms that cannot produce their own food through carbon fixation, but depend on other sources of carbon mainly plants for their nutrition. Heterotrophs are consumers in the food chain. There are two major types of heterotrophs.

Phagotrophs (Macroconsumers)
The Phagotrophs also known as macro-consumers are organisms that cannot manufacturer their own food through carbon fixation and therefore derive their food from other sources of organic carbon. They are mostly animals that ingest plant-based organic materials or other animals as their food source. Autotrophs therefore feeds on organic compounds produced by other living organisms through the process of ingestion. There are three different categories of photographs:

- Herbivores: Organisms mainly animals that feeds on plants as their source of food. They are also referred to as primary consumers. Rabbit, goat, deer and elephants are examples of herbivores.
- Carnivores: Organisms that feeds on other animals. Examples of carnivores include lion, tiger and hyena. Carnivores are secondary consumers.
- Omnivores: Animals that feeds on either plants or animals as their food. Cockroach, chimpanzees and man are examples of omnivores.

Saprotrophs
These are organisms that feeds on dead and decaying organic materials as source of food. Examples of saprotrops are fungi and certain group of bacteria. Saprotrophs release certain enzymes that act on complex organic matter and break it down into its constituents which can easily be utilized. Thus, they play an important role in the ecosystem through the decomposition of the organic materials and recycling of nutrients back into the ecosystem.

Parasites
Parasites are organisms that live in or on other organisms and feed at the expense of their host. Most parasites are harmful to the host's health; sometimes they even kill the host. Both animals and plants can serve as hosts of parasites.

Abiotic Component
Plants and animals cannot grow and carry out their activities within an ecosystem without the support of several non-living (chemical and physical) factors. The abiotic component includes all the non-living factors that affects the living organisms within the ecosystem. The abiotic components vary from one and ecosystem to another. In a terrestrial ecosystem for example, the abiotic factors include soil, temperature, wind, nutrients sunlight etc. Similarly, abiotic factors in aquatic ecosystem may include pH, salinity, temperature, dissolved oxygen, turbidity etc. The abiotic component can be categorized based on three major factors, edaphic, climatic and physiographic factors.

Edaphic Factors
Soil structure and composition that affect the diversity of organisms that live there are known as edaphic factors. Because soil is vital to many plants, it is a very important environmental element.

- All the essential mineral nutrients for the growth and development of plants and animals are present in the soil.
- The soil also provides water for plants.
- A variety of living things, including earthworms, insects, fungi, and bacteria can be found in good soil.
- Additionally, it contains humus, which is made up of animal and plant remains that have died and decomposed. Humus makes the soil productive.

Soil texture

- Sandy soils are well aerated, drains excess water quickly and is easy to cultivate. However, they do not retain much water and dry out quickly, and contain few soil nutrients necessary for plant growth

- Clay soils are suitable for plant growth because they retain large amounts of water and are rich in mineral nutrients. They are poorly aerated, get wet quickly and are difficult to cultivate.
- Loam soils possess the desirable qualities of sand and clay - they have high water retention, good aeration, good nutrient content, and are easy to cultivate. It is the most suitable soil for the production of many crops

Soil pH

- Soil acidity or alkalinity (soil pH) affects soil biological activity and the availability of certain minerals.
- Thus, the pH of the soil has a greater impact on the growth and development of plants.
- Some plants thrive best in acidic soil while others thrive better in alkaline soil.

Soil Salinity

- Soil salinity is the presence of water-soluble salts, including Sodium, Chloride, Potassium and Sulphate in the soil.

Soil Air

- Soil air is in the spaces between the soil particles that are not filled with soil water.
- The amount of air in a soil depends on how tightly the soil is compacted.
- In a well-aerated soil, at least 20% of its volume is air.

Soil temperature

- below a depth of about 30 cm, the temperature of the ground is almost constant during the day, but seasonal temperature variations do occur.
- At lower temperature, there is little decomposition of organic matter by soil microorganisms

Climatic factors

Water

- Water in the form of pons, rivers, lakes seas and oceans cover about 70% of the earth's surface.
- It is an important component of the living system as 70% of our body is made up of water.
- Water is the most abundant natural resource on the surface of the Earth. It is the most essential requirement of all living organisms.
- The existence of water within the ecosystem is necessary for numerous life processes such as seed germination, adsorption of nutrients, digestion and absorption of food, removal of metabolic waste products and the circulation of various substances within the body system
- The distribution of plants and animals depends on the amount of water in the ecosystem.

Air

- Atmospheric carbon dioxide is absorbed by plants to manufacture their food through the process of photosynthesis.
- Oxygen an important component of the air needed for respiration is also produced as a bio-product of photosynthesis
- Nitrogen makes up 78 percent of the earth's atmosphere and is part of all living tissues. It is a vital element for all living organisms being a component of DNA and therefore part of the genetic code.

Light

- The sun is the ultimate source of light and heat energy on planet earth.
- Green plants can absorb solar energy and use it to produce food. The energy stored in the food produced by plants, is transferred to all other living things via the natural food chain.
- It affects the closing and opening of stomata, germination of seeds, flowering sleeping and feeding

- The behaviour of some animals is also influenced by light. Most creatures known as diurnal animals can tolerate intense light and are active during the day. Some are referred to as nocturnal animals, because they are more active in the night. Earthworms and cockroaches are examples of nocturnal animals

Temperature

The Earth's surface temperatures vary. Each organism can only survive a certain range of temperature.

- The majority of organisms survive in temperatures ranging from 20 to 45 degrees Celsius.
- Different species have different adaptations against temperature fluctuations in their environment.
- Many cacti have fleshy stems and leaves modified into the spine to reduce water lost due to excess heat
- Some animals for example lizards hibernate when cannot tolerate the cold weather.

Physiographic Factors

These factors relate to the landforms of the area such as altitude, land slope, and the position of the area in relation to the sun and/or rain-bearing winds. Zones of vegetation are influenced by altitude and slopes.

Materials and Energy Flow in an Ecosystem

Ecosystems are maintained through the cycling of energy and nutrients supplied from external sources. The chemical energy of food is the main source of energy required by all living organisms. This energy is transmitted to various trophic levels across the food chain. The energy flow within the ecosystem is governed by the two laws of thermodynamics. The first law of thermodynamics holds that energy can neither be created nor destroyed; it can only be transformed from one form to another. The second law of thermodynamics states that as the energy is transferred from one trophic level to another, more and more of it is lost.

Cycling of Nutrients and Energy flow

For an ecosystem to function, there must be flow of energy from one trophic level to another. At the first trophic level, the green plants and other autotrophs capture radiant energy to synthesise organic material through the process of photosynthesis. Herbivores or primary consumers that feeds on the plants only, make up the second tropic level. Predators that feed on herbivores constitute the third trophic level. Organisms that feed at multiple trophic levels are classified at higher trophic levels. Bacteria, fungi and other decomposers break down the dead organic matter to restore nutrient to the soil. Only 10% of the energy is transferred from one trophic level to another, while 90% is lost mainly as heat.

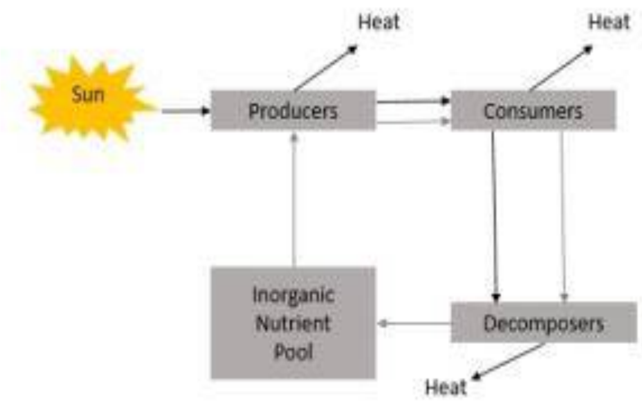

Figure 2 Flow of energy and materials within the ecosystem

The transfer of materials and energy within the ecosystem is achieved through food chain, food web and ecological pyramids.

Food Chain

The term food chain refers to the process by which food energy is transferred from a source in plants to a sequence of other organisms that go through repeated eating and being eaten stages. A simple food chain might look as follows;

Producers → Herbivores → Carnivores

The various steps in the food chain are called tropic levels.

Thus, in a typical grassland ecosystem, a simple food chain might look like;

Grass → mouse → snake → Hawk

In a forest ecosystem however, a food chain may be represented as

Grass → deer → lion

The type of food chain in which the organism feeds exclusively on dead bodies of animals and plants is called a detritus food chain. The organisms with this pattern of feeding are the detrivores. Bacteria, fungi and some protozoans are examples of detrivores. These organisms ingest and digest the dead organic materials and convert it into CO_2 and water.

Food web

Although a simple linear food chain is common in many ecosystems, the feeding relationships are often more complex, such that most herbivores consume various plants and the majority of carnivores feed on a wide range of herbivores and other carnivores. As a result, several food chains are interconnected to form a food web.

i. Grass → Grasshopper → Lizard → Hawk
ii. Grass → Grasshopper → Hawk
iii. Grass → Rabbit → Hawk
iv. Grass → Mouse → Hawk
v. Grass → Mouse → Snake → Hawk

In grassland ecosystems, grasses are eaten by grasshopper, rabbit and mouse. The grasshopper is eaten by the garden lizard, which is eaten by the hawk. In addition, hawk also directly eats a grasshopper and mouse. Thus, five lines are interconnected to form a food web. Food webs are crucial in maintaining the stability of an ecosystem.

Ecological Pyramids

The ecological pyramids illustrate the relationships between different trophic levels in an ecosystem and help us understand the flow of energy and nutrients through the food chain. In a natural ecosystem, the number, biomass and energy of organisms gradually decline from producers to consumer tropic levels. There are three types of ecological pyramids viz:

Pyramid of number

The pyramid of numbers illustrates the relationship between the number of producer organisms at the lower tropic level and the successive consumer levels. Pyramid of numbers are most common in grassland where the grasses form the pyramid's base due to their large number. The pyramid of number. In grassland ecosystem grasses are more in number. The grasshoppers that feed on grasses are less in number, the lizard feeding on the grasshoppers are still lesser in number. Hawk feeding on the lizard are still fewer in number

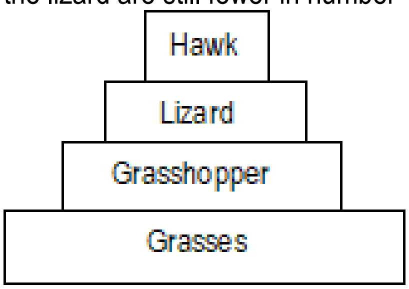

Figure 3: Pyramid of number in a grassland ecosystem

Pyramid of biomass

The pyramid of biomass is one of the ecological pyramids representing the biomass of the different trophic levels within the ecosystem. Similar to the pyramid of numbers, the producers at the lowest trophic level occupy the greater portion of the biomass. On average, only 10–20% of the total biomass moves from the lower trophic level to the immediate trophic level above.

In a typical forest ecosystem for example, trees being at the lower level have the highest biomass, while tiger being at the topmost level has the least biomass

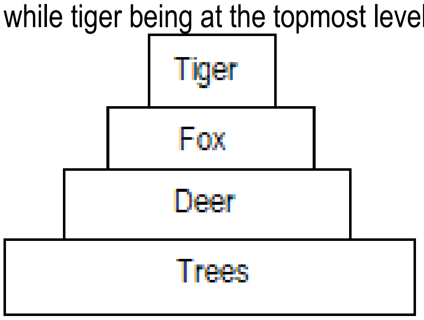

Figure 4: Pyramid of Biomass in a forest ecosystem

Pyramid of energy

In general, the flow of energy decreases from the producer to the consumer in an ecosystem. In a grassland ecosystem, for example, the maximum sun light energy is captured by the grass. Gradually, the energy decreases as it moves towards the top consumer trophic level.

While moving from one trophic level to the next a large portion of the energy is lost. On average 90% of the total energy is lost as heat.

Types of Ecosystems

As earlier mentioned at the beginning of this chapter, ecosystems can generally be divided into two classes, natural and artificial. Artificial ecosystems are man-made while the natural ecosystems thrive naturally without human intervention. However, ecosystems are also classified based on their regions on the basis of their structure and functions including climate, food chain, energy flow and the organisms dwelling within the environment. Thus, two major types of ecosystems are identified as follows:

Terrestrial Ecosystem

These are ecosystems found on land only. It has a relatively less amount of water compared to the aquatic ecosystem. However, they have better availability of sunlight (the major source of energy) for photosynthesis. The terrestrial ecosystem is further sub-divided as follows:

- **Forest Ecosystem:** This is a type of terrestrial ecosystem densely packed with many species of plants and animals with a high number of organisms per unit area. A lot of attention is focused on the ecosystem because of the rare species of plants and animals found here. Forest ecosystem sequester a lot of CO_2 a greenhouse gas implicated in greenhouse effects and climate change. The forest also supplies most of the oxygen we breathe.
- **Grassland Ecosystem:** A grassland ecosystem is an area dominated by grasses. About 20% of the total earth surface is covered by one form of grassland or another. It is an ecosystem where the rainfall is not enough to support the growth of many trees. The temperatures in the grassland ecosystems are moderate and have well defined hot and dry, warm and rainy season. The productivity of the grasses in the ecosystem is enough to support many animal species including herbivores and insectivores.
- **Desert Ecosystem:** The desert is an ecosystem with harsh temperature, scarce vegetation and receive a rainfall of less than 10 inches per annum. Due to the harsh climatic conditions, the diversity of plants and animals in the desert is less compared with those in other ecosystems. The nature of the environment makes it difficult for most plants and animals to survive and the few that lives in the area have evolved various adaptation strategies.

  The plants found in desert called xerophytes have evolved to adapt to the dry conditions. Most of them have succulents, thick and fleshy tissue to store more water and waxy leaves to reduce lost through transpiration. Most plants have thorns and spines as a defence mechanism against grazing animals. Animals found in the desert are called xerocoles. Xerocoles adapt to water scarcity by remaining dormant during the hot season and living beneath the ground where the temperature is low compared to the surface temperature. Most animals such as rats, rabbits and foxes are nocturnal, while others are found only close to the existing water sources such as oases and aquifers

Aquatic Ecosystem

The aquatic system is a water-based environment such as lakes, oceans, rivers and lakes. The creatures found within the ecosystem include amphibians, fishes etc. Organisms survive by using dissolved oxygen found in the water. Aquatic ecosystem is much large and occupies greater portion of the planet earth. There are two major types of aquatic ecosystems.

- **Marine Ecosystem:** It includes all the oceans and seas and constitutes about 71% of the earth's surface. About 97% of the water on earth falls under this category. Sharks, whales, dolphins, seals, walrus, and many more come in this ecosystem.
- **Freshwater Ecosystem:** It includes all the rivers, lakes, ponds, and water bodies that are not salted. This accounts for 0.8% of earth's water and 0.009% of total water present on earth. There are three types of this ecosystem lotic system where the water is fast-moving, e.g., rivers.

The lentic system where the water remains stagnant, e.g., ponds and lakes. The wetlands where the soil remains saturated for most of the time period.

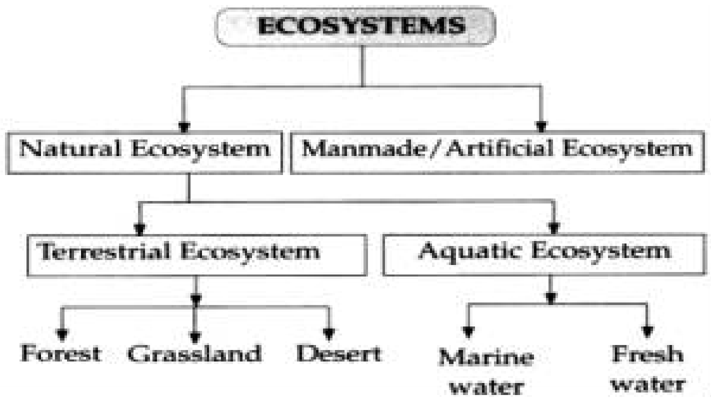

Figure 5: Different types of ecosystem

Biogeochemical Cycles

For any ecosystem to function properly, it requires a continuous supply of certain essential elements that make up the living cells. The movement and transformation of an essential element of living matter through the biotic and abiotic components of the earth is referred to as the biogeochemical cycle. Some of these elements may not necessarily be available within the immediate environment and must be supplied from external sources. Biogeochemical cycles can be classified as gaseous, where the reservoir is the air or oceans (through evaporation), and sedimentary, where the reservoir is the earth's crust. The following section discussed carbon, Nitrogen and Phosphorous cycles

Carbon cycle

Plants capture carbon dioxide from the air and incorporate carbon into their tissues through the process of photosynthesis. Producers and consumers convert some of the carbon in their food back into carbon dioxide through respiration. Decomposers release into the atmosphere the carbon stored in dead plants and animals. Another important exchange of carbon dioxide occurs between the oceans and the atmosphere. The CO_2 dissolved in the oceans is used by marine biota for photosynthesis. Another important process that release CO_2 into the atmosphere is the burning of fossil fuels.

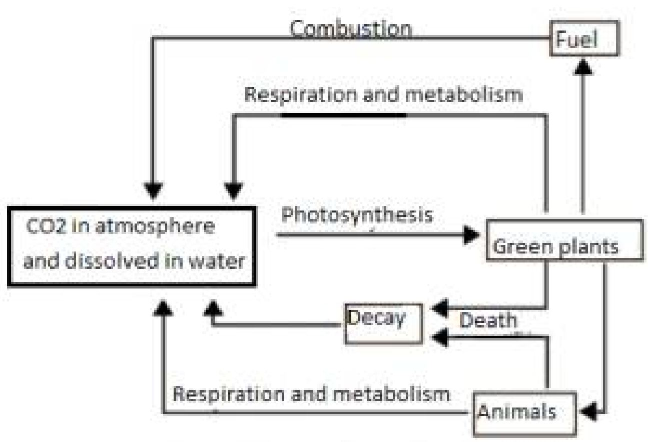

Figure 6: The Carbon cycle
Source: https://biologywise.com/carbon-cycle-diagram

Nitrogen cycle

A complete nitrogen cycle consists of the following stages – Nitrogen Fixation (Biological and Chemical), Nitrification, Assimilation, Ammonification and denitrification. Details of these processes are explained as follows:

Nitrogen Fixation:

It is the initial step of the nitrogen cycle in which atmospheric nitrogen is deposited on to the soil through precipitation. Nitrogen fixation occurs with the aid of nitrogen -fixing bacteria, Azotobacter and Rhizobium. These bacteria secrets nitrogenase enzymes capable of combining Nitrogen and Hydrogen to form ammonia. Nitrogen fixation also occurs either through atmospheric fixation involving lightening or industrial fixation that occurs chemically under special conditions of high temperature and pressure in the manufacture of ammonia and nitrogen-based chemical fertilizer.

Nitrification

During nitrification, ammonia is converted into nitrate by the action of some bacteria. The process occurred in two phases. In the first phase, ammonia is converted into nitrite with the aids of Nitrosomonas. Later, in the second phase, Nitrobacter assisted in the conversion of nitrite to nitrate. The nitrification process is represented in the following chemical reactions

$2NH_3 + 3O_2 \rightarrow 2NO_2^- + 2H^+ + 2H_2O$

$2NO_2^- + O_2 \rightarrow 2NO_3^-$

Assimilation

Nitrogen in the form of ammonia, nitrite and nitrate ions are absorbed by plants from soil. The ions are used in the formation of proteins. Through this process, the Nitrogen enters the food chain when animals eat these plants.

Ammonification

This is the process in which the organically bound nitrogen contained in dead plants and animals are released back into the soil by the activities of decomposers. This decomposition process produces ammonia, which is then used for other biological processes.

Denitrification

In this process, nitrogen compounds are released back into the atmosphere through the conversion of nitrate into gaseous nitrogen. Denitrification is performed by the denitrifying bacterial species Clostridium and Pseudomonas, which process nitrate to gain oxygen and give off free nitrogen gas as a by-product

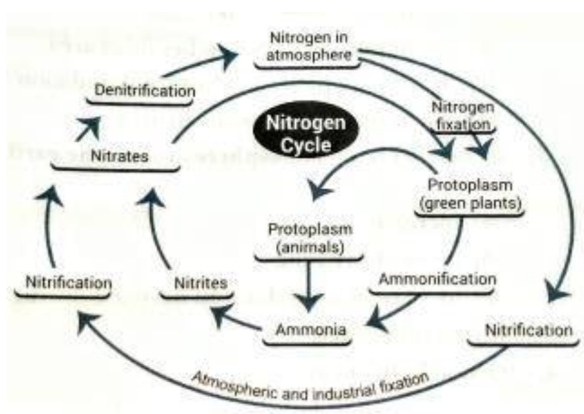

Figure 7: The Nitrogen cycle Source: https://brainly.in/question/12896880

Phosphorus Cycle

Phosphate is one of the major constituents of Ribonucleic Acid (RNA), Deoxyribonucleic acid (DNA), biological membranes and energy transfer systems such as Adenosine Triphosphate (ATP) and Adenosine diphosphate (ADP). Unlike the case of carbon and Nitrogen cycles, the main reservoir of phosphate is not the atmosphere but the sedimentary phosphate rock. Phosphate is transferred to the soil solution through chemical weathering and is absorbed by plants. Herbivorous and other animals obtain the phosphate from the plants through the feeding process. Dead plants and animals are decomposed by phosphate-solubilizing bacteria releasing the phosphate.

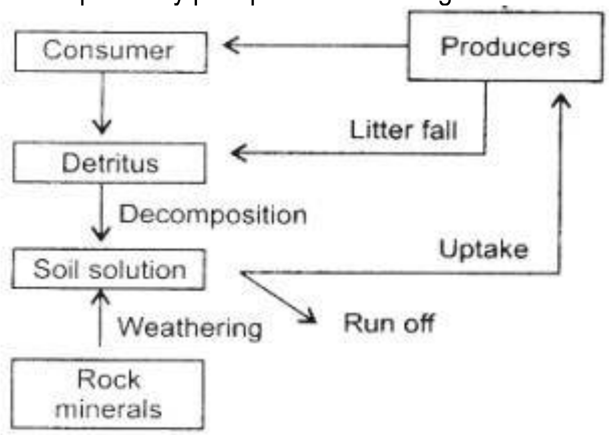

Figure 8: Phosphorous cycle Sources: https://byjus.com/question-answer/how-are-reservoirs-of-phosphorus-recycled

Summary

An ecosystem is a self-sustaining system of living organisms interacting with one another and with the physical environment. Natural ecosystems thrive on their own without human intervention, while artificial ecosystems require continuous monitoring and maintenance. Ecosystems are also classified into aquatic and terrestrial based on their regions, structure and functions.

The structure of an ecosystem includes its biotic and abiotic components, as well as climatic conditions. Biotic components are divided into autotrophs and heterotrophs, with autotrophs using photosynthesis or chemosynthesis to produce their own foods. Heterotrophs are consumers, including herbivores, carnivores and omnivores as well as saprotrophs and parasites. Abiotic components include edaphic, climatic and physiographic factors, such as soil composition, water, air, light, temperature and landforms

Ecosystems rely on cycling of energy and nutrients from external source. Energy is transferred through trophic levels in a food chain but 90% is lost as heat. Food webs are interconnected food chains that maintain ecosystem stability. Ecological pyramids illustrate the relationships between trophic levels and the flow of energy and nutrients.

The biogeochemical cycle is the movement and transformation of essential elements of living matter through the biotic and abiotic components of the ecosystem. Examples of biogeochemical cycles include carbon, nitrogen and phosphorous cycles.

Exercise

1. Define ecosystem and briefly explain the component of an ecosystem
2. In a tabular form, give the differences between natural and artificial ecosystems
3. Briefly explain the six attributes of an ecosystem.
4. With the aids of balanced chemical equations explain the two major types of autotrophic nutrition.
5. Explain the differences between saprotrophic and parasitic nutrition

6. Mention and briefly explain any five (5) abiotic factors of ecosystem
7. What do you understand by the terms food chain and food webs
8. Draw a five organism's terrestrial and aquatic food chain.
9. Explain in details the ecological pyramids
10. Explain the basic classification of terrestrial ecosystem
11. In a tabular form give the differences between a marine and freshwater ecosystems
12. Define a biogeochemical cycle and with the aids of diagrams explain the carbon, nitrogen and phosphorous cycles

References

Akintunde, O. A., adedire, M. O., Alegbeleye, W.O. and Akintunde, O.A. (2013) Lecture notes on FWM 303 Natural Ecosystems, University of Agriculture Abeokuta. http://unaab.edu.ng/wp-content/uploads/2009/12/465_FWM%20303.pdf Date accessed 19/4/2023

BYJUS (2023) https://byjus.com/biology/difference-between-natural-and-artificial-ecosystem/ Date accessed 12/4/2023

BYJUS (2023) https://byjus.com/question-answer/how-are-reservoirs-of-phosphorus-recycled-in-a-terrestrial-ecosystem-show-with-the-help-of/ Date accessed 30/04/2023

Ghazoul, J. (2020) Ecology: A Very Short Introduction. Oxford University Press 1st Edition

Urban P., Sabo, P., Plesník, J., 2021. How to define ecology on the basis of its current understanding. *Folia Oecologica*, 48 (1): 1–8.

Williams, D. B. and Sally D. H (2020) Ecology, 5th Edition. Oxford University Press. London. Pgs. 744.

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CHAPTER 5

Introduction to Built Environment

By

USMAN Sani Umar and ABDULHAMID Adamu Ibrahim

Overview

This chapter is an exposition on many dimensions of the built environment, particularly its formation and the way it affects the environment. It begins with an explanation of the concept of the built environment and its definition. Its relationship with the increase in the world population and urbanisation. The basis for the division of the world into developed and developing countries and the characteristics of the built environment in each category. Demonstrating the effects of economic growth on the environment using the Environmental Kuznets Curve Hypothesis. The division of the world into developing and developed countries is based on the countries' prevailing economic sectors (primary production, secondary production and services). A comparison of the built environment conditions in developed and developing countries shows that developed countries have better environmental conditions. The three main economic production systems (free market, command/planned and mixed economies) are highlighted and the major ways in which they affect the environment are explained. These ways are the production of raw materials, industrial processing, power generation, transportation and urbanisation. Urban utilities are components of the built environment, which also serve as indicators of its quality. The most widely used urban quality indices that use urban utility parameters and others are also explained

Objectives

At the end of this course, students should be able to:

i. Explain the concept of a built environment
ii. Describe the relationship between the world population and the world-built environment
iii. Describe the differences in environmental conditions of cities in developed and developing countries
iv. Explain the major economic production systems and how they affect the environment
v. Explain how the effects of economic growth on the environment differ between developed and developing countries.
vi. Describe how urban quality indices are used in assessing the quality of a city

Concept of Built Environment

Throughout history, humans have been recreating or modifying the natural environment through development activities. These activities arise as a result of human needs, wants and values. They also increase with increases in human population and technology, which lead to more recreation or modification of the environment. Therefore, every structure, facility or utility we see has been produced to serve a purpose or a set of purposes. A collection of such structures, facilities and utilities are called the Built Environment, as portrayed in Figure 1. It can be seen from the Figure that the Built Environment is made up of many man-made structures.

It is also clear that the term is not limited to buildings that accommodate humans for residential, commercial or educational purposes. Rather, it also encompasses other physical structures and facilities. As such, the built environment comprises human-made structures and facilities, which facilitate human activities. It can be considered from a single building or road level to a town or city level. The United States Environmental Protection Agency (USEPA) defines the built environment as the man-made or modified structures that provide people with living, working and recreational spaces (USEPA, 2022).

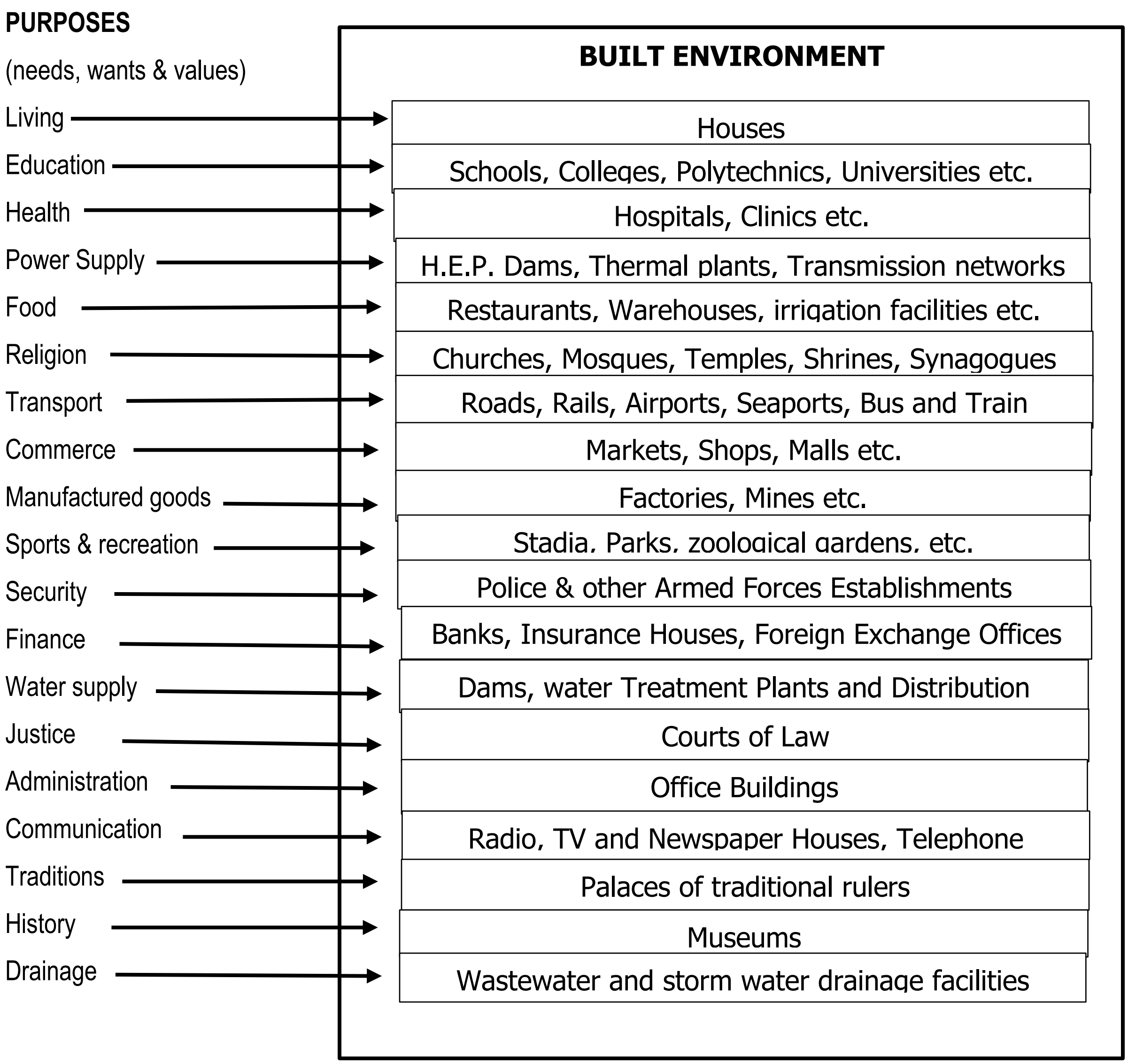

Figure 1: Components of Built Environment

The World Population

The world population simply refers to the total number of living human beings in the world. It has been changing over time. However, the rate at which it has been changing during the past millennia (thousands of years) and centuries was slow compared to recent times. In the past, it takes hundreds to thousands of years before the world population doubles. From Figure 2, it takes the world population 123 years (from 1804 to 1927) to double (from 1 to 2 billion). However, in recent decades, it takes the world population just 40 years (from 1965 to 2005) to double (from 3.3 to 6.6 billion). The Figure also indicates that the world population is projected to reach 9.7 billion by 2050.

The world population reached 8 billion people in November 2022 and more than half of the future increase will occur in the Democratic Republic of Congo, Egypt, Ethiopia, India, Nigeria, Pakistan, the Philippines and Tanzania (United Nations Department of Economic and Social Affairs, 2022). The continuous growth of the world population results in continuous increases in human wants, needs and values. In order to satisfy these wants, needs and values more structures, facilities and utilities are produced, which increase the built environment. Therefore, the world-built environment increases with an increase in the world population.

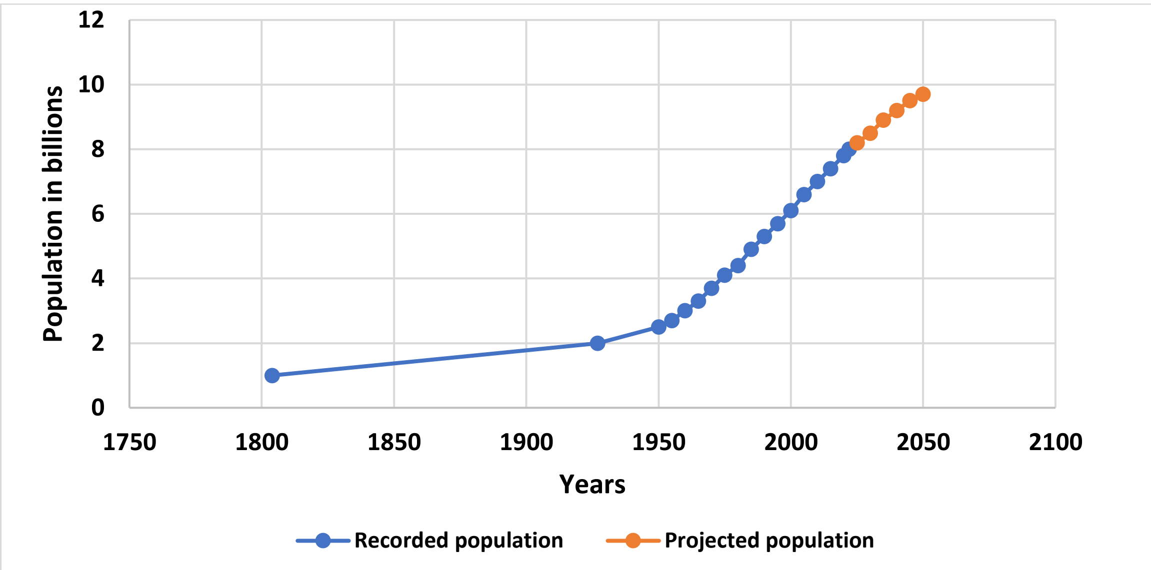

Figure 2: World Recorded and Projected Population
Source: Based on data from United Nations (2022)

World urbanisation
Urbanisation simply means the increases in the physical size and human population of cities and the growth of small settlements into urban areas. The natural increase in population due to high birth rates and low mortality rates is one of the reasons for urbanisation. Another reason is rural-urban migration. In Nigeria, Aduku (2021) identified the major reasons for rural-urban migration as overcoming poverty, escaping conflicts and coping with economic and environmental shocks. It is clear that these reasons are forcing the rural people to leave the rural areas. That is why they are also called push factors. The rural migrants are attracted to the urban areas by expectations of better economic opportunities (like employment), better healthcare, and better education for their children. These are called pull factors. Therefore, push and pull factors are the major causes of rural-urban migration.
In the past, the majority of the world's population lives in rural areas (see Figure 3). This is because the major occupation then was agricultural production. However, the widespread shift of occupation from agricultural production to industrial production has been leading to the growth of villages and small towns into cities. It has also been attracting more people to cities. As a result, from 2007, the number of people living in urban areas in the world became larger than that of people living in rural areas. This also means an increase in the world-built environment.

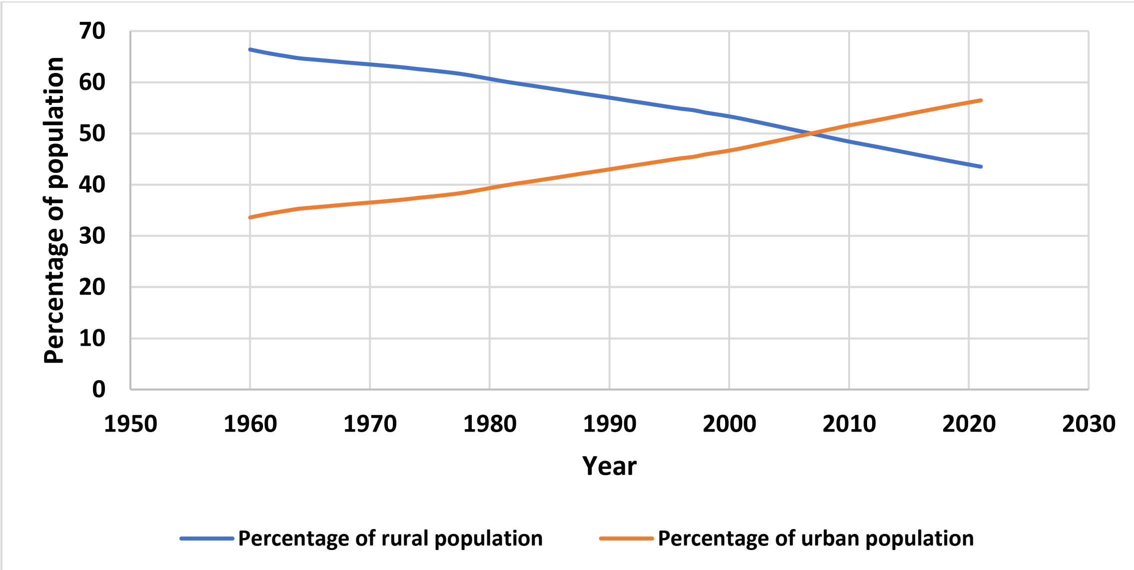

Figure 3: Decrease in World Rural Population and Increase in Urban Populations over Time
Source: Based on data from Macrotrends (2023a) and Macrotrends (2023b)

As the population of people in urban centres continues to increase, more physical structures are provided. This is because whenever the urban population increases, the needs, wants, values and desires of people also increase in size and type. Consequently, more and more complex built environments are created. UN-Habitat (2020) reported that the physical growth of cities in developed countries is 1.5 times higher than their population growth. Figure 4 shows a positive correlation between the population of 50 cities from all over the world and the sizes of their built environment (built-up area). It indicates that the higher the city's population, the bigger the city's size. In simple terms, it means whenever the population of a city increases a commensurate increase in the physical size (built-up area) of the city will also be experienced. The coefficient of determination (R^2) with a value of 0.9604 means that 96.04% (0.9604x100) of the city sizes from all over the world can be attributed to the population of the city dwellers. Therefore, it is clear that both increases in world population and urbanisation lead to increases in the number, size and complexity of the built environment.

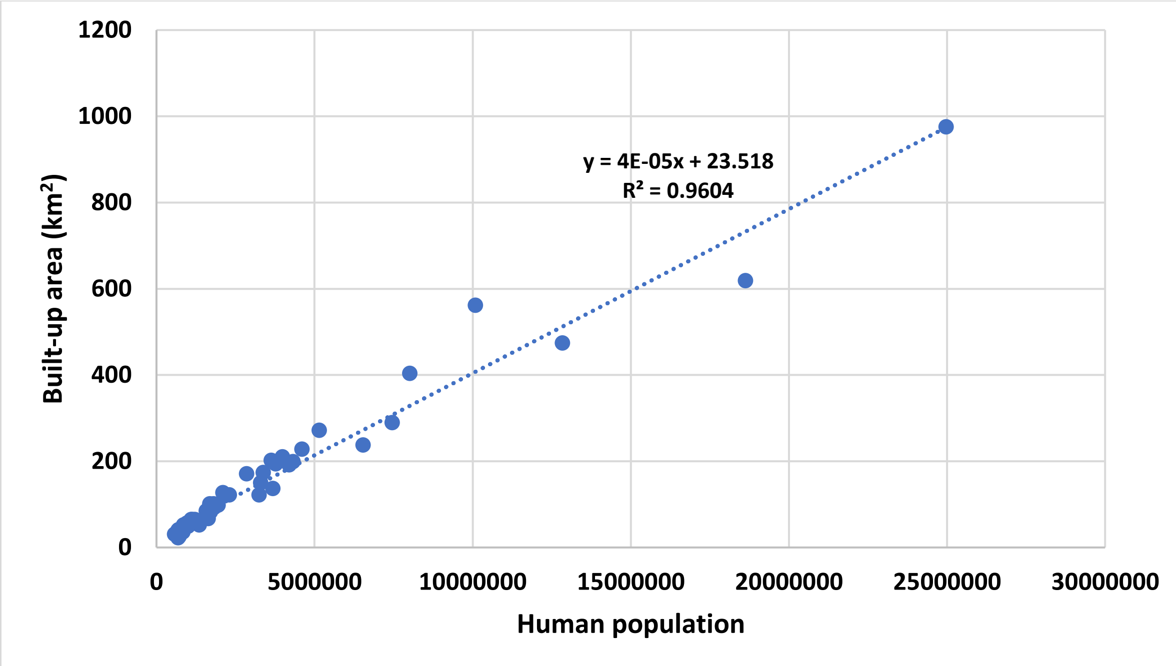

Figure 4: Relationship between the population of some 25 world cities and their built-up sizes
Source: Based on data from Demographia (2022: 57)

Sectors of Economic Production

The increases in world population and urbanisation give rise to an increase in demand for manufactured goods and services. This leads to a series of production processes through which the goods and services are provided. The nature and materials produced by each production process are used in classifying different types of production processes into primary production, secondary production and services sectors. At the global level, it is the United Nations Statistics Division that produces and maintains the standard used in classifying the economic production sectors into these major divisions. The standard is known as International Standard Industrial Classification (ISIC).

i. **Primary production:** It refers to the production of mainly raw materials, which require further processing to produce manufactured goods. Examples of primary production are the production of crude oil (petroleum), mining of metal ores like iron, copper and aluminium, logging as well as fishing and production of crops and livestock.
ii. **Secondary production:** It refers to the industrial manufacturing of goods from raw materials. Examples of secondary production are the manufacturing of cars, trucks, airplanes and ships from metal ores and other materials involved. Refining petroleum, which involves the production of various byproducts like aviation fuel, petrol, diesel, kerosene, asphalt and many other petrochemicals is another example of secondary production.
iii. **Services**: Services refer to the production of nonmaterial goods. Examples of services are education, banking, insurance, consulting, communication and healthcare.

It is based on these that the countries of the world are divided into developed and developing countries. Detailed classifications and the indices used are issued every year by the United Nations Department of Economic and Social Affairs in the form of an annual report called World Economic Situation and Prospect.

Developed/Industrialised Countries (First World countries)

These are the countries in which the economy is largely based on the primary production and services. This means the major economic activities in these countries are the industrial production of goods and their exchange as well as the provision of services. They are characterised by the presence of large factories which specialised in the large-scale production of industrial goods (such as machines used in the production of manufactured goods), vehicles, electronics and other consumer goods. Most of these goods are exported to developing countries. Examples of developed countries are; the United States of America, Japan, Germany, Britain, France, Italy, Canada and many other European countries.

Conditions of the built environment in developed countries

Developed countries have strong and highly developed economies. This means they generate a lot of wealth, which results in an increase in their needs, wants, values and desires. As a result of this, their built environments consist of complex structures. They also use the wealth in improving their educational, environmental, health, agricultural and other sectors. However, it should be noted that they were able to achieve these through widespread industrialisation. In the initial stages of industrialisation, they experienced a lot of environmental degradation, which sometimes led to the deaths of many people, especially through air pollution episodes. This made them take precautions by reducing the environmental impacts of their development. Table 1 portrays the environmental conditions of the built environment in developed countries. It describes the characteristics of some components of the built environment.

Table 1: Environmental Characteristics of the Developed Countries

Environmental component		Characteristics
Cities	i.	Physical planning: they are well-planned with adequate compliance to land-use zoning (separate residential, commercial, industrial and institutional areas etc.), adequate provision of open and green spaces, facilities and utilities
	ii.	Environmental concern: They have effective solid, liquid and gaseous waste management culture, which makes them neat and tidy
Farms	i.	Farm power: Mostly mechanised farm power is used in all the agricultural operations.
	ii.	Scale of production: Large-scale agricultural production is practiced, which is why only a very small proportion of the population is engaged in farming yet, it produces enough to feed the nations and export to other countries.
	iii.	Agricultural products: improved (high yielding) crop and (highly productive) livestock varieties are produced. Organically produced crops (produced using organic manure and organic pesticides) are mostly preferred because they have fewer negative effects on the environment and human health
	iv.	Environmental concern: Effective regulations concerning the use of agrochemicals (chemical fertilizers, herbicides and insecticides) are strictly observed
Factories	i.	Scale of production: Most of the factories are involved in the large-scale production of goods.
	ii.	Specialisation: Most of the factories are highly specialized in their productions, which makes them use highly skilled labour.
	iii.	Environmental concern: Regulations concerning industrial emission of gases, discharge of effluents and solid waste management are strictly observed. Effective use of resources in production through

		reuse and recycling. Widespread use of Environmental Impact Assessment (EIA) to prevent or reduce the negative effects of industries.
Road and Rail Transport	i.	Network: They have high-density road and rail networks, which are also highly interconnected.
	ii.	Condition: The roads and rail are well-constructed and highly maintained, which makes them efficient and safe.
	iii.	Environmental concern: Traffic regulations are strictly enforced, especially as regards emissions from vehicles and the conservation of biodiversity. EIA is always conducted before constructing highways and rail lines. Energy-efficient and clean energy vehicles are fast replacing fossil fuel-powered vehicles.

Developing/Less Developed Countries (Third World countries)

These are the countries in which the economy is largely based the primary production. This means the major economic activities in these countries are the extraction of raw materials and their export to developed countries. These countries are characterised by small-scale production of consumer goods (such as food, beverages and personal care products) and importation of manufactured goods. Examples of such countries are; African countries (including Nigeria), Middle Eastern and South American countries.

Conditions of the built environment in developing countries

Developing countries have weak economies thus, they do not have enough resources to adequately take care of their environment. The economies also can hardly withstand economic and environmental shocks. For example, the drop in oil prices at the world market (economic shock) affects the Nigerian economy badly. This is because the economy is heavily dependent on the export of crude oil. Drought (environmental shock) affects the largely agrarian economies of the Horn of Africa countries (especially Somalia and Kenya). Table 2 portrays the conditions of the built environment in developing countries. It describes the characteristics of some components of the built environment.

Table 2: Environmental Characteristics of the Developing Countries

Component	**Characteristics**	
Cities	i.	Physical planning: Most of the cities are poorly planned with inadequate land-use zoning. Open and green spaces are hardly provided. Facilities and utilities are mostly inadequate. They are characterised by the presence of squatter settlements or slum areas
	ii.	Environmental concern: They are mostly characterised by ineffective solid, liquid and gaseous waste management practices, which makes them dirty and untidy
Farms	i.	Farm power: Mostly human and/or animal power is used in all agricultural operations, which involves the use of simple farm tools.
	ii.	Scale of production: Small-scale and subsistence agricultural production are predominantly practiced. That is why most of the population is engaged in farming yet, it hardly produces enough to feed the nations. Agricultural products: unimproved (low-yielding) crops and (low-productive) livestock varieties are produced.
	iii.	Environmental concern: Regulations concerning the use of agrochemicals (chemical fertilizers, herbicides and insecticides) are hardly observed

Factories	i. Scale of production: Most of the factories are involved in the small-scale production of consumer goods. ii. Specialisation: Most of the factories are not highly specialised in their productions, which makes them use unskilled and semi-skilled labour. iii. Environmental concern: Regulations concerning industrial emission of gases, discharge of effluents and solid waste management are hardly observed. Proper EIA is hardly conducted before establishing farms.
Roads	i. Network: They have low-density road networks, which are poorly interconnected. ii. Condition: The roads are not well-constructed and poorly maintained, which makes them barely motorable, especially during the wet season. iii. Environmental concern: Traffic regulations are hardly enforced, especially as regards the roadworthiness of vehicles (good condition for a vehicle to be safely driven on the road), emissions from vehicles and conservation of biodiversity. Energy efficient and clean energy vehicles (for example electric vehicles) are hardly found.

Economic Production Systems

An economic production system means a system that regulates or manages resources for the production of goods and services needed by the people. It decides what resources are to be used, when, where and how they are to be used as well as whom to use the resources for production. Three major types of economic production systems have been identified (Economic in Context Initiative, 2021):

i. **Free market economy:** This is a production system in which individuals or groups of individuals who form businesses or firms decide what to produce, the resources to be used, where, when and how to produce as well as how much to produce. Simply, industries that produce goods and services are owned by individuals and private firms. Their decisions are influenced by demand and supply forces and their aim is to make a profit. An example of a free-market economy is the United States of America.
ii. **Command or planned economy:** This is a production system in which the government mostly decides what to produce, the resources to be used, where, when and how to produce. The decisions are based on satisfying the citizens' needs. In this system, all industries are owned by the government. Examples of command economies are the defunct Union of Soviet Socialist Republics, Cuba and North Korea.
iii. **Mixed economy:** This is a system in which the government owns some businesses while private firms and individuals own others. Nigeria is an example of a mixed economy. The government owns the energy (electricity generation and petroleum and gas producing) sector while almost all the other industries are owned by individuals and firms.

Factors Influencing Economic Production Systems

All the economic production systems are helped to grow by some factors as described by Agarwal (2022), which are:

i. **Natural resources:** Natural resources include water, good agricultural land, good climatic condition, petroleum, natural gas, forests, metal ores and precious stones. The presence of such resources can help in boosting the economic growth of a nation or region. For instance, petroleum and natural gas resources have been helping the economic production and growth in Nigeria and many other petroleum-producing countries. Money obtained by exporting these resources is being used to import machinery for agricultural and industrial productions.

ii. **Physical capital or infrastructure:** The provision of factories, roads, rail lines and machinery lower the cost of economic production. This is because effective mechanised production is better, faster and cheaper than manual production. Good transportation systems (good roads, rails, inland waterways and pipelines) ease the movement of raw materials to processing sites and manufactured goods to the market.

iii. **Labour population:** Large human population means the availability of labour (people who work in factories and farms) for the production of goods and services as well as food and cash crops. Availability of labour makes economic production easier than when there is a shortage of labour.

iv. **Human capital:** How skilled, knowledgeable and experienced people of a country are in economic production help in improving their productivity and that of the country. That is why investment in producing skilled people is good for any country that wishes to develop.

v. **Technology:** Improvement in technology leads to enhancement in production techniques. This helps in increasing the scale of production (increasing the number of products produced) and in cutting down the time and cost of production. Therefore, technology helps in boosting economic production.

vi. **Law:** Adequate and appropriate laws (including policies, rules and regulations) provide an enabling environment for economic production's smooth running and development. Such laws include those that protect the investors in the production systems, the consumers as well as laws enabling access to funds through credit or loans from government and commercial banks.

Economic Growth is at the expense of the Natural Environment

Whenever the economy of a country or a region is growing it means a lot of processes are taking place, which enable economic growth. In most cases, the smooth-running of the processes leads to environmental degradation. The ways in which economic growth leads to environmental degradation are common to all production systems, and they are:

i. **Production of raw materials:** For the economy to grow through a sustained increase in industrial production, natural resources have to be used as raw materials. In most cases, the extraction of natural resources leads to environmental degradation. Examples of the production of raw materials are petroleum and natural gas production in Nigeria, timber production in Brazil and Indonesia and mining of copper in Zambia and the Democratic Republic of Congo. Production of petroleum and natural gas results in land and water pollution through oil spillage and air pollution through gas flaring (Sakib, 2021). Logging (felling of trees) mostly for timber and paper production causes deforestation, which leads to land degradation (especially soil erosion) and loss of habitat for wildlife and people (Green Earth, 2023). Copper mining causes air, land and water pollution. The land is degraded through the digging of large holes and dumping of mine tailings, which mostly contain heavy metals. Particulate matter is also released, which pollutes the air (Pesa, 2021).

ii. I**ndustrial processing:** In the course of processing raw materials in order to produce manufactured goods, a lot of environmental pollutants are released. Examples of industrial processing are the production of cement from limestone and textile materials from cotton in Nigeria. Production of cement involves noise pollution and the release of a large amount of particulate matter and other air pollutants. In the case of the production of textile materials, it involves the release of gaseous and solid waste as well as effluents, which mostly consist of heavy metals (dyes and other chemicals used in treating the materials).

iii. **Power generation:** For any significant economic growth to be achieved, there must be an adequate and reliable supply of electricity. This is because most of the processes of raw material production involve the use of electricity. In addition, modern factories and machinery used in industrial production are powered by electricity. And the generation of electricity for industrial production mostly involves using environmental resources such as running water, natural gas, diesel, coal and radioactive metals like uranium. Generation of electricity using any one of these have one form of negative effect on the environment or the other. First, the extraction of some of the energy minerals (like coal, natural gas, uranium and petroleum) involves environmental degradation. Second, the generation of power using each source have negative effects on the environment. For instance, using hydroelectric dams have adverse effects on the downstream areas of the dams. Using coal, diesel and natural gas releases air pollutants. Using radioactive metals (nuclear power plants) produces radioactive wastes, which are very harmful to the environment.

iv. **Transportation:** Economic growth involves the transportation of raw materials from points of extraction to factories for processing into manufactured goods. It also involves the distribution of manufactured goods to points of sale or consumption. However, the provision of transport infrastructure such as roads, railway lines, pipelines, airports, seaports and train stations involve disruption of the natural environment. Furthermore, the operation of the means of transport such as cars, trucks, trains, airplanes and ships involve environmental pollution. This is because most of them have internal combustion engines, which mostly burn petrol or diesel and emit gaseous pollutants. In Kano City, Usman *et al* (2017) estimated the carbon dioxide (CO_2) emission of tricycles, cars, buses and lorries to be 22.39 tonnes from the combustion of petrol and diesel every hour during the day. This causes serious air pollution in the city.

v. **Urbanisation:** Economic growth also leads to urbanisation, which is the increase in the size of cities and the growth of small towns and villages into large urban areas and cities. Both extraction of raw materials and industrial activities attract people and lead to urbanisation. Examples in Nigeria are the emergence and growth of Enugu due to coal mining and Jos due to tin mining. Urbanisation affects the environment in many ways, which include; one, use of natural resources for the increase in the built environment. Things like iron and steel, sand, laterite, cement, rocks (like gravel), water, glass and timber for construction and continuously used. Production of these materials entails different forms of environmental degradation. Two, the presence of the built environment itself affects the natural environment. For instance, Usman *et al* (2019) reported that the presence of buildings accounts for 59% of the urban heat island effect in the Kaduna metropolis. The urban heat island effect means the higher surface and air temperatures obtained in urban areas compared to their rural surroundings. Three, other activities within the urban areas such as domestic, commercial and urban agriculture generate solid and liquid wastes, which pollute the environment.

Economic Growth and the Environment in Developed and Developing Countries

Even though economic growth in all the economic production systems involves environmental degradation yet, there are differences in the extent of the degradation between developed and developing countries. One of the famous hypotheses used to show the relationship between economic growth and environmental degradation between developed and developing countries is the Environmental Kuznets Curve Hypothesis (Figure 5). It was propounded by Nobel laureate Simon Kuznets in 1955 (Igbru & Meshack, 2021). The hypothesis normally involves regression analysis between environmental parameters (especially air and water quality) and Gross Domestic Product (GDP) in a given city or region.

It shows that as cities or countries develop economically, their environments get degraded at the initial stages. The degradation ranges from the phase of raw material extraction to the processing and product use phases. During the raw material extraction phase, the environment is polluted. For instance, soil and water get polluted as a result of the excessive use of agrochemicals in the production of agricultural raw materials. In the case of oil production in Nigeria, the environment is polluted through oil spills and gas flaring.

During the production phase, large volumes of gaseous, liquid and solid pollutants are released into the environment by the industries that process the raw materials into finished goods. Environmental pollution also occurs during the product use phase. Products like motor vehicles and machines emit gases, which pollute the environment.

The hypothesis further postulated that as economic growth through industrialisation continues, people accumulate more wealth. Demand for manufactured goods also increases, which encourages more industrial production. Environmental degradation also becomes more apparent, which at a stage necessitates taking actions and measures of protecting the environment. This is called the turning point, whereby the economy is growing but the environmental degradation is reducing.

Most of the developing countries are in the first phase, in which environmental degradation is increasing with an increase in economic growth. The developed countries have passed through the first phase and are now in the second phase. The economy is growing but concern for the environment has made them take adequate environmental conservation measures. This continuously limits the negative effects of their economic growth on the environment.

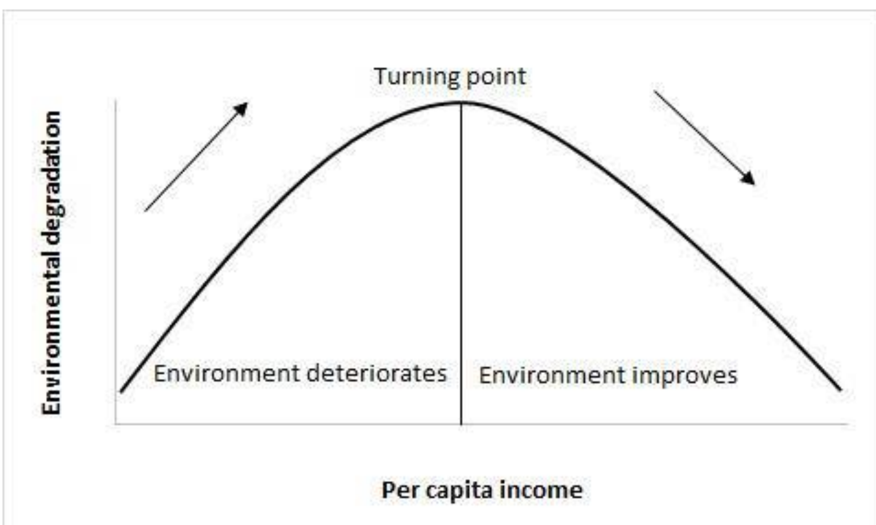

Figure 5: Environmental Kuznets Curve

Source: Modified and drawn by Authors after Beyene and Kotosz (2020)

Urban Utilities

Urban utilities are the essential services necessary for the smooth operations of cities. Examples of urban utilities are water, gas, electricity, telecommunication and Internet facilities, storm and wastewater drainage, solid waste management, education, healthcare, financial and transport services as well as urban open spaces and urban green areas. They are good indicators of the economic, social and environmental conditions of any city. On one hand, high-quality urban utilities denote good conditions of living including the health and well-being of the inhabitants. On the other hand, low-quality urban utilities denote poor conditions of living.

Urban Quality Indices

Urban quality indices are indicators used to assess the economic, social and environmental performances of urban areas. Most of the indices are either directly or indirectly related to the quality of urban utilities. Some of the indices use a single parameter or indicator for the assessment. Others use multiple parameters. Many national and international organisations use these indices in determining the quality of cities. Based on this, the world's major cities are ranked annually by such organisations as shown in Table 3.

Table 3: Types of Urban Quality Rankings

Organisation	**Name of ranking**
Economist Intelligence Unit	Global Liveability Ranking
Number	Quality of Life Ranking
Deutsche Bank	Liveability Survey
Global Finance Magazine	World's Best Cities to Live
Monocle Magazine	Quality of Life Survey
Mercer	Quality of Living Ranking

Source: Wikipedia (2023)

Example of Urban Quality Indices

Urban quality induces can be divided into two based on the number of parameters involved:

a) One parameter index

In some indices, only one parameter is used in assessing the quality of cities. An example of such indices is Air Pollution Index. The parameter being used in this index is particulate matter (2.5μg/m^3) air pollution data of the cities being assessed for the last 12 months. This parameter is chosen because when inhaled, it (particulate matter 2.5μg/m^3) can pass from human lungs into blood vessels, which makes it a dangerous air pollutant. The index is used in determining the most polluted cities in a country or the world.

b) Multiple parameter index

Other indices use many parameters in assessing the quality of cities. One of the most popular indices that uses multiple parameters in assessing the quality of cities is Global Liveability Ranking developed and being used by the Economist Intelligence Unit. In this ranking, 30 indicators grouped into 5 categories are used in assessing the quality of cities (Economist Intelligence Unit, 2022). These are:

Category 1: Stability (25% of total points)

a) Prevalence of petty crime b) prevalence of violent crime c) Threat of terror d) Threat of military conflict e) Threat of civil unrest/conflict

Category 2: Healthcare (20% of total points)

a) Availability of private healthcare b) Quality of private healthcare c) Availability of public healthcare d) Quality of public healthcare e) Availability of over-the-counter drugs f) General healthcare indicators

Category 3: Culture and Environment (25% of total points)

a) Humidity/temperature rating b) Discomfort of climate for travellers c) Level of corruption d) Social or religious restrictions e) Level of censorship f) Sporting availability g) Cultural availability h) Food and drink i) Consumer goods and services

Category 4: Education (10% of total points)

a) Availability of private education b) Quality of private education c) Public education indicators

Category 5: Infrastructure (20% of total points)

a) Quality of road network b) Quality of public transport c) Quality of international links d) Availability of good-quality housing e) Quality of energy provision f) Quality of water provision g) Quality of telecommunications

Table 4 shows the year 2022 ranking of 172 cities (Top 10 and Bottom 10 positions) in the world based on these indicators. According to this ranking, Lagos City (Nigeria) is the second least liveable city in the world.

Table 4: Most and Least Liveable Cities in the World for the Year 2022

Top 10 ranking cities				**Bottom 10 ranking cities**			
City	**Country**	**Rank**	**Total points**	**City**	**Country**	**Rank**	**Total points**
Vienna	Austria	1	99.1	Tehran	Iran	163	44.0
Copenhagen	Denmark	2	98.0	Douala	Cameroon	164	43.3
Zurich	Switzerland	3	96.3	Harare	Zimbabwe	165	40.9
Calgary	Canada	3	96.3	Dhaka	Bangladesh	166	39.2
Vancouver	Canada	5	96.1	Port Moresby	Papua New Guinea	167	38.8
Geneva	Switzerland	6	95.9	Karachi	Pakistan	168	37.5
Frankfurt	Germany	7	95.7	Algiers	Algeria	169	37.0
Toronto	Canada	8	95.4	Tripoli	Libya	170	34.2
Amsterdam	Netherlands	9	95.3	Lagos	Nigeria	171	32.2
Osaka	Japan	10	95.1	Damascus	Syria	172	30.7
Melbourne	Australia	10	95.1				

Source: Economist Intelligence Unit (2022)

It is clear from this Table that the most liveable cities (cities with the highest scores in all the indices) are located in developed countries while the least liveable cities (cities with the lowest scores in all the indices) are located in developing countries. This further demonstrates the difference in environmental qualities between developed and developing countries.

Summary

Built environment refers to the environment created or modified by humans to serve their diverse needs, wants and values. It increases with an increase in population and urbanisation due to the accompanied increases in human needs, wants and values. Both the built and natural environment are negatively affected by the world population growth through an increase in economic production. Prevalence of economic production sectors (primary production, secondary production and services) is used in dividing the world into developed and developing countries. Some of the most important distinguishing characteristics that between the built environment in developed countries and that in developing ones are the conditions of utilities in their cities. Countries of the world are further divided into free market, command/planned and mixed economies based on the production systems they operate. Despite these differences, their economic growths are mostly to the detriment of the environment. This is because they have some common features, which affect the environment. These are; raw materials production, industrial processing or production, power generation, transport and urbanisation.

However, the Environmental Kuznets Curve Hypothesis indicates that as economic growth progresses, a point is normally reached at which the negative effects of the growth on the environment begin to decrease with an increase in the economic growth. The first half of the curve characterises the situation in developing countries while the second half characterises that of developed countries. In addition, the built environment also comprises utilities, which aid its effective functioning. In urban areas, the condition of such utilities (urban utilities) is mostly used as an indicator of the urban areas. Several indices have been produced, which utilise parameters involving urban utilities.

Exercise

1. (a) Explain the concept of the built environment
   (b) Why do humans produce the built environment?
2. (a) How is the built environment related to the world population?
   (b) Explain how urbanisation contributes to the growth of the built environment
3. Briefly explain four the environmental differences between the built environments of the developed and developing countries
4. Mention the major economic production systems and how they affect the environment.
5. Explain how economic development affects the environment using the Environmental Kutznets Curve Hypothesis
6. (a) What do you understand by the term urban utilities?
   (b) Explain how Air Pollution Index and Global Liveability Ranking are used in assessing the quality of cities.

References

Agarwal, P. (2022). *Economic growth.* https://www.intelligenteconomist.com/economic-growth/

Beyene, S.D. & Kotosz, B. (2020). Testing the Environmental Kuznets Curve Hypothesis: An empirical study for East African countries. *International Journal of Environmental Studies, 77*(4), 636-654 https://doi.org/10.1080/00207233.2019.1695445

Demographia (2022). *Demographia world urban areas: Built up urban areas or world agglomerations*. 18th Annual Edition. http://www.demographia.com/db-worldua.pdf

Economic in Context Initiative (2021). *Comparative economic systems: Capitalism and socialism in the 21st century.* An ECI Teaching Module on Social and Economic Issues. Global Development Policy Centre, Boston University https://www.bu.edu/eci/files/2021/08/Comparative-Economic-Systems.pdf

Economist Intelligence Unit (2022). *The global liveability index 2022: Recovery and hardship*. Economist Intelligence Unit Limited https://www.eiu.com/n/campaigns/global-liveability-index-2022/#mktoForm_anchor

Green Earth (2023). *Deforestation in Indonesia and its impact on the environment*. https://www.green.earth/blog/deforestation-in-indonesia-and-its-impact-on-the-environment#:~:text=According%20to%20data%20from%20the,changes%20to%20the%20local%20climate

Igbru, O. & Meshack, I.S. (2021). Environmental degradation and economic growth: An empirical perspective from Nigeria. *International Journal of Innovative Finance and Economics Research, 9*(4), 1-6

Macrotrends (2023a). World rural population – Historical data https://www.macrotrends.net/countries/WLD/world/rural-population

Macrotrends (2023b). World urban population – Historical data https://www.macrotrends.net/countries/WLD/world/urban-population

Sakib, S.M.N. (2021). The impact of oil and gas development on the landscape and surface in Nigeria. *Asian Pac Environ Cancer, 4*(1), 9-17 https://doi.org/10.31557/APJEC.2021.4.1.9

United States Environmental Protection Agency (2022). *Basic information about the built*

environment. https://www.epa.gov/smm/basic-information-about-built-environment#:~:text=Built%20Environment%20important%3F-,What%20is%20the%20Built%20Environment%3F,get%20from%20place%20to%20place
UN Habitat (2020). *World cities report 2020: The value of sustainable urbanisation*. UN Habitat. https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf
United Nations (2022). *2022 revision of the world population prospects.* Population Division, Department of Economic and Social Affairs of the United Nations. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf
United Nations Department of Economic and Social Affairs (2022). World population to reach 8 billion on 15 November 2022. https://www.un.org/en/desa/world-population-reach-8-billion-15-november-2022
Usman, S.U., Abdulhamid, A.I., Gwadabe, S., Usman, A.K., Isah, B. and Mallam, I. (2017). Urbanisation and climate change: The role of road transport in carbon dioxide emission in Kano Metropolis, Nigeria. *Bayero Journal of Pure and Applied Sciences, 10*(10), 536-540 http://dx.doi.org/10.4314/bajopas.v10i1.101S
Usman, S.U., Gwadabe, S., Muazu, A., Abdulhamed, A.I., Isah, B. & Azare, I.M. (2019). An assessment of the effect of surface cover composition on spatial variation of near surface air temperature in Kaduna Metropolis during hot dry season. *Journal of the Nigerian Geophysical Society, 1*(1), 74-80
Wikipedia (2023). *City quality of life indices*. https://en.wikipedia.org/wiki/City_quality_of_life_indices#

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CHAPTER 6

Fundamentals of Environmental Management Valuation

By

MADUEME Stella

Overview

The environment contains elements that are very important for human existence. Some of them have social, economic, aesthetic and religious intrinsic values which are cherished by generations of men such as waters, mountains, trees, forest, animals etc. The United Nations instituted the Millennium Ecosystem assessment as far back as 2000, due to its importance, to find out about ecosystems, their sustainability and conservation. This led to the development of a myriad of tools for valuation of tangible and intangible goods in the environment. Traditionally, environmental valuation is generally thought to be concerned with only goods with non-market values. However, such goods and services such as recreation parks, beaches, water have become organized as business ventures with marketable values. The importance of valuing the environment is of paramount importance because of many economic and non-economic benefits derived from its goods and services. Sometimes, new decisions about property rights and compensations have to be taken when such goods and services have to be destroyed and replaced with alternatives or preserved for the community where they exist. For example, a forest with trees for shades, firewood, hunting and timber might need to be destroyed for roads or railways to be constructed, markets or schools to be built. Such decisions on willingness to accept such decisions or pay for the destruction or preservation of such goods and services will depend on their estimated value established through the process of valuation. This process will provide the basis of choice of compensation methods and amounts where property rights and inheritance laws are attached to them. The willingness to pay from community members will also show their level of commitment to policies to destroy or preserve an environmental good or service. Hence, this chapter will provide information on various methodologies for valuing tangible and intangible environmental goods and services for students, firms, policy makers and communities.

Objectives

By the end of this chapter, students should be able to:

1. explain the meaning of valuation;
2. state the importance of valuation;
3. distinguish between use and non-use values;
4. distinguish between discounted and undiscounted measures of project worth;
5. explain seven basic terms used in environmental valuation;
6. mention and explain five economic valuation tools for tangible environmental goods; and
7. describe the six environmental valuation methodologies.

The Concept of valuation

Valuation, according to Schidt (2023), is a process of determining the Present value of an asset, investment or a company. The assets in this case can be tangible, intangible or financial assets. Valuation is the art and science of determining, at some specific dates, for specific purposes and by one authorized, the monetary value of the property rights encompassed in an ownership and the value so determined (Salau, 2016). It involves engaging rational and measured investigation and reasoning after systematic collection and analysis of data. Baum and Crosby (2021) defined valuation as the "estimate or prediction of the most likely selling price". Implicit in the definition is the reason for valuation which is that of acting as a proxy for market price or as a substitute for having to sell an asset. Madueme (2023) defined it as the act or process of determining the value of a business, business ownership interest, security and/or intangible asset. From the foregoing, valuation is simply a planned act of determining quantitatively the value of an entire firm or industry, its assets and investments. The valuation of assets and liabilities are important because the world of business is often affected by a myriad of factors, such as size of market, number of customers and suppliers, level of competition, size and type of firm or product etc.

The purpose and importance of valuation

Households, businesses and governments are all involved in some process of valuation at one point or the other. Hence the importance and purpose of valuation, according to Madueme (2023) and other researchers are:

1. It shows the market value or economic worth of a business venture;
2. It provides indices for comparing the worth of similar businesses or investments;
3. It serves as an effective decision-making tool for curtailing or increasing expenditures;
4. It enables firms in determining labour, capital and technological needs with precision;
5. It provides the basis for liquidation or reduction of the scope of business;
6. It provides the basis for decisions concerning business expansion through mergers and acquisitions;
7. It helps business owners to build firms or companies that can be transferred;
8. It provides the basis for judging the success or failure of a business;
9. It portrays extent of business transparency, efficiency and accountability;
10. It determines the competitiveness of a firm at each period;
11. It affects the capacity of the firm or company to access capital;
12. It helps in determination of the share price of a particular company; and
13. It influences the total number of company's shares sold at the stock market.

Basic concepts in valuation

- **a. Surrogate markets**: A substitute market used to estimate value or worth when there is no existing market for the environmental good or service.
- **b. Compounding:** This means generating earnings from reinvested assets which have produced previous earnings for the firm.
- c. **Discount rate**: This is the percentage rate that is needed to compute the present value of a future stream of cash to the firm.
- d. **Discounted Cash Flow (DCF):** This refers to the estimation of future streams of income which are discounted with a discount factor to obtain the present value of such cash flows.
- e. **Discounting**: The process of determining the present value of payment(s).
- f. **Net Present Value (NPV)**: This is also called net present worth. This refers to the worth of all future cash inflows and outflows in the company after discounting.
- g. **Enterprise Value (EV)**: This is also referred to as the Total Enterprise Value (TEV), Entity Value or Firm Value (FV). It takes into account the assets and liabilities of a firm in estimating the entire value of an enterprise.
- h. **Equity**: Total assets minus total liabilities. Also called total shareholders' equity or net worth.

i. **Environmental goods**- They are part of public goods, which in many instances, are non-market goods such as mountains, forests, air, water, game reserves etc.
j. **Environmental good and service sector:** All organizations that are involved in the management and protection of environmental goods and services.
k. **Market capitalization**: This is the share prices times the number of shares outstanding for a publicly-traded company.
l. **Environmental goods agreement**: Agreement by many countries to achieve climate and environmental protection.
m. **Non-use values**: These are less tangible but occur when values are not related to the use of an environmental good or service.
n. **Use values**. This occurs when the use of a resource in the present or future produces tangible things that have direct impact on people's lives.
o. **Bequest value:** This refers to value that is estimated on an environmental good which is believed to be good enough to be preserved for future generations.
p. **Valuation**—Determination of the value of an environmental good or service.
q. **Ecosystem**: This is an area where the physical environment such as weather and landscape interact with plants and animals to provide goods and services. They can be tundra, freshwater, grassland, tropical, marine, tropical rainforest etc. types of ecosystems.
r. **Intrinsic value**: This is an assessment of the worth of a good or service which is usually based on the prevailing market price.
s. **Biodiversity**: Plant, animal life etc. in a habitat.

Methods of environmental valuation

The environment is made up of tangible goods like trees, water etc. and intangible goods like air, light etc. The nature of such goods will determine the method of valuation to be used. In addition, some environmental goods could be used as a social good for the community. In other instances, such environmental goods are used as business ventures wherein an investor or group of investors pool capital from private sources, such as banks or the stock markets in order to set up such ventures. When an environmental good or service is a business venture, economic or financial valuation methods are used unlike when it is used only as a social good. Some of the economic valuation methods for environmental goods and services which also are business ventures for investors are:

1. **Time revenue**: This method portrays the projected profitability of a business venture. These values, needed for this method are the revenues of the enterprise and the expected growth rate of the firm. In applying this method, the average annual revenue of such a business venture like a national park or game reserve is calculated. This is multiplied by the industry multiplier to get the time revenue valuation of the venture. Hence, if the revenue is two million naira annually and the industry multiplier is 3, then the time revenue will be calculated as: 2,000,000 x 3 = 6,000,000 Naira.
2. **Liquidation value:** Liquidation of a venture that occurs when all the assets are sold and all the liabilities are paid for. The balance will be the liquidation value. For example, if the total asset used to set up a forestry reserve is 10 million Naira and the liabilities of that venture is eight million Naira, then the liquidation rate = 10,000,000 – 8,000,000 = 2,000,000 Naira. This means that the real value of that forestry reserve is two million Naira only. This method is also referred to as the **Book value**.
3. **Market capitalization:** The total value of the shares of any business venture in the stock market is the market capitalization. In applying this method for business valuation, the total number of shares of the company is multiplied by the price of is share at the stock exchange

to get the value for market capitalization. Therefore, if the current price for a share is 100 Naira and its shares are 2,000,000 in the stock market, the market capitalization will be 20.000,000 million Naira.

4. **Relative valuation**: The name is derived from the practice where there is a comparison of the worth of other similar companies with the company that is undergoing a valuation process. Under this method, if an amusement park has liquidated and is worth 10,000,000 million Naira, it is assumed that another amusement park that is similar in size and facilities will be worth the same amount if it is valued.
5. **Return on investment approach:** Valuation under this method is assessed using the profitability of the business. This method uses the value of the return on investment for the assessment of the profitability of the business. The return on investment is the amount that people who invest in the business venture will get annually which will also portray the length of time that investors will have to wait to recover their original investment. Hence, if an investor commits 120,000 thousand Naira into a business venture to be paid 20 percent then, 120,000 Naira/0.2 = 600,000 Naira is what he will get. This means that a similar venture with the same level of investment that will give the investor 850,000 Naira is deemed to have a greater value or worth with respect to its valuation and vice versa.
6. **Undiscounted measures of project worth**

a) The Payback Period (PBP)

The payback period, according to Madueme (2023), is defined as the expected number of years that is needed for investors to recover their initial capital that is injected into such a business venture. Hence, it is a measure of project liquidity. Therefore, a project that yields profit such that the initial investment or capital can be recovered in a short time period is deemed of a higher worth compared to another one that will take a longer time to recover its original investment.

b) Ranking by inspection

This method compares the worth of alternative projects requiring the same capital outlay by simple inspection of their cost and income stream. According to Madueme (2023), the following options can be used for valuation:

I. If project A and B produce the same net value of production for a period, project B is of a higher value if it continues to bring in earnings after that period.

II. Project C is better than D if it brings in more cash flow at a shorter time period compared to others even if it has the same net value of production with other projects over some years.

III. Project E is of greater worth than F if it has lesser costs of production.

c) Total earning per naira of outlay

This method divides the total income earned from each project by the initial capital outlay. Projects, where total earnings per naira of outlay are higher, are deemed to be the better projects. For example, if the initial capital outlay for Projects A and B is 50,000 Naira each. If A and B earn 62,000 and 66,000 respectively, then applying the formula:

Project A = 62,000/50,000 = 1.24 and B = 66,000/50,000 = 1.32

Then, B is of a higher value than A because its total earning per Naira of outlay is 1.32 which is higher compared to 1.24 from A.

d) Average annual earnings per naira of outlay

In this method, the total earnings from each project is divided by 'n' where n is the number of years that income is received from the investment. The value obtained is then divided by the initial investment. Any value which has the highest average annual earnings per Naira of outlay is considered of higher value.

e) Use of break-even charts

A factory that is operating at a break point means that its costs and benefits are equal. Any point below this means that the firm costs are greater than benefits and vice versa. This means that projects are worthwhile once they are operating at points that are higher than their break-even point. However, project A is preferable if it is operating at a much higher point from the breakeven point than project B.

7. Discounted measures of project worth

The process of discounting to determine worth of an investment involves reducing the future benefit and cost streams to their present worth. It is opined that this process enables us to:

a) Compare present worth estimates with each other either to derive a ratio of present worth of benefits

to their costs (known as the benefit cost ratio); and

b) Consider the difference between their present and future worth (the net present worth measure);

c) See what discount rate would be necessary to make the net present worth equal zero (a measure of the earning capacity of the internal rate of return.

Hence, the process whereby the present worth of income earned at a future date is calculated is called discounting. Interest rates are used for this process of discounting and they are referred to as the discount rate. Hence discount rate according to him is the interest rate used to discount or calculate the future costs and benefits so as to arrive at their present values. It is also known as the opportunity cost of capital investment. They are usually based on government bonds or market interest rates for cost of capital whose maturity is about same as the time period of the project being evaluated.

Closely related to this term is the discounted cash flow. This is a valuation method used to estimate the attractiveness of an investment opportunity. The discounted cash flow projection is discounted (most often using the weighted average cost of capital) to arrive at a present value which is used to evaluate the potential for investment. Hence, discounting shows the present worth of future streams of income at various interest rates. Some examples are the Net Discounted Present Value (NDPV), the Benefit Cost Ratio (BCR) and the Internal Rate of Return (IRR).

The NDPV

With respect to the net discounted present value approach, projects are viable and of high worth when value obtained is greater than zero and vice versa (Madueme, 2023). Therefore, NDPV > 0 means project is viable, NDPV < 0 means project is unviable while NDPV = 0 means costs and benefits of project are equal.

The BCR

BCR = Present worth of benefits/ Present worth of costs.

The present values are obtained by multiplying the net cash with the selected discount factor. The implication is that if the value for the benefit cost ratio are positive, investment is a worthwhile venture in terms of its profitability and viability.

The IRR

The internal rate of return is the discount rate which equates or makes the net present worth of the cash inflow equal to zero (CFI, 2023). It is a method used to evaluate investments. It is a rate that equates future income from investment with the original cost of investment. If the internal rate of return is higher than the cost of investment then the investment is worthwhile and if less than original capital outlay then it means that investment is not beneficial to investors. The internal rate of return can be determined graphically where a curve is plotted to show the relationship between the net present value of a project and the discount rate. The discount rate is represented at the y axis while the net present value is represented on the x axis. This curve is known as the net present value profile. The IRR occurs at the point where the net present value profile cuts the horizontal axis. The internal rate of return can also be computed by dividing the initial cost of investment (the present value of an annuity) by its cash flow to obtain a value. The table value of an annuity per period for 'n' periods is checked to see where the value falls under the various interest rates. This method is only applicable where the firm is experiencing constant cash flows. Another method of calculating the internal rate of return is to divide the initial capital outlay by the future value of money at the end of the 'n' period. The value obtained is checked against the table of the present value of $1 due at the end of a 'n' period to find the interest rate it will fall under in order to determine the IRR.

8. Methods for environmental valuation

Environmental valuations estimate the worth of a project, good or service. Some goods or services have direct use values which translates into their market prices while others might have indirect use values which are intrinsic in nature. Valuations are based on the underlying assumption that people have value for the good or service and are willing to pay for them through its market price or to offer to pay for the preservation of that good or service. This means that when people feel that some other party such as external donors or the government should bear the responsibility of establishing or providing a good or service, they might not be willing to pay for that good hence some methods of valuations discussed above cannot be applied to assess the worth of that good or service. For example, if people feel that it is the sole responsibility of the government to build and maintain roads, they will be unwilling to make any contribution to that effect. Therefore, such valuations will depend on either the expressed preference methods of environmental valuations which ascertains how much people are willing to pay for an environmental good or service or the revealed preference methods which shows how much people pay for a similar good in the market. Some examples are as follows:

The contingent valuation method

It is basically applied for the assessment of goods with non-use values such as certain environmental goods like rivers, hills, mountains etc. According to Hoyos and Mariel (2013), it is an economic valuation of natural resources using information from stated preferences. This method can only be applied when consumers are well acquainted with and environmental good and also accept the responsibility to pay for the sustenance or continual existence or destruction of the good or service. It usually employs the survey research design methodology to identify and describe the characteristics of the good to be valued and the amounts respondents are willing to pay to avoid extinction or destruction of the good. The data collected from consumers could be analyzed using chi square or related form of statistics to determine the significance of their responses. The various methods under the contingent valuation approach are the trade-off game, costless-choice and Delphi methods. The tradeoff game approach provides different bids for people to choose from to show at what price they will be indifferent to retain or destroy different levels of the environmental good or service. For example, a community preference for retaining a mountain site for religious worship or tourism compared to its partial or total destruction for a new road could be assessed through this method. This method of environmental valuation is referred as the costless-choice method when monetary values are excluded to elicit their preferences. There are instances where only a few individuals have little knowledge about the impact of an environmental good or service such as installation of nuclear power plants in an area. In such instances, survey methods are used to interview experts in that area about the positive value or harm to the community in order to make decisions on the worth of that good or service to that community. This method, where expert opinion is used to determine the worth of good or service is called the Delphi method.

The averting behavior method

Dickie (2017) defined averting behavior as actions taken to defend against environmental hazards whether by reducing exposure or by mitigating adverse effects of exposure. The basic assumption of this method is hinged on the fact that many products are not demanded due to their beauty or other appealing qualities. The quantity demanded of a product and its price depends on the extent to which people are willing to avert the negative effects of another product. Hence, people buy sunglasses to avert the negative effects from sun rays or harsh winds. The price at which people wish to pay for the sun glasses in this case depends on their assessment of the degree of negative effects of exposure to sun rays and harsh winds. People pay for electricity to avert the negative effects of staying without light compared to a community that has private solar lightning facilities installed in their houses. Another example is that a price a fishing community is willing to pay for the government to clean their waters from refuse dumping and pollution will be different from a non-fishing community or a price an agrarian community is willing to pay to maintain their community bore holes which is their major source of water supply is different from a non -agrarian community who uses water only for household needs. This method of environmental valuation uses the direct market prices of the goods purchased to avert expected negative impacts of another good or service. In the first instance, the environmental value of sun rays will be determined by the market price of sunglasses while the environmental value of water or electricity will be assessed through the level of taxes or communal contributions people will be willing to pay for clean water or electricity.

The hedonic pricing method

The hedonic pricing method is also known as hedonic regression method and hedonic demand methods (Kanijia, Khan and Jadhar, 2016). The philosophy of hedonism deals with the fact that pleasure is the chief value in life. Hence people are willing to pay more for goods or services they derive greater pleasure or comfort from. Consumers are more willing to pay more for a house with better aesthetics, beautiful and quiet surroundings, nearness to the sea and social infrastructure than the same size of house without such surroundings, located in an area known for criminal activities, floods or pollution. Therefore, the hedonic price approach tries to find out the difference in the worth of both houses based on the aforementioned environmental qualities and how much such people will be willing to pay to upgrade such facilities to their taste. This implies that the market price of a good or service is a function of its utility and impact on consumers pleasure. The services or intrinsic qualities of such goods as perceived by the consumer directly affects its market price. It usually employs the regression method of analysis in its valuation. It is based on the accurate assessment of all the intrinsic qualities of the good or service. This is because the value of the good is regressed against all such intrinsic qualities to obtain the hedonic price function. Hence, in relation to our example, the Hedonic Price Function (HPF) of the value of the house will be given as:

HPF = f (taxes in surrounding community, nearness to sea, nearness to basic infrastructures, amenities, flower arrangement + error term). The environmental value of the house can be assessed by the willingness to pay for a marginal change in each of the identified variables that are part of the regression equation.

The market price method

This is a method of valuation. It assumes that the value of a good or service is shown by its market price. Hence it determines the economic value of goods with the prevailing prices in the market for such goods. An application of this valuation method will involve determination of the good or service to be valued and obtaining information on the market prices of such goods. Subsequent calculations are based on the data obtained. This method is however applicable for goods which are sold in the market especially goods that have direct use values.

The travel cost method

This method uses a surrogate market approach in its valuation and is used mainly for valuation of tourism sites like amusement parks, game reserves etc. Valuation of the economic benefits of recreation sites is critical to policy matter and the general public, to enable them integrate ecological perspectives and economic considerations as Chee cited in Kosby et al (2019). The underlying assumption of this method is that the cost of travelling to a site to enjoy a good or service is synonymous with its economic value. It assumes that consumers who live at various locations from the good or service have uniform preferences. Hence the average travel costs (even by researchers) from various locations where the consumers live from the good will serve as the value or worth of that environmental good or service.

The product factor method

This method assumes that the inputs or resources of production have significant impact on the total cost of production. The materials used for this method of valuation are the inputs or raw materials for the process of production. The first step under this method is to ascertain such inputs required and the impact on the production of the good to be valued. These are translated into quantitative terms for the purposes of valuation. The production factor method is obtained by the market price multiplied by the change in the quantity demanded of the good.

Human capital or foregone earning approach:

This method of environmental valuation uses the effect of environmental goods or services on the quality and quantity of labor. It is derived from the knowledge that some environmental goods can have adverse effects to labor when exposed to them which could cause illness, early death etc. The loss earnings approach focuses on the impact which adverse environmental conditions have on human health and the resultant costs to society in terms of income lost through illness, accidents and spending on medical treatments. Wages of the worker are regarded as the capital life earnings of the worker which is an index for his productivity. Hence if exposure to such environmental goods causes early death, his earnings will cease and the society will lose his productivity. Hence this method tries to place a value on the life of the worker using the value of labour.

The Cost Effectiveness Analysis (CEA)

This focusses on efficiency of interventions, analyzing outcomes relative to costs (Steijger; 2023). Its usefulness in valuations is varied. It can be effectively applied to compare total costs (summation of direct and indirect costs) of projects, project outcomes in line with costs, expected impacts of alternatives before and after implementation of intended program. The steps involve in carrying out a cost effectiveness analysis include:

i. Identification of specific policy objective;
ii. Examination of extent to which target objective is met;
iii. Identification of potential sources of pressures and impacts from human and physical activities related to policy objective;
iv. Analysis of which policy intervention can reasonably achieve regulatory targets relative to the specified baseline option;
v. Measurement of costs of policy measures;
vi. Determination of program effectiveness with suitable weighing indicators; and
vii. Ascertaining the cost-effectiveness ratio of different policy measures.

The cost effectiveness ratio is derived by finding the ratio of costs to impact. Hence, it is the net cost ratio. It includes the Marginal Cost Effectiveness Ratio (MCER) which deals with the specific changes that will occur to total costs if the project is increases or decreases in size or scope. The Incremental Cost Effectiveness Ratio (ICER) deals with differences in program costs per additional outcome while the Average Cost Effectiveness Ratio (ACER) compares the net cost with the counterfactual; if the project does not exist. Projects with lower costs are deemed more efficient and of greater worth.

Preventive expenditure method
This method of valuation is used when a damage is expected to occur with respect to an environmental good or service such as water pollution, gas flaring, deforestation, erosion, illegal poaching or fishing etc. It is a valuation method that is based on cost estimates of preventing a damage. Hence, the monetary value people are willing to pay in order to avoid such damages from deforestation, pollution, erosion etc. is the basis for valuation using this approach.

Relocation and replacement methods
Under these methods, valuation estimate is based on the monetary cost estimation of relocating or replacing a damaged environmental good or service such as trees, rivers, a game reserve, tourist center etc.

Dose response method
This method is based on the underlying assumption that environmental goods or services could have a link to negative impacts on humans and other things. For example, increased water pollution levels due to industrial wasted could lead to adverse health effects on immediate community, loss of income from fishing and reduced yield in agricultural productivity. Hence the estimated market prices of such loses are used for computation under this approach.

Opportunity cost method
Opportunity cost is the cost of a forgone alternative. Hence, this method of environmental valuation focuses on the cost of losing an environmental good or service. For example, what will be the cost of uprooting trees in an environment to be replaced by a new road into the community who depend on such trees for firewood, shade, timber etc. It is this form of valuation that is used when governments or donors want to determine the level of compensation to such communities for the loss of that environmental good or service.

Summary

Valuation of environmental goods and services is imperative for households, firms, industries, policy makers and the general public. This chapter has provided an overview on the concept of valuation, basic terminologies, objectives and importance and methods of valuing tangible and intangible goods in the environment. Strict adherence to its principles will provide the basis for sound decision making for assessment of its worth, property rights, compensation plans, protection, conservation and liquidation of environmental resources.

Exercise

1. Explain the meaning of valuation in your own words.
2. State the importance of valuation to policy makers, firms and the general public.
3. Distinguish between use and non-use values in environmental valuation.
4. Distinguish between discounted and undiscounted measures of project worth.
5. Mention and explain seven basic terms used in environmental valuation.
6. Mention and explain five economic valuation tools for tangible environmental goods.
7. Mention and explain six methodologies for valuation of environmental goods and services.

References

Baum, A. and Crosby, N. (2021). Property investment Appraisal. USA: Wiley-Blackwell.

Cooperate Finance Institute (CFI) (2022). Internal Rate of Return: How to use the IRR formula. https://coporatefinanceinstitute.com

Dickie, M. (2017). Averting behavior method. In A Primer on market valuation. 293 -346.

Hoyos, D. and Manel, P. (2013). Contingent valuation: Past, present and future. Prague economic papers. 4, 329 - 343

Kanojia, A., Khan, M. and Jadkar, U. (2016). Valuation of residential properties by hedonic pricing method: A state of the art. ISSN Online 4(4) 2347-2812.

Kosby, N, Shuid, A. Ramach-Chandian, S. and Afaneli (2019). Economic valuation using Travel Cost Method. Journal of Tropical Forest Science. 31(1)78-89.

Madueme, I. S. (2023). The ABC of Economics of Production. Nigeria: JoyIn Publishers.

Salau, L. (2016). Valuation: Meaning And Concepts. Nigerian institution of estate surveyors and valuers.https://www.niesv.org.ng/blog_details.php?articlenumber=Valuation:%20Meaning%20and%20Concepts.

Schidt, J. (2023). Process of determining the present value of a company, investment and asset. www.oratefinanceinstitute.com.

Steijger, D., Chatterjee, C. Groot, W. and Paaviova, M. (2023). Challenges and limitations in distributional cost effectiveness analysis: A systemic literature review. International journal of environmental res public health. 20(1)505.

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CHAPTER 7
Introduction to Valuation of Real Estate
By
IGE Victor Olutope

Overview
This chapter is designed to provide students with an understanding of the fundamental principles of investment mathematics and property valuation. It covers various topics related to simple and compound interest calculations, basic valuation mathematics and different ways of expressing the main components in the formula, such as interest, number of periods and invested capital. Additionally, students will learn about the nature, theories and definitions of value, purposes and functions of valuation. The chapter explores the relationship between income, prices, costs and their impact on value, economic, constitutional, geographical, sociological, environmental, political and legal bases of property value. Also, the principal types of landed property in Nigeria are discussed. Furthermore, the chapters develop students' critical thinking and analytical skills to make informed decisions in the areas of investment mathematics and property valuation.

Objectives
At the end of the chapter, students should be able to:
1. calculate simple and compound interest;
2. apply basic valuation mathematics to determine the value of Nigeria currency (Naira);
3. describe the main components in the valuation formula such as interest (i), number of periods (n), and the invested capital;
4. define the nature and theories of value as well as purposes of valuation;
5. explain the functions of valuers and their roles in determining property value;
6. analyze the relationship between income, prices, cost and value;
7. explain the economic, constitutional, geographical, sociological, environmental, political and legal bases of property value in Nigeria; and
8. identify the principal types of landed property in Nigeria.

Introduction to investment mathematics

Definition of Investment Mathematics
Investment mathematics is a branch of applied mathematics that deals with the quantitative analysis of financial instruments which include stocks, bonds, options and futures. It involves the use of mathematical models and techniques to analyze the behavior of financial markets and make informed investment decisions. Investment mathematics is essential for investors, financial analysts and portfolio managers as it provides a framework for evaluating the risks and returns of different investment opportunities.

Importance of Investment Mathematics

a) Systematic and precise structure for evaluating financial instruments and arriving at well-informed investment choices;
b) Effective management of investment portfolios; and
c) Assessement of the performance of investment portfolios.

Types of investments

1) *Stocks*
2) *Bonds*
3) *Real Estate*
4) *Mutual Funds*
5) *Exchange*

Advantages of investing in real estate

1. Tangible asset
2. Potential for passive income
3. Appreciation Potential
4. Diversification

Disadvantages of investing in real estate

1. Requires significant capital
2. Illiquid asset
3. Market fluctuations
4. Requires expertise

Factors to consider when investing in real estate

1. Location
2. Market conditions
3. Cash flow
4. Financing
5. Investment goals
6. Legal and regulatory factors
7. Exit strategy

Advantages of investing in stocks, bonds, and mutual funds

1. Liquidity
2. Diversification
3. Professional management
4. Accessibility

Disadvantages of investing in stocks, bonds, and mutual funds

1. Market fluctuations
2. No tangible asset
3. No passive income
4. Limited control

Simple interest

Simple interest is a type of interest that is calculated based on the principal amount of a loan or investment which does not take into account any interest that has been accrued over time. Simple interest is often used in short-term loans such as payday loans or bridge financing, where the borrower is expected to pay back the principal amount plus a fixed interest rate within a short period. This can be functionally stated as shown in equation 1.

$$SI = P \times R \times T \tag{1}$$

Where:

SI = Simple Interest.
P = Principal (Amount of money borrowed or invested).
R = Rate (Frequency of Interest, expressed as a percentage).
T = Time (Duration for which the money is borrowed or invested, typically measured in years).

Example 1: If a person borrows ₦ 1,000 at a simple interest rate of 5% per year for a period of 3 years, the simple interest would be calculated based on equation 1 as follows:

SI = ₦ 1,000 x 0.05 x 3
= ₦ 150

Therefore, the total amount the borrower would need to pay back at the end of the 3 years would be ₦ 1,150. That is, ₦ 1,000 (Principal) plus ₦ 150 (Simple Interest).

Example 2: Suppose ₦ 5,000 was invested in a savings account that pays 3% simple interest per year. If the money is left in the account for two years, what would be the earned interest?

SI = ₦ 5,000 x 0.03 x 2 = ₦ 300

Therefore, the total amount in the account after two years would be ₦ 5,000 + ₦ 300 = ₦ 5,300

Advantages of Simple Interest

1) It is easy to understand and calculate;
2) Since the interest rate is fixed, the returns from a simple interest investment are predictable and easy to estimate; and
3) It is suitable for short-term investments where the investor requires liquidity and predictability of returns.

Limitations of Simple Interest

1) It tends to offer lower returns compared to other types of interest calculations, such as compound interest;
2) Since the interest earned is not reinvested, there is no compounding effect.
3) It does not take inflation, which can erode the purchasing power of the returns over time, into account.

Compound Interest

Compound Interest is the type of interest obtained from the principal and the interest accumulated over the previous periods. In other words, compound interest is interest on interest. This is different from simple interest where the interest is only calculated on the initial principal. The formula for its calculation is given by equation 2.

$$A = P\,(1 + r/n)^{nt} \tag{2}$$

Where:

A = Total amount including principal and interest

P = Principal amount
r = Annual interest rate
n = Number of times the interest is compounded per year
t = Number of years
Also, equation 2 can be expressed as shown below.

$$A = P\,(1 + i)^N$$

Where:
i = Periodic interest rate $(i = r/n)$
N = Total number of periods.

Steps for the calculation of Compound Interest.

1. Determine the principal amount (P).
2. Determine the annual interest rate (r).
3. Determine the number of times the interest is compounded per year (n).
4. Determine the number of years (t) for which the interest is compounded.
5. Use equation 2 to calculate A.

Example 3: If ₦ 1,000 is invested at an annual interest rate of 5% compounded monthly for 3 years, the total amount would be:

$$A = 1000\,(1 + 0.05/12)^{(12x3)} = ₦\ 1{,}159.27$$

In the above example, it should be noted that the interest is compounded monthly (n = 12) and the total number of periods is 12 X 3 = 36.

Example 4: Suppose ₦ 5,000 was invested in a savings account with an annual interest rate of 5% that is compounded quarterly. How much will the investor have after 3 years?
Step 1: P = ₦ 5,000
Step 2: r = 5%
Step 3: n = 4 (since interest is compounded quarterly)
Step 4: t = 3
Using equation 2, the total amount (A)including principal and interest (A) can be calculated as follows:
A = ₦ 5,000 $(1 + 0.05/4)^{(4x3)}$
A = ₦ 5,000 $(1.0125)^{12}$
A = ₦ 5,000 (1.445)
A = ₦ 7,225
Therefore, after 3 years, the investor would have a total of ₦ 7,225 in the savings account which includes the principal and the interest earned.

Table 1: Comparison between Compound and Simple Interests

S/N	Main Differences	Compound Interest	Simple Interest
1.	Calculation method	Compound interest is calculated on both the principal and the accumulated interest over time.	Calculated based only on the initial principal amount.
2.	Interest rate	The interest rate for compound interest can change based on the compounding period (i.e., monthly, quarterly, annually).	The interest rate for simple interest remains the same throughout the term of the loan or investment.
3.	Earnings	Compound interest, the earnings increase over time due to the interest being reinvested.	The earnings on the investment or loan are fixed and do not change over time.
4.	Time value of money	Compound interest takes into account the time value of money, as the interest earned is reinvested	Simple interest does not
5.	Return on investment	Yields a higher return on investment due to the compounding effect	Yields a lesser return

Basic valuation mathematics

Valuation mathematics is the application of mathematical concepts and techniques to determine the value of an asset which includes real estate. The valuation process for real estate typically involves analyzing various factors that contribute to the property's value such as location, physical condition, market demand and comparable sales data. This analysis is often done using mathematical models and tools to calculate the present value of future cash flows, the return on investment and other financial metrics.

Importance of valuation mathematics in real estate

Some of the key reasons why valuation mathematics is important in real estate are:

1. Investment analysis
2. Financing
3. Taxation
4. Insurance
5. Listing and selling properties

Amount of one-naira calculations

The amount of one naira is a concept used in real estate valuation to determine the future value of a single unit of money invested in a property. It represents the amount of money that an investor can expect to receive in the future for each naira invested in the property today. The formula for calculating the amount of one naira in real estate valuation is given by equation 3.

$$AN = FV / PV \quad (3)$$
$$FV = PV \times (1 + IR)^n \quad (4)$$

Where:
AN = Amount of One Naira
FV = Future Value of Investment (The expected value of the investment at a future point in time).
PV = Present Value of Investment (The current value of the investment)
n = Number of periods
IR = Interest Rate

Examples 5: Assuming an investor is considering investing in a real estate property with a current value of ₦ 10,000,000. If the investor expects the property to appreciate at an annual rate of 10%, what is the amount of one naira invested in the property?
Using equations 3 and 4, it can be determined that:
FV = 10,000,000 x $(1 + 0.01)^1$ = ₦ 11,000,000
AN = 11,000,000/10,000.000
= ₦ 1.1
Therefore, it can be inferred that for every naira invested in the property today, the investor can expect to receive ₦ 1.10 in the future.

Present value of one-naira calculations
The present value of one naira is the amount of money that a single unit of currency today would be worth in the future, taking into account the effects of time and interest rates. It is calculated by discounting the future value of the currency back to its present value using a suitable discount rate.
The formula for calculating the present value of one naira is as follows:

$$PVN = FVN/(1 + DR)^n \quad (5)$$

Where:
PVN = Present Value of one naira
FVN = Future Value of one naira
DR = Discount Rate
n = Number of Periods
Alternatively, the PVN can be expressed as an inverse of the Amount of ₦ 1 as follows:

$$PVN = 1/AN \quad (6)$$

Where:
AN = Amount of N1 expressed as: $AN = (1 + IR)^n$
Therefore, in order to calculate the present value of one naira, the future value of the currency and the appropriate discount rate and number of periods must be determined.

Example 6: If the expected value of one naira is to be ₦ 1.10 in one year and the discount rate is 5%, what will be the present value of one naira?
PVN = 1.10 / $(1 + 0.05)^1$
= ₦ 1.05

Example 7: An investor is considering purchasing a rental property that generates an annual net cash flow of ₦ 100,000. If the investor expects to hold the property for five years and the discount rate is

10%. What is the present value of the net cash flows generated by the property over the five years?
PVN = 100,000 / $(1 + 0.10)^1$ + 100,000 / $(1 + 0.10)^2$ + 100,000 / $(1 + 0.10)^3$ + 100,000 / $(1 + 0.10)^4$ + 100,000
/$(1 + 0.10)^5$
= ₦ 322,000
Therefore, the present value of the net cash flows generated by the rental property over the five years is
₦322,000.

The interrelationship between the amount of one naira and the present value formula
In real estate valuation, it is essential to understand the interrelationship between the amount of one naira and the present value formula. This understanding enables real estate professionals to make informed decisions and evaluate the financial feasibility of real estate investments. The amount of one naira refers to the value of a naira today while the present value formula calculates the value of future cash flows in today's terms. Therefore, the two concepts are related because the amount of one naira is used to calculate the present value of future cash flows.

Examples of how the two concepts are used together in real estate valuation
Example 8: Assuming an investor is considering two real estate investment opportunities. Investment A is expected to generate cash flows of ₦ 500,000 per year for the next ten years while Investment B is expected to generate cash flows of ₦ 750,000 per year for the next five years. Assuming a discount rate of 10%, the present value of Investment A is ₦ 3,486,850 while the present value of Investment B is ₦ 3,254,152. Therefore, the investor should choose Investment A even though Investment B has higher annual cash flows. This example illustrates how the interrelationship between the amount of one naira and the present value formula is used to compare different investment opportunities.

Different ways of expressing the main components in the formula such as interest (i), number of (n) and the capital invested
Interest (i), number of periods (n) and capital invested (C) are the main components in the formula used for real estate valuation. Interest refers to the rate at which money grows over time while the number of periods is the length of time the investment will last. Capital invested is the amount of money invested in the real estate project. There are several ways to express interest, number of periods and capital invested in the real estate valuation formula. For example, interest can be expressed as a percentage, a decimal or in a nominal or real sense. The number of periods can be expressed in years, months, quarters, or any other relevant period. Capital invested can be expressed as a lump sum amount or as a series of payments made over time.

Illustration on how to express interest, number of periods, and capital invested
Example 9: An investor wants to calculate the present value of the expected future cash flows. The investment requires an initial capital investment of ₦ 500,000 and will generate annual cash flows of ₦ 50,000 for the next five years. Assuming a 10% interest rate, the number of periods can be expressed in years.
The formula for calculating the present value of the cash flows is given as equation 7.

$$PVC = C / (1 + IR)^n \qquad 7$$

Where:
PVC = present value of the cash flows,
C = Capital invested,

Using the above example, the interest rate can be expressed as 0.10, the number of periods as 5 years and the capital invested as ₦ 500,000.

Therefore, PVC = 500,000 /(1 + 0.10)^5

= ₦ 305,379.35

Nature/Theories and Definitions of Value

The nature of value and the theories that explain it vary depending on the context. In the context of real estate, value is typically defined as the worth of a property or asset in terms of its exchange value which is the amount of money that a willing buyer would pay to a willing seller in an arm's length transaction.

Key theories of value

a) Market value theory
b) Cost Approach

Value is a concept that has different meanings in different contexts.

1) In economics, value refers to the worth of a product or service in terms of its utility or usefulness to the consumer.
2) In real estate, value refers to the worth of a property or asset in terms of its market demand and the conditions of supply and demand.

Definitions and Purposes of Valuation

Valuation has been variously defined by different authors in the field of real estate. Some of the definitions include:

1. Valuation is the act or process of estimating value (Appraisal Institute, 2021).
2. Valuation is the process of determining the value of an asset or liability as of a specified date, based on the expected future benefits and risks associated with the asset or liability (International Valuation Standards Council (IVSC), 2021).
3. Weston and Brigham (2013) defined valuation as "the process of estimating the worth of an asset or a liability.
4. Pennington and O'Connor (2016) defined valuation as "the process of determining the value of an asset or a liability by using one or more valuation techniques."
5. The Royal Institution of Chartered Surveyors (RICS) defined valuation as "the process of estimating the market value of real estate assets, securities, or intangibles" (RICS, 2017).
6. Brueggeman and Fisher (2011) defined valuation as "the process of estimating the value of a property or asset based on a set of assumptions about the market, the property, and the surrounding environment."
7. Valuation is the process of determining the value of an asset, liability, or equity interest, using one or more valuation techniques, based on a set of assumptions and expectations about the future (Miles and Berens, 2014).

Valuation has various purposes. These include:

a. Transactional,
b. Accounting, and
c. Legal purposes.

Functions of a Valuer

A valuer is a professional who is trained to determine the value of a property or asset. The roles of a valuer include:

1. Conducting market research to determine current market conditions.

2. Inspecting the property or asset to assess its condition, features, and potential income.
3. Selecting appropriate valuation methods and approaches based on the nature of the property or asset.
4. Analyzing market data, such as comparable sales and rents, to determine the market value of the property or asset.
5. Preparing a valuation report that summarizes the findings and conclusions of the valuation.

Income, prices, cost and their relation to value

Income refers to the money that an individual or organization earns from their economic activities such as wages, salaries, profits, or interest.

Prices refer to the amount of money that is charged for a particular good or service. Prices are determined by the interaction of supply and demand in a market and reflect the relative scarcity of the good or service in question. In a competitive market, prices will tend to move towards the level at which supply equals demand.

Cost refers to the expenses that are incurred in the production of a good or service.

The *value* of a good or service is ultimately determined by the preferences and needs of consumers. A good or service that is in high demand and scarce relative to its supply will generally command a higher price, while a good or service that is abundant and not in high demand will tend to have a lower price. The cost of production also plays a role in determining the value of a good or service as producers will only be willing to supply a good or service if they can cover their costs and make a profit.

Relationship between Income, Prices, Cost, and Value

The relationship between income, prices, cost, and value is complex. The value of a property is influenced by all of these factors and not just one. For instance, a property with a high-income stream may have a higher value, but its value may be limited by the cost of reproducing or replacing it. Similarly, a property in a high-demand area may have a high market price, but its value may be limited by the cost of construction or the income stream it generates.

The economic constitutional, geographical, sociological, environmental, political and legal bases of property value

The value of a property is influenced by various factors. These include the economic, constitutional, geographical, sociological, environmental, political and legal bases of property value. These bases of property value can be broadly categorized as follows:

1) Economic Basis: Property value is influenced by the supply and demand of real estate in the market. Economic factors such as inflation, interest rates and economic growth also affect property value.
2) Constitutional Basis: The rights to ownership, use, and transfer of property are governed by the Constitution, which affects property value.
3) Geographical Basis: Property value is affected by the location and physical features of a property, such as proximity to amenities, transportation, and natural resources.
4) Sociological Basis: Property value is influenced by social factors such as demographics, lifestyle, and cultural norms.
5) Environmental Basis: Environmental factors such as climate, natural disasters, and pollution can affect property value.
6) Political Basis: Property value can be influenced by political factors such as government policies, taxes and regulations.

7) Legal Basis: Property value is influenced by laws and regulations governing real estate transactions, such as zoning laws and property rights.

Principal types of landed property in Nigeria

a) Residential Property: It includes properties used for living purposes such as apartments, bungalows, duplexes and mansions.
b) Commercial Property: This includes buildings and land used for commercial purposes such as offices, shops, malls and hotels.
c) Industrial Property: It includes properties such as factories, warehouses and storage facilities.
d) Agricultural Property: It includes properties such as farmland, ranches, and plantations. Agricultural properties are typically located in rural areas and are influenced by factors such as soil quality, topography, climate and proximity to markets.

Summary

Investment mathematics is a vital tool in understanding and analyzing financial instruments such as stocks, bonds, options, futures, and real estate. This branch of applied mathematics deals with the quantitative analysis of such instruments, providing investors with valuable insights into how to invest their money wisely. Investing in real estate offers tangible assets, passive income, appreciation potential and diversification but it requires significant capital, an illiquid asset which is subject to market fluctuations and expertise. When investing in real estate, investors must consider location, market conditions, cash flow, financing, investment goals, legal/regulatory factors and exit strategies. Stocks, bonds and mutual funds offer liquidity, diversification, professional management and accessibility which are subject to market fluctuations, no tangible asset, no passive income and have limited control. Valuation mathematics is essential in real estate for investment analysis, financing, taxation, insurance and listing and selling properties. The amount of one naira and the present value of one naira are key concepts used in real estate valuation to determine the future value of a single unit of money invested in a property.

Exercise

1. Find the present value of an investment that will be worth N 50,000 in 5 years, assuming a 3% annual interest rate.
2. Calculate the compound interest earned on an investment of N 1,000 for 5 years at an annual interest rate of 8%, compounded annually.
3. Determine the annual simple interest earned on an N 5,000 investment at a 4% interest rate over a period of 3 years.
4. Discuss the advantages and disadvantages of investing in real estate compared to other types of investments, such as stocks, bonds, and mutual funds.
5. What factors should investors consider when deciding whether to invest in real estate?
6. What is basic valuation mathematics and how does it relate to real estate valuation?
7. What is the present value of one naira and how is it used in real estate valuation?
8. Assuming an annual interest rate of 6%, what will be the amount of Naira 1 in 5 years?
9. Identify and discuss the different theories and definitions of value in real estate valuation.

References

Adegbaju, A. A. (2016). Investment mathematics and financial analysis. Lagos: Albedo Publishers.

Appraisal Institute (2021). Appraisal Glossary. Retrieved from https://www.appraisalinstitute.org/glossary.

Baker, H. K. and Nofsinger, J. R. (2018). Investments: An introduction. Cengage Learning.

Johansson, S. (2018). The interrelationship between the amount of one naira and the present value formula. Journal of Investment Strategies, 7(3), 31-42.

Brueggeman, W. B. and Fisher, J. D. (2011). Real Estate Finance and Investments. McGraw-Hill.

International Valuation Standards Council (2021). What is Valuation? Retrieved from https://www.ivsc.org/about-ivsc/what-is-valuation

Miles, M. B. and Berens, G. (2014). Toward an understanding of why valuation errors occur: A framework for systematic analysis. Journal of Applied Corporate Finance, 26(4), 71-78.

Olowe, R. A. (2019). Introduction to property valuation. Lagos: Concept Publications.

Pennington, R. and O'Connor, P. (2016). Property Valuation: The Five Methods. Routledge.

Royal Institution of Chartered Surveyors (2017). Red Book Global Standards 2017. Retrieved from https://www.rics.org/globalassets/rics-website/media/upholding. Professional-standards/sector- standards/valuation/red-book-2017-valuation-standards-global-1st-edition.pdf.

Ross, S. A., Westerfield, R. W. and Jaffe, J. F. (2019). Corporate finance (12th ed.). McGraw-Hill Education.

Weston, J. F. and Brigham, E. F. (2013). Essentials of managerial finance. Cengage Learning.

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CHAPTER 8
ECONOMICS of ENVIRONMENTAL MANAGEMENT
By
ABDULLAHI Amina Sheikh and IBRAHIM Ahmed Maigari

Overview

Environmental economics is the study of the cost-effective allocation, use and protection of the world's natural resources. Economics, broadly speaking, is the study of how humans produce and consume goods and services. Environmental economics focuses on how they use and manage finite resources in a manner that serves the population while meeting concerns about environmental impact. This helps governments weigh the pros and cons of alternative measures and design appropriate environmental policies. The main focus of environmental economics is to maintain a balance between economic development and environmental quality. In order to achieve this, environmental economists have to explore the various socio-economic possibilities to reduce pollution and uplift the standard of living of the people. Environmental economics attempt to tackle environmental problems from an economic welfare framework. The welfare framework covers scarce resources and market failures due to property rights and ethical aspects of different problems of pollution. Thus, it suggests the best possible means to tackle the environmental problems. Environmental issues are about resources. The neo-classical economists have analyzed the use of various resources like fisheries, forests, fossil fuels and water in a rational manner as well as with environmental values. In fact, environmental values are economic values. It is important for the society to conserve its limited resources in the interest of economic efficiency and welfare. Environmental economics can generally be treated under the introduction to environmental economics, natural resource economics, pollution and environmental quality,
valuation of environmental resources, international environmental issues, environmental policy and management and environmental justice.

Objectives

At the end of this chapter, students should be able to:

1. explain the role of natural resource economics and management as a subfield of environmental economics that focuses on the economic and environmental management of natural resources;
2. explain pollution and environmental quality as important topics in environmental economics;
3. discuss the role of economic valuation of environmental goods and services and mention how it can help to inform policy decisions related to environmental management, conservation, and development; and
4. analyze cost-benefit relationship, as a tool that can be used to evaluate the economic efficiency of environmental policies.

The history/origin of environmental economics

The origin of environmental economics dates back to the 1960s, when industrialization was experiencing a boom, particularly in the western world and pollution from industrial activity became an increasing concern. Also, environmental activism started to increase due to the perceived negative consequences of environmental degradation. The world became aware of rapid economic growth and its consequences to the environment. Environmental economists see the environment as a form of natural capital that provides amenities and life support functions to the earth's inhabitants. Environmental economics was premised on the neoclassical approach dealing with issues such as inefficient natural resource allocation, market failure, negative externalities and management of public goods. As the movement developed over time, other intricate details on the relationship between the environment and the economy became apparent. The study brought about powerful environmental arguments and propositions, which gave rise to contemporary environmental policies and regulations around the world. It led to the establishment of new environmental bodies like the United Nations Environment Programme (UNEP) in 1972.

Natural resource economics and management

This is a subfield of environmental economics that focuses on the economic and environmental management of natural resources, such as forests, fisheries, minerals and water. Some of the key topics in natural resource economics and management include:

1. **Resource depletion and conservation**: Natural resources are finite and can be depleted over time if not managed properly. Resource conservation aims to ensure the sustainable use and management of natural resources in order to maintain their availability for future generations;
2. **Property rights and access:** Property rights play a crucial role in the management of natural resources, as they determine who has the right to use and benefit from a resource. Also, access to natural resources is an important consideration, particularly for marginalized communities that rely on natural resources for their livelihoods;
3. **Market-based instruments:** Market-based instruments, such as tradable permits and taxes can be used to manage natural resources by creating incentives for conservation and reducing waste;
4. **Common-pool resources:** Common-pool resources, such as fisheries and forests, are resources that are owned by no one and are available to all. The management of common-pool resources can be challenging as users may have competing interests and incentives to overuse the resource; and
5. **Ecosystem services:** Ecosystem services are the benefits that humans derive from natural ecosystems, such as clean water, air, and soil. The economic valuation of ecosystem services can help to inform natural resource management decisions.

Pollution and Environmental Quality

Pollution and environmental quality are important topics in environmental economics, as they can have significant economic and health impacts. Some of the key topics related to pollution and environmental quality include:

1. **Types of pollution:** Pollution can take many forms which include air pollution, water pollution and soil contamination. Each type of pollutions can have different impacts on human health and the environment;

2. **Economic costs of pollution:** Pollution can have significant economic costs, including health care costs, lost productivity and environmental damages. These costs can be difficult to quantify but are important considerations in policy decisions related to pollution control;
3. **Market-based pollution control:** Market-based instruments, such as pollution permits and taxes, can be used to control pollution by creating incentives for firms to reduce their emissions. These instruments can be more efficient than traditional command-and-control regulations, as they allow firms to find the least-cost way of reducing their pollution;
4. **Environmental regulation:** Environmental regulations, such as emissions standards and clean water regulations, are another way to control pollution. These regulations can be effective but may be more costly than market-based instruments; and
5. **Valuation of environmental quality:** The economic valuation of environmental quality can help to inform policy decisions related to pollution control. Methods for valuing environmental quality include contingent valuation, stated preference methods and revealed preference methods.

Micro-economic principles and concepts

Micro-economic principles and concepts are fundamental to understanding environmental economics as they provide the theoretical framework for analyzing the behaviour of individuals, firms and markets. Some of the key micro-economic principles and concepts, relevant to environmental economics, include:

1. **Supply and demand:** The law of supply and demand is a fundamental principle of micro-economics, which states that the price of a good or service will adjust until the quantity supplied equals the quantity demanded. In the context of environmental economics, supply and demand analysis can be used to analyze the market for environmental resources such as pollution permits or renewable energy credits;
2. **Externalities:** These are costs or benefits of economic activity that are not reflected in market prices and can have negative or positive impacts on third parties. In the context of environmental economics, externalities can arise from pollution, habitat destruction or other activities that impact natural resources or the environment;
3. **Market failure:** This occurs when the market fails to allocate resources efficiently, resulting in suboptimal outcomes for society as a whole. In the context of environmental economics, market failure can occur when externalities are not internalized or when environmental resources are treated as common property and subject to overuse or depletion;
4. **Marginal analysis:** This involves examining the additional benefits and costs of a decision in order to determine the optimal level of output or consumption. In the context of environmental economics, marginal analysis can be used to determine the optimal level of pollution abatement or resource conservation;
5. **Cost-benefit analysis:** This involves comparing the costs and benefits of a policy or project in order to determine whether it is worth pursuing. In the context of environmental economics, cost-benefit analysis can be used to evaluate the economic and environmental impacts of different policy options, such as pollution control measures or renewable energy investments;

Valuation in Environmental Economics

Valuation of environmental goods and services is an important area of environmental economics. The economic valuation of environmental goods and services can help to inform policy decisions related to environmental management, conservation and development. Some of the key topics related to the valuation of environmental goods and services include:

1. **Methods of valuation:** There are several methods that can be used to value environmental goods and services. These include contingent valuation, travel cost method, hedonic pricing method, and ecosystem services valuation;
2. **Non-use values:** Non-use values are the values that individuals place on environmental goods and services even if they do not use or directly benefit from them. Non-use values include existence value, option value and bequest value;
3. **Use values:** These are the values that individuals place on environmental goods and services that they use or directly benefit from, such as recreation and tourism.
4. **Benefit-cost analysis**: This is a method of comparing the costs and benefits of a project or policy, including the environmental impacts of the project or policy. Valuation of environmental goods and services is an important component of benefit-cost analysis.
5. **Sustainable development:** Valuation of environmental goods and services can help to inform policy decisions related to sustainable development including decisions related to resource use, conservation and development.

Cost-benefit analysis

Cost-benefit analysis is a tool that can be used to evaluate the economic efficiency of environmental policies. It involves comparing the costs of an environmental policy to the benefits it generates. The benefits of an environmental policy can include the value of environmental goods and services that are protected or restored as well as any indirect benefits such as improved public health or increased economic productivity. Some key topics related to the cost-benefit analysis of environmental policies include:

1. **Discounting:** It is a technique used in cost-benefit analysis to account for the fact that benefits and costs that occur in the future are worth less than those that occur in the present;
2. **Uncertainty:** Cost-benefit analysis involves making predictions about future costs and benefits, which can be uncertain. Techniques such as sensitivity analysis and Monte Carlo simulation can be used to account for this uncertainty;
3. **Distributional impacts:** Environmental policies can have distributional impacts, meaning that they may affect different groups of people in different ways. Cost-benefit analysis can be used to assess the distributional impacts of environmental policies;
4. **Environmental justice:** Cost-benefit analysis can be used to assess the environmental justice implications of environmental policies by evaluating how the costs and benefits of a policy are distributed among different demographic groups; and
5. **Trade-offs:** Cost-benefit analysis can be used to identify trade-offs between different environmental policies by comparing their costs and benefits.

Summary

This chapter discussed the roles of environmental economics in environmental and natural resource management. It revealed how economics can be used to manage finite resources for the present and future generations. Also, the chapter examined basic economic concepts as they relate to environmental management. Environmental economics is an important tool in making environmental policies and aids policy makers in taking informed decisions. Environmental economics is an evolving discipline that developed as a result of environmental damage caused by economic activities and the pursuit of sustainable development.

Environmental economics aim to tackle environmental problems from an economic welfare framework. Thus, it suggests the best possible means to tackle environmental problems. It is concerned with the design of environmental policies and their implementation. Environmental economics was premised on the neoclassical approach dealing with a number of issues such as inefficient natural resource allocation, market failure, negative externalities and management of public goods.

Exercise

1. Mention the roles of economics in environmental policy.
2. Define the basic economic concepts and principles of supply and demand, market equilibrium and externalities.
3. Identify and discuss renewable and non-renewable resources.
4. What are the causes of resource depletion?
5. Mention the costs and benefits of environmental policies.
6. Mention how to handle uncertainties and risk assessment in environmental management.
7. What is the relationship between environmental pollution and market values?
8. Mention the conditions of tradable permits and emissions trading.
9. Give examples of environmental economics in practice.
10. Draw the organogram and explain the policy-making process.
11. Define the environmental regulation and enforcement policy.

References

Arrow, K., Cropper, M., Eads, G., Hahn, R., Lave, L., Noll, R., Portney, P., Russell, M., Schmalensee, R., Smith, V., and Stavins, R. (1996). Is there a role for benefit-cost analysis in environmental, health
and safety regulation? Science, 272(5259), 221-222.

Boardman, A. E., Greenberg, D. H., Vining, A. R. and Weimer, D. L. (2017). Cost-benefit analysis: Concepts and practice. Cambridge University Press.

Brown, G. K. and Shogren, J. F. (1998). Economics of natural resources and the environment. Prentice Hall.

Conrad, J. M. and Hilchey, D. (2010). Resource economics: An economic approach to natural resource and environmental policy. John Wiley & Sons.

Hanley, N., Shogren, J. F. and White, B. (2013). Introduction to environmental economics. Oxford University Press.

Johansson, P. O. (2006). The economics of ecosystems services and biodiversity: An introduction.
Environmental and Resource Economics, 39(1), 1-7.

Mankiw, N. G. (2014). Principles of microeconomics. Cengage Learning.

Perman, R., Ma, Y., McGilvray, J. and Common, M. (2011). Natural resource and environmental
economics. Pearson Education.

Ready, R., Navrud, S. and Day, B. (Eds.). (2015). Environmental valuation in developed countries: Case studies. Springer.

Smith, V. K. (2000). Environmental economics: In theory and practice. Palgrave.

Tietenberg, T. and Lewis, L. (2016). Environmental and natural resource economics. Routledge.

https://corporatefinanceinstitute.com/resources/economics/environmental-economics/ accessed on 4/04/2023.

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CHAPTER 9

PRINCIPLES of LAND ECONOMICS I

By

AKINBOGUN Solomon Pelumi

Overview

Land Economics is the study of the economic aspect (use and allocation) of land and environmental resources such as housing and public utilities. It deals with all those forces that affect the demand and supply of land as a resource and as a factor of production. That is, those forces which influence optimum allocation of the resource land during the production process of consumer goods and services. According to Young and Lambert (2014), land economics involves the application of economic principles to the use and management of land, natural resources and the environment. It considers a range of factors that affect land use decisions which include property rights, zoning regulations, environmental regulations, market forces, social and political factors. One of the most significant characteristics of land is that its scarce, relative to the total flow of goods and services which the human society desires to produce. This relative scarcity correspondingly creates a need for their efficient allocation in the process of production so that the result of their combination can help satisfy the human needs as fully as possible. Basically, the study of land economics is divided into two which are rural land economics and urban land economics.

Objectives

At the end of this chapter, students should be able to:

1. explain the basic principles of land economics;
2. describe the concept of land;
3. apply the basic concept of economics to land;
4. describe the characteristics of land;
5. discuss land market, its demand, supply and the price mechanism;
6. explain the theories of consumption;
7. describe the nature of land as investment; and
8. explain the basic concept of highest and best use.

Basic principles/assumptions of land economics

Scarcity: Land is a finite resource and its supply is limited. As a result, there is competition among different users of land for its use which creates scarcity.

Location: The value of land is largely determined by its location. Land in areas with high demand such as urban areas, is generally more valuable than land in less populated or rural areas.

Externalities: Land use decisions can have spillover effects or externalities on other parties. For example, a factory located near a residential area may create pollution that affects the health of nearby residents.

Productivity: The value of land is also influenced by its productivity which refers to the amount and

quality
of goods and services that can be produced from the land.
Public goods: Land can be a source of public goods such as parks, forests and other natural resources that
provide benefits to society as a whole.
Inter-temporal allocation: Land use decisions can have long-term consequences and it is important to
consider the inter-temporal allocation of land resources over time.
Land-use planning: This is an important tool for managing land resources and ensuring that land is used in
a way that maximizes its benefits for society.

Characteristics of land

Land is a natural resource with various characteristics which include:

1. **Limited supply:** Land is a finite resource and its supply is limited. It cannot be created artificially and its
quantity is fixed;
2. **Permanence:** Land is permanent in nature and remains in existence as long as the earth exists. Although, it
can be improved but its basic characteristics cannot be changed;
3. **Heterogeneous:** Land is not uniform. It differs in quality, fertility and other attributes depending on its location
and geological characteristics;
4. **Immobile:** Land cannot be moved from one place to another. This immobility makes location a critical factor
in the value of land;
5. **Interdependence:** The value of land is influenced by its relationship with other natural resources such as
water, minerals and timber which are often found on or beneath it;
6. **Economic rent:** Land generates economic rent which is the income earned from its use. Economic rent
arises from the scarcity of land and its ability to produce income;
7. **Multiple uses:** Land can be used for a wide range of activities such as agriculture, forestry, mining, recreation
and urban development. Its value depends on the most profitable use; and
8. **Inelastic supply:** The supply of land cannot be increased or decreased in response to changes in demand.
As a result, changes in demand can have a significant impact on the value of land.

Concept of land

From a layman point of view, land is the part of the earth's surface that is not covered by water. However, the term 'land' in economics is often used in a wider sense. It does not mean only the surface of the soil, it comprises all naturally occurring resources whose supply is inherently fixed. Examples are any and all particular geographical locations, mineral deposits, forests, fish stocks, atmospheric quality, geostationary orbits and portions of the electromagnetic spectrum. Property and conveyancing law of Western Nigeria states that land includes land of any tenure, buildings or parts of buildings (whether the division is horizontal, vertical or made in any other way) and other corporal hereditaments and an easement, right, privileged or benefit in, over or derived from land. By implication, ownership claim can be exercised more than just the physical surface. This is expressed in a Latin maxim "*cuiusestsolum, euisestusqueadcoelum et ad inferos"*. This may be translated as "he who owns the surface also indefinitely owns upwards and downwards from the surface. The grant of land includes the surface and that is above, houses, trees, fixtures and the like and all that is below. Items attached to the land falls into three categories namely; fixtures (plumbing fixtures), chattel (personal goods) and other things that becomes parts and parcel of the land. Whether or not certain attachment becomes part of the land is a matter of common sense. The tendency to treat a fixture as a land depend on two major factors. First is the degree of annexation, second is the purpose of such annexation. The more firmly a thing is attached to the land, the more the presumption. This may be rebutted by the following evidences that it is not the intention behind fixing the things to the land:

1. A conveyance of land;
2. The express agreement of sale of land and not good; and
3. Where land is mortgaged, the security includes fixtures (unless specifically excluded) and fructus naturales.

Properties of land

1. Land is a unique type of factor of production which possesses the following properties:
2. Free gift of nature and its supply is inelastic;
3. Land is a primary factor of production;
4. Land is a passive factor of production;
5. Land is immovable;
6. Land has some original indestructible powers;
7. Land differs in fertility; and
8. Land is permanent.

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Principal types of land use

1. Residential land use;
2. Commercial land use;
3. Institutional land use;
4. Industrial land use;
5. Agricultural land use; and
6. Recreational land use.

Concept of rent

According to Malthus (1766-1834), as population increases faster than the food supply, there is an increase in the demand for agricultural products. Land differs in fertility, whereas, the labour and capital applied to different areas yielded different results. The difference in productivity of the best land over the poorer constituted a surplus which went to the landlord as rent.

Classical theory of rent

The classical theory of rent is associated with Malthus (1766-1834) and David Ricardo (1772-1823). Malthus agreed with the Physiocrats that land produced more than enough to maintain those who tilled it. He added to his own observation that population tended to increase faster than the food supply, resulting in increasing demand for agricultural products. Also, it was stated that land differs in fertility and the labour and capital applied to different areas yielded different results. The difference in productivity of the good land over the bad constituted a surplus which goes to the landlord as rent. Ricardo's statement on the concept of rent is not greatly different from that of Malthus. Their assumption and principle are quite similar. However, Ricardo's approach was more systematic and a little more detailed. According to Ricardo, rent is that portion of the produce of the earth which is paid to the landlord for the use of the original and indestructible powers of the soil. There is no rent when land of nearly equal fertility is present in sufficient abundance to supply human needs.

The modern/neoclassical theory of rent

In the modern theory of rent, the concept of economic rent has been generalized and extended to the surplus payments made to other factors of production besides land. Ricardo regarded land as a free gift of nature and considered the whole earnings of land as the economic rent. Later on, his concept of rent has been extended to designate a part of earnings of other factors of production labour, capital and entrepreneurial ability over and above the minimum necessary income required to induce the factors to do their work. Thus, in accordance with Ricardo's concept, from the social point of view, Joan Robinson say "The essence of the conception of rent is the conception of a surplus earned by a particular part of a factor of production over and above the minimum earnings necessary to induce it to do work." Thus, in modern economic theory, economic rent is not merely confined to land, it also refers to the surplus payments made to some units of other factors over and above what is necessary to keep them in the present industry or use. Thus, the units of other factors may also earn economic rent. In the semblance of the principle of marginal productivity, it has been applied by the neoclassical school to all factors of production. The concept of rent is, however, not limited to natural resources. In the semblance of the principle of marginal productivity it has been applied by the neoclassical school to all factors of production.

Types of rent

Rent can be classified into different types as:

1. **Contract rent:** Contract rent refers to the total amount of money paid as a hiring charge or for the use of land. It is the amount of money paid to a landlord for allowing the tenant to use a piece of land or landed properties. It could be higher or lower than the open market rent.

2. **Economic rent:** The classical economists used the term economic rent as that part of the total payment which is made for the use of land only as distinguished from the payment made for the capital invested therein. Suppose a tenant is paying N20,000 per annum to his landlord, this amount represents the contract rent. If N5,000 represents interest on capital invested, the remaining N15,000 which is the actual amount paid for the use of the land is the economic rent.

3. **Commercial rent:** Commercial rent is the payment for the use of land which consist of two components namely; transfer earning and the economic rent. *Transfer Earnings* represents the amount which a factor can earn in its next best paid alternative use.

4. **Gross rent:** Gross rent is the total rent paid for the services of land and the capital invested on it before deducting the cost of outgoings. Outgoings may include the cost of repair, security, taxes etc. Gross rent consists of economic rent, interest on capital invested for improvement of land and reward for risk taken by landlord in investing his capital.

5. **Scarcity rent:** This rent refers to the price paid for the use of the homogeneous/similar land when its supply is limited in relation to demand. If all land is homogeneous but demand for land exceeds its supply, the entire land will earn economic rent by virtue of its scarcity. In this way, rent will arise when supply of land is inelastic. Prof. Ricardo opined that land was beneficial but it was also scarce. Productivity of land was indicative of the generosity of nature but its total supply remaining more or less fixed symbolized niggardliness of

6. **Differential Rent:** This is the rent paid due to the differences in the fertility of land. In every country, there exists a variety of land. Some lands are more fertile while some are less fertile. When the farmers are compelled to cultivate less fertile land, the owners of more fertile land get relatively more production. This surplus which arises due to difference in fertility of land is called the differential rent. This type of rent arises under extensive cultivation. According to Ricardo, "In order to increase production on same type of land, more units of labour and capital are employed".

Land market

Land market refers to the exchange of land as a commodity, where land is bought and sold like any other good or service. It is a critical component of the broader real estate market and can have significant impacts on the economy, social welfare and environment. It operates on the principles of supply and demand, with the price of land determined by the interaction of these two factors. The supply of land is generally fixed as land is a finite resource, although new land can be created through reclamation or land-use changes. The demand for land, however, is determined by various factors such as population growth, economic development and urbanization. Land markets are typically characterized by high transaction costs and significant information asymmetry which can make it difficult for buyers and sellers to reach efficient outcomes. For example, buyers may have incomplete information about the quality of land or the zoning regulations affecting a particular parcel. Additionally, the transfer of land ownership can involve complex legal processes which can further increase transaction costs. Public policies, such as land-use regulations and tax policies, can have significant impacts on the land market. For example, zoning regulations can restrict the use of land for certain purposes such as residential or industrial development. Property taxes can also influence the demand for land as higher taxes may discourage development and reduce the value of land.

Theories of land asset prices

1. **Location Theory**: The value of land is primarily determined by its location. The closer the land is to centers of economic activity, such as urban areas, transportation hubs and commercial centers, the more valuable it is likely to be (Duranton, 2020 and Akinbogun and Jones, 2018);
2. **Supply and demand theory**: This theory suggests that land prices are determined by the interaction of supply and demand. If demand for land increases, prices will rise and vice versa. Similarly, if the supply of land is limited, prices will be higher;

3. **Capitalization theory:** This says that land prices are based on the net present value of the expected future income streams that the land can generate. This income can come from rent, crop yields or other sources. The price of land is determined by the expected future income stream, discounted to reflect the time value of money;
4. **Expectations theory**: This suggests that land prices are based on the expectations of future changes in demand and supply. Investors and speculators may purchase land based on their expectations of future demand, which can drive up prices;
5. **Hedonic pricing theory:** This says that land prices are determined by the characteristics of the land, such as its location, size, soil quality and other amenities. Buyers and sellers consider these characteristics when determining the price of land; and
6. **Auction theory**: This suggests that land prices are determined by the competitive bidding process in auctions. The highest bidder wins and the price is determined by the willingness of bidders to pay for the land.

These theories are not mutually exclusive. That is, land prices may be influenced by multiple factors at the same time.

Demand for land

The demand for land refers to the desire or willingness of individuals, organizations or governments to acquire or use land for various purposes. This can arise due to a variety of reasons such as population growth, urbanization, economic development, environmental conservation or infrastructure development. The demand for land can be classified into different types, including residential, commercial, industrial, agricultural and public. Residential land is the land used for housing purposes while commercial land is used for business and commercial activities such as shopping centers, office buildings and hotels.

Global demand for land

There are about 15 billion hectares of land worldwide. About 2 percent of this area is covered by cities and infrastructures (built-up land). Built-up land is expected to cover 4 to 5 percent of the global land area by 2050. In many cases, built-up area expansion occurs at the expense of agricultural land. Countries with very low land productivity dominated by grassy landscapes and savannahs which are often being farmed very extensively rank among the ten countries with the highest actual land demand. The United States of America (USA), Japan and EU countries stand out because of their high import rates which is a common picture within highly industrialized countries tightly interconnected through international trade. Among the top ten countries, significant differences in the results can be observed. For instance, USA uses 4.5 times more land than Japan. In absolute terms, high actual land demand can be observed not only in countries with high levels of consumption but also in countries with an elevated population such as China and India.

Land market and price determination

Land prices are the result of a trade between purchasers and sellers in the land markets (Demand and Supply force). This trade only occurs when a purchaser has higher expectations than the seller about the future gains from that land. The price of land is an expression of the prospective gains for the three attributes as shown in equation 1.

$$P = Q - C + I \quad (1)$$

Where:

P = **price**

Q = **productive quasi-rents**: the expected gains from productive uses of the property. The value of

this
factor depends on the expected gains resulting from possession of the land and others such as credits
or government subsidies.

C = **maintenance costs:** expected costs of maintaining the land, such as the transaction costs, land taxes
and the like.

I = **liquidity premium**: the ability to sell the land in the future. This is the least objective part of the price
computation. It is formed by the purchasers/agents' expectations in relation to the land.

Land resources requirements

These refer to the amount of land needed to meet various human needs such as food production, housing, infrastructure development and conservation of natural ecosystems. The specific land requirements vary depending on the particular need or use, population, other local contexts and conditions. Land resource could be required for different purposes as shown below.

1. **Food production:** The amount of land needed to produce food depends on factors such as the type of crop, the yield per hectare and the agricultural practices used. In general, food production requires large amounts of land, particularly for crops such as wheat, corn, and soybeans.
2. **Housing:** The amount of land required for housing depends on factors such as population density, housing type and urban planning policies. In general, high-density urban areas require less land per housing unit than low-density suburban or rural areas.
3. **Infrastructure development**: The amount of land required for infrastructure development depends on the type of infrastructure such as roads, airports and power plants as well as the location and scale of the project.
4. **Conservation of natural ecosystems**: The amount of land required for conservation varies depending on the size and type of ecosystem being protected, as well as the level of protection needed. Protected areas, such as national parks and nature reserves, require large amounts of land to maintain biodiversity and ecological functioning.

Comparative and complementary land uses

Comparative land uses

This refers to the uses of land that are similar or compete for the same resources such as agricultural and urban land uses. In contrast, complementary land uses refer to the uses of land that work together to create a positive outcome such as a park and a residential area. For example, agricultural land uses and urban land uses are comparative land uses because they both require land, water and other resources. As urbanization expands, it may compete with agricultural land uses for resources, leading to a reduction in agricultural land at potentially higher food prices (Olufemi, 2022).

Complementary land uses

Complementary land use refers to a land use pattern where different land uses or activities are coordinated and integrated to produce a mutually beneficial outcome. In complementary land use, different land uses work together to enhance the overall productivity, efficiency and sustainability of an area. For instance, the park provides recreational opportunities and green space for residents which enhances the quality of life in the residential area. The residential area, in turn, supports the park by providing a population of users and potential volunteers for park maintenance and improvement efforts

(Giannoccaro, and Prosperi, 2022, Mehdizadeh, et al,. 2021 and Oke and Ajibade 2020).

Theories of consumption

These are models that attempt to explain why individuals and households make certain purchasing decisions. Some of the notable theories of consumption include:

1. **The marginal utility theory**: This theory suggests that consumers make purchasing decisions based on the marginal utility or satisfaction they will receive from consuming an additional unit of a good or service.
2. **The income theory of consumption**: This proposes that individuals will spend a larger percentage of their income on consumption as their income increases. The theory was developed by the economist John Maynard Keynes in the 20th century.
3. **The life cycle theory of consumption**: This suggests that individuals will adjust their consumption patterns over their lifetime based on their expected future income. The theory was proposed by the economists Franco Modigliani and Richard Brumberg in the mid-20th century.
4. **The behavioral theory of consumption**: This says that individuals' purchasing decisions are influenced by psychological factors such as habits, social norms and emotions. The theory draws on insights from psychology and sociology to explain why individuals may make irrational or non-optimal consumption choices.
5. **The social comparison theory**: This suggests that individuals' consumption choices are influenced by social comparisons with others. According to this theory, people make consumption decisions based on how their consumption compares to that of their peers or reference groups (Festinger, 1954).

Theories of income

Theories of income are models that attempt to explain the factors that determine an individual's or a household's income. Some examples of these are:

1. **Human capital theory**: This theory suggests that an individual's education, training, and experience can increase their productivity and earning potential. The theory argues that investing in human capital, such as acquiring new skills or obtaining higher education, can lead to higher income levels (Becker, 1962).
2. **Dual labor market theory**: This theory proposes that the labor market is divided into two segments, the primary and secondary labor markets. The primary labor market consists of high-skilled, high-paying jobs, while the secondary labor market includes low-skilled, low-paying jobs. The theory argues that individuals who are employed in the primary labor market earn higher incomes than those in the secondary labor market (Doeringer &Piore, 1971).
3. **Institutional theory**: This theory suggests that the institutional context in which an individual operates, such as government policies, laws, and regulations, can influence their income level. For example, minimum wage laws, unionization and progressive tax systems can help raise the income of lower-income individuals (Ingram and Silverman, 2015).
4. **Rent-seeking theory**: This theory proposes that income levels are affected by the ability of individuals or groups to extract rent or economic surplus from others. According to this theory, some individuals or groups may use their power and influence to gain advantages over others, leading to income inequality (Tullock, 1967).

Land investment decision

Land investment is a type of real estate investment that involves purchasing and holding land for the purpose of generating income or capital gains. The nature of land investment can vary depending on the specific goals of the investor but some common characteristics include:

1. **Long-term holding**: unlike other forms of real estate investment, land investment often involves holding the property for a longer period of time with the expectation that its value will appreciate over time. This is because land is a finite resource and as demand for land increases, its value tends to rise.
2. **Passive income generation**: Land investment can also generate passive income through leasing or renting the land to tenants. This can include leasing land to farmers, ranchers or developers for residential or commercial purposes.
3. **Limited development**: Land investment may involve limited development such as subdividing the land into smaller parcels or developing basic infrastructure such as roads, water supply and utilities. However, the primary focus of land investment is often on the appreciation of the land value rather than on development.
4. **Higher risk and lower liquidity**: Land investment can be riskier than other types of investments, as the value of the land can be affected by factors such as zoning regulations, environmental concerns, and market demand. Additionally, land is often less liquid than other investments, meaning that it may be more difficult to sell the property quickly if needed.
5. **Diverse investment opportunities**: Land investment offers a diverse range of investment opportunities, from agricultural land to commercial and residential development. This allows investors to choose a land investment strategy that aligns with their specific goals and risk tolerance.

Land Investment Decision and Appraisal.

The nature of land investment decision and appraisal involves evaluating the feasibility and profitability of a potential land investment opportunity. The decision-making process typically involves several stages, including market analysis, financial analysis, risk assessment, and legal and regulatory compliance. Here is a discussion of the key aspects of land investment decision and appraisal with references:

1. **Market analysis:** This involves evaluating the demand and supply dynamics of the land market as well as the competitive landscape and the potential for future growth. The analysis typically includes a review of market trends, demographic data, zoning and land use regulations and infrastructure and transportation networks (Gatzlaff and Haurin, 2021 and Okoye and Iroham, 2020).
2. **Financial analysis:** It involves assessing the profitability and risks of the land investment opportunity as well as the sources and cost of financing. The analysis typically includes a review of cash flow projections, income and expenses, taxes and fees and return on investment metrics (Ling and Archer, 2021).
3. **Risk assessment:** This involves identifying and evaluating the risks associated with the land investment opportunity as well as developing strategies to mitigate or manage these risks. The assessment typically includes a review of market and economic risks, environmental and physical risks and legal and regulatory risks.
4. **Legal and regulatory compliance:** It involves ensuring that the land investment opportunity complies with applicable laws, regulations and standards as well as obtaining necessary approvals and permits. The compliance typically includes a review of land ownership and rights, land use and zoning regulations, environmental regulations and building codes as well as standards (Brounen and Cohen, 2021, Onyejeose, Aiyetan and Ige, 2020).

Private cost and social cost of investment decision

Private and social costs are two important aspects of investment decision-making that need to be considered.

Private cost: Private costs refer to the direct financial costs and benefits of an investment for the individual or organization making the investment. It includes the costs of acquiring and developing the investment as well as the expected financial returns from the investment. Private benefits include the expected cash flows, capital gains and other financial benefits that accrue to the investor. Private costs are usually expressed in monetary terms and can be easily quantified.

Social cost: Social costs refer to the indirect costs and benefits of the investment for society as a whole. They include externalities such as pollution, traffic congestion and other negative impacts that may be caused by the investment. Social benefits include positive externalities such as job creation, increased economic activity and other positive impacts that may be generated by the investment. Social costs are often more difficult to quantify than private costs and may require the use of non-monetary measures.

Land resources allocation

Land resource allocation refers to the process of distributing land resources among competing uses in order to maximize efficiency and productivity. However, resource allocation can also lead to a number of problems that can negatively impact economic growth and social welfare.

Problems of resource allocation:

1. **Misallocation of resources**: This occurs when resources are not distributed efficiently and are allocated to uses that do not generate the highest possible returns. This can occur due to various reasons such as government regulations, market failures and inefficiencies in the allocation process.
2. **Inequality:** Land allocation can lead to unequal distribution of resources which can exacerbate social and economic inequality. Wealthier individuals and corporations may have access to more resources, which can give them an unfair advantage in the marketplace.
3. **Environmental degradation**: Resource allocation decisions can also lead to environmental degradation as resources are often allocated to industries that generate pollution or cause other environmental problems. This can lead to negative externalities such as air pollution, water pollution and climate change.
4. **Corruption and political interference:** *C*orruption and political interference are significant problems in land resource allocation in many African countries where land is often used as a political tool or as a means of rent-seeking. According to Olokesusi (2018), corruption and political interference have resulted in inefficient land use, misallocation of resources and increased social and economic inequality.
5. **Inadequate infrastructure and services**: In many African countries, inadequate infrastructure and services such as roads, water supply and electricity have limited the potential for land use and development. According to Aina and Omotayo (2020), the lack of infrastructure and services in Nigeria has resulted in limited access to land, particularly in rural areas which has negatively impacted agricultural productivity and rural development.
6. **Inadequate legal frameworks**: There is a lack of adequate legal frameworks for land tenure and use in many African countries which has led to conflicts over land ownership, use and control. According to Adepoju (2019), the absence of clear land tenure laws and regulations has resulted in land disputes and insecurity which have negatively impacted agricultural productivity, urban development and overall economic growth.
7. **Lack of effective land-use planning**: Many African countries lack effective land-use planning mechanisms, which has resulted in unplanned urbanization, encroachment on agricultural land, and unsustainable use of natural resources. According to Ademiluyi and Oke (2018), the lack of effective land-use planning in Nigeria has led to environmental degradation, loss of biodiversity and increased vulnerability to natural disasters.

Organization and its effect on land value

The organization of land use can have a significant impact on the value of land. There are different ways to organize land use such as zoning, clustering and mixed-use development. Discussion of examples on how organization can affect land value are given below.

1. **Zoning:** This is a land-use planning tool used by local governments to regulate the use of land within a given area. It can affect land value by restricting certain uses or activities in certain areas which can limit the potential use of the land and, in turn, reduce its value. On the other hand, zoning can protect certain areas from undesirable uses such as industrial activities which can enhance the value of neighboring properties. For example, residential properties located in areas zoned for single-family homes may have a higher value than those located in areas zoned for multi-family or commercial use.
2. **Clustering**: This is a land-use planning tool that involves grouping similar land uses or activities in a specific area. It can affect land value by promoting efficiency and reducing the cost of infrastructure and services, which can increase the value of neighboring properties. For example, clustering of retail businesses in a shopping center can increase the value of neighboring residential properties by providing convenient access to goods and services.
3. **Mixed-use development:** It is a land-use planning tool that involves combining different types of land uses such as residential, commercial and industrial, within a given area. It can affect land value by creating vibrant and walkable neighborhoods which can increase the value of residential and commercial properties. For example, a mixed-use development that includes retail stores, restaurants, and residential units can increase the value of neighboring properties by providing a desirable and convenient place to live, work and shop.

Concept of highest and best use and land use capability

Highest and Best Use (HBU).

It is the likely use, selected from a number of available choices, to which an area of land or a building may be put based on what is physically possible, legally possible (complying with the zoning and building regulations) and economically viable (to produce the most profitable present value of the land). The legal use of land or improved property which, at any point in time, is likely to produce the highest return to an investor. Highest and best use is a function of the social value to the public and economic value of the private owner of the land.

Land capability.

This is the ability of a piece of land to sustainably support a specific land use. If land is used beyond its capability, degradation will occur. An assessment of Land capability enables the reconciliation of development on it and protection.

Principles of comparative and absolute advantage in resources allocation.

The principles of comparative and absolute advantage are important concepts in economics that help to explain how resources can be allocated more efficiently.

Absolute advantage

This is an economic concept which refers to a situation where a country or individual can produce a good or service more efficiently than another country or individual. This means that they can produce more of the good or service with the same amount of resources or produce the same amount of the good or service with fewer resources. In this case, it makes sense for the country or individual to specialize in the production of the good or service where they have an absolute advantage and trade with other countries or individuals for the goods or services they need.

Comparative advantage

This refers to a situation where a country or individual has a lower opportunity cost of producing a good or service compared to another country or individual. This means that they can produce the good or service at a lower cost in terms of the alternative goods or services they could produce with the same resources. In this case, it makes sense for the country or individual to specialize in the production of the good or service where they have a comparative advantage and trade with other countries or individuals for the goods or services they need.
The principles of comparative and absolute advantage suggest that countries or individuals can benefit from specializing in the production of goods or services where they have a relative advantage and trading with others for goods or services that they do not produce as efficiently. This leads to greater efficiency in resource allocation and an increase in overall economic welfare. In the context of land allocation, a region or country may have an absolute advantage in producing a particular crop or commodity due to favorable climatic conditions or natural resources. For example, a region with fertile soil and ample water supply may have an absolute advantage in producing crops such as wheat or corn.

Land use values and pattern

Land use values

This refer to the benefits or services that are derived from the use of land, such as agricultural production, urban development, recreational opportunities, and conservation of natural resources. Land use patterns are the physical arrangement and distribution of different land uses within a particular area or region. The values associated with land use can vary depending on the specific location, the types of activities taking place, and the needs and preferences of the community.

Land use patterns

This refers to the arrangement or distribution of different types of land use within a defined area, such as a city, region, or country. The land use pattern in an area is the result of various factors such as historical development, geography and economic activities. It has a significant impact on the environment and on human well-being. For example, sprawling development patterns that consume large amounts of land can lead to habitat loss, fragmentation, and degradation, as well as increased energy consumption and transportation emissions. On the other hand, compact and mixed-use development patterns that promote walkability, public transit, and access to green spaces can support environmental sustainability, social equity, and economic vitality. Therefore, understanding the values and patterns of use is essential for effective land use planning and management, which can help to balance competing interests and promote sustainable development.

Urbanization

According to the United Nations Human Settlements Programme (UN-Habitat), urbanization is defined as "the process by which cities grow or by which societies become more urban." This process is driven by various factors, including natural population growth, rural-urban migration and changes in land use patterns (UN-Habitat, 2016).

Reasons for urbanization are:

1. Economic opportunities;
2. Improved social services;
3. Infrastructure and amenities;
4. Security;
5. Cultural and social diversity;
6. Access to education;
7. Access to healthcare;

8. Better access to goods and services;
9. Higher standards of living; and
10. Migration from rural to urban areas.

Despite the inherent opportunities of urbanization for people in search of greener pastures in urban areas, it is often faced with a lot of challenges.

Problems of urbanization include:

1. Overcrowding or Overpopulation;
2. Unemployment;
3. Transportation and traffic congestion;
4. Housing problems;
5. Development of slums;
6. Sanitation problems;
7. Water shortage problems;
8. Health hazards;
9. Degraded environmental quality;
10. Waste Disposal and Management; and
11. Urban crime

Summary

Land is the basis of all human activities. This explains the need for proper understanding of its' principles for efficiency and sustainability. Its supply is limited and relatively scarce, calling for judicious use and application of economic principles. Uncontrolled land uses could lead to incompatibility of uses, negative externality with a negative effect on human welfare. The social cost and private cost are important consideration in taking land use decision. This chapter provides a good understanding of the necessary principles to equip students with the basic knowledge to guide the demand, supply and use of land.

Exercise

1. Explain the principles of land economics.
2. Explain the characteristics of land.
3. What is land market?
4. Discuss the demand for land.
5. Explain the concept of rent.
6. Explain five theories guiding the determination of land and real property prices.
7. What is land capability?
8. Explain the Highest and Best Use (HBU) of land.
9. Explain the nature of land investment.
10. State three theories of consumption.
11. State the reason and problems of urbanization.
12. Explain comparative and absolute advantage in resources allocation.

References

Adepoju, A. (2019). Land tenure system and agriculture productivity in Nigeria: A critical review.

Journal of Land and Rural Studies, 7(1), 73-84.

Ademiluyi, I. A. and Oke, I. A. (2018). Land use and the environment in Nigeria: A review of trends, policies, and impacts. *International Journal of Environmental Science and Technology,* 15(10), 2137-2148.

Aina, T. A. and Omotayo, A. M. (2020). Land governance and infrastructure development in Nigeria: A review. Journal of Urban Management, 9(2), 105-117.

Akinbogun, S. P. and Jones, C. A. (2018): Externalities and Planning Failure in the Housing Market of an African City, *International Journal of Housing Market and Analysis*. Vol. 11. (3).

Alonso, W. (1964). Location and land use: Toward a general theory of land rent. Harvard University Press.

Becker, G. S. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy,* 70(5), 9-49.

Brounen, D. and Cohen, K. J. (2021). Legal and regulatory issues in real estate. *Journal of Real Estate Research,* 43(1), 156-194.

Dixit, A. K. and Pindyck, R. S. (1994). Investment under uncertainty. Princeton University Press.

Doeringer, P. B. and Piore, M. J. (1971). Internal labor markets and manpower analysis. Lexington Books.

Duranton, G. (2020). Urbanization: Concepts, externalities, and policy challenges. *Journal of Economic Perspectives,* 34(3), 1-27.

Fama, E. F. (1970). Efficient capital markets: a review of theory and empirical work. *The Journal of Finance*, 25(2), pp. 383-417.

Gatzlaff, D. and Haurin, D. (2021). The real estate development process. Journal of Real Estate Research, 43(1), 41-78.

Giannoccaro, G. and Prosperi, M. (2022). Land use conflicts and synergies in rural areas: A comparative analysis of farmers' preferences for complementary land uses. *Land Use Policy,* 112, 105874.

Ingram, P. and Silverman, B. W. (2015). Institutional theory: Explanation, reformulation, and replication. In t*he Sage Handbook of Organizational Institutionalism* (pp. 41-62). Sage Publications.

Kahneman, D. and Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263-292.

Ling, D. C. and Archer, W. R. (2021). Real estate investment and finance. Journal of Real Estate Research, 43(1), 79-117.

Mehdizadeh, M., Salehi, M. and Ghorbani, M. (2021). Promoting complementary land uses for sustainable rural development: A case study of two Iranian villages. *Land Use Policy*, 108, 105433

Oke, M. O. and Ajibade, L. T. (2020). Complementary land use and its impact on the livelihood of farmers in rural southwestern Nigeria. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 121(2), 223-233.

Okoye, C. O. and Iroham, C. O. (2020). Real estate market analysis for property investment decisions: A review of Nigerian practice. International Journal of Real Estate Studies, 14(2), 44-53.

Olokesusi, F. (2018). Corruption and land administration in Nigeria: A critical review. African Journal of Land Policy and Geospatial Sciences, 1(1), 55-65.

Oloyede, O. T. and Owolabi, J. D. (2020). The challenges of environmental risk management in property development in Nigeria. International Journal of Real Estate Studies, 14(2), 1-12.

.Oluwafemi, A. (2020). Comparative land use evaluation for urban expansion using multi-criteria

decision analysis: A case of Akure, Nigeria. *Land Use Policy*, 97, 104736.
Onyejeose, T., Aiyetan, O. A., and Ige, F. O. (2020). Statutory planning regulations and compliance in Nigerian property development. *International Journal of Real Estate Studies,* 14(2), 25-34.
Tullock, G. (1967). The welfare costs of tariffs, monopolies and theft. *Western Economic Journal*, 5(3), 224-232.
UN-Habitat (2016). Urbanization and Development: Emerging Futures. United Nations Human Settlements Programme.

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CHAPTER 10
Introduction to Remote Sensing and Geographic Information Systems
By
OGUNBADEWA Ebenezer Yemi

Overview
This chapter focuses mainly on the fundamental principles of Remote Sensing (RS) and Geographic Information Systems (GIS) by starting from the introduction of basic scientific concepts through the theories, terminologies to the practical aspects leading the learners to proficiency in accessing, processing and visualizing digital imagery including the use of essential software in image analysis and interpretation of remotely sensed data. This chapter is written to stimulate interest of the beginners, teachers and learners in allied disciplines to benefit from the utilization of RS and GIS as multi-disciplinary tool that will be very valuable to all irrespective of their various academic background in environmental sciences and related field of studies.

Objectives
At the end of this chapter, students should be able to:

1. discuss the fundamental principles of RS and GIS including allied instruments plus the use of relevant software for image processing;
2. analyze the capabilities and functions of various types of RS and GIS instruments;
3. discuss data collection, measurement, analysis and interpretation techniques in RS and GIS;
4. explain the use of RS and GIS in conjunction with allied instruments;
5. discuss skill acquisition by the utilization of RS and GIS methods in practical exercise;
6. explain the techniques of storing and managing RS and GIS data in digital format; and
7. discuss the applications of RS and GIS which include the limitations of these technologies.

Fundamentals of Remote Sensing (RS) and Geographic Information Systems (GIS)

Remote Sensing (RS)
Remote Sensing (RS) is defined as the art, science and technology of obtaining information about an object/phenomenon and its environment through the electromagnetic spectrum without physical contact with the object/phenomenon and its environment using devices (Cameras, RADAR, Scanners, LIDAR and Lasers systems) mounted on the ground, air and space-borne platforms (Ogunbadewa,2022). Information/data obtained by any of these devices are either emitted or reflected or absorbed radiation that is produced by the features of the object/phenomenon and its environment within some specific portion of the electromagnetic spectrum. This does not include data that are derived from Geophysical, Sonar and Medical Imaging Sensing instruments which use gravity or magnetic or sound potentials to obtain data/information about an object/phenomenon and its environment instead of electromagnetic radiation.

Geographic Information Systems (GIS)

Geographic Information Systems (GIS) is defined as computer-based systems that is having capabilities to input, store, manipulate, analyze, output and display geographically (spatially) referenced data/information of anywhere on the earth's surface in a database system by using appropriate software (Ogunbadewa,2022). The word "Geographic" does not mean that GIS is restricted to Geography as a discipline but for the fact that the data captured in a GIS system are geographically (spatially) referenced and location-based. There is another device that is used together with RS and GIS which deserves to be mentioned and defined. This is called the Global Positioning Systems (GPS)**.**

Global Positioning Systems (GPS)

Global Positioning Systems (GPS) is defined as a system of earth-orbiting satellites that can provide precise location of any part of the earth's surface with accuracy ranging from sub-centimeter to 100 meters along with the latitude and longitude coordinates or equivalents with the aid of appropriate receiving equipment (Ogunbadewa, 2022). The combination of RS, GPS and GIS for acquiring and handling location-specific data on the earth's surface are known as **Geospatial Technologies Systems (GTS).** The relationship of these Geospatial Technologies Systems will be discussed in the later part of this chapter. However, emphasis of this chapter will be more on RS while GIS and GPS will just be treated as elements of RS.

History of Remote Sensing (RS)

The term" Remote Sensing" was introduced in 1962 by two geographers, Evelyn, L., Pruitt and Walter, H. Bailey at the 1st symposium on remote sensing of the environment held at the University of Michigan, where the phrase" remote sensing" was first used (Pruitt, 1979, DeBats and Lafreniere, 2018). The historical developments of RS have passed through different era of diverse techniques, materials, platforms and purposes, starting from the era of aerial photography remote sensing in 1800s to the era of satellite remote sensing systems in the present day (Cohen, 2000).

Era of balloons, kites, pigeon and mountain remote sensing (1800 to late 1900)

The initial type of remote sensing started with photography. The first photograph (ground photo) was taken by Nicephore Niepce in 1939. In 1840, Argo the Director of Paris (France) encouraged the use of photography for surveying and topographic mapping. The first aerial photograph known as "Nadar" was taken with balloon by Gaspard Felix Tournachon in 1858 at the height of 80m in Bieve, France while James Wallace took the first air photograph over Boston in the USA in 1860 and ED Archibald, in 1882, obtained air photo from kites for meteorological purposes in Britain.

Era of airplanes remote sensing (early 1900 to 1950)

The invention of aero plane, in 1903, was a major milestone in the development of aerial photography remote sensing. Wilbur Wright took the first aerial photo from an aircraft platform over Centocelli, Italy in 1909. During the first and second world war (1914 to 1918 and 1939 to 1945), airplanes were used to carry cameras for military espionage and reconnaissance purposes. This provided the greatest impetus for photo interpretation and analysis. After the first world war, the aerial/air photography was deployed more for large scale aerial surveys, thus laying the foundation for the science of photogrammetry, mapping, recording energy beyond visible spectrum (infrared) of the electromagnetic spectrum. Aerial photography, during second world war, included the development of kodak programs film with yellow filter that is sensitive to green, red, NIR (0.7 - 0.9 μm) including detection of camouflage netting, tanks painted green show up as blue instead of red colour like surrounding vegetation.

Era of satellite remote sensing (1960s-Till date)
Development of satellite remote sensing programs began with the launch of sputnik satellite by the Russians in 1957 and later followed by the US in launch of the Explore 1 satellite in 1960. These satellites were mainly designed for espionage, weather and communications purposes but were later used for resource mapping. In the 1970s, digital imagery for earth mapping becomes popular because of volumes of data being generated from satellite remote sensing systems leading to data "explosion" making manual image processing cumbersome. Hence, there is a need to incorporate computer-based system into the processing of remotely sensed data. Therefore, integration of RS into GIS database became inevitable and the best option for solving challenge of remote sensing data "boom". In the 1980s, 1990s and 2000 till date, there have been more government and commercial satellites with very high resolution, including availability of free web-based RS data and GIS software. Also, there is increased availability of reasonably cheap miniature optical cameras and non-optical sensors with the capabilities of very high spatial resolution of less than 1metre Drones/Unmanned Air Vehicles (UAV) has given a boost to the use of remote sensing, not only for scientific investigation but for personal, private and public observations in security, mapping and event coverage in the year 2010 till date.

History of Geographic Information Systems (GIS)
Geographic Information Systems (GIS) is not actually a novel tool nor a product of the computer age. It dated back to the ancient times of cartographers/geographers carrying out spatial analysis processes via hand-drawn maps and atlas with the use of instruments like compass, telescope and sextant. Nonetheless, GIS started gaining momentum in 1832 during the era of cholera outbreak in Paris when a French geographer, Charles Picquet, drew the first heat maps to illustrate the area of cholera prevalence and in 1854 John Snow, a physician, used the same approach of spatial data analysis to show the link between contaminated water sources and cholera deaths in London (Firehock and Walker, 2019). However, GIS started replacing the manual methods of storing information with computers and creating maps with symbols, scale and colours in the 1960s (DeBats and Lafreniere, 2018). Computer applications became vital when it was appreciated that GIS is fast, can preserved, update, provide accurate information on spatial and temporal changes over time which was not possible with manual maps. The "father" of GIS, Roger Tomlinson was the one that laid the foundation for the rapid evolution of GIS in the 1960s by popularizing GIS as a powerful tool that can enable spatial and attribute data from different sources to be merged into a single format which can be used by all and sundry (Flores and Gallardo, 2021). From 1960 till date, there has been a lot of digital transformation that are widely available for businesses. This includes using GIS for artificial intelligence and machine learning because of its spatial elements.

Components of RS
RS comprises of the Electro Magnetic Radiation (EMR), Sensor and Remote Sensing Platforms.

Electro Magnetic Radiation (EMR)
EMR is a radiant energy that is transported within a free space and through the air from the sun to the earth's surface in form electromagnetic waves combing two fluctuating fields of both electric and magnetic properties that travels at the same speed of light. The waves are perpendicular to the direction of travel, at right angles to one another and are characterized by a **frequency** and a **wavelength** as shown in figure 1. These two quantities are related to the speed of light by the equation

1.

$S = F \times W$ 1

Where: S = speed of light, F = frequency and W = wavelength

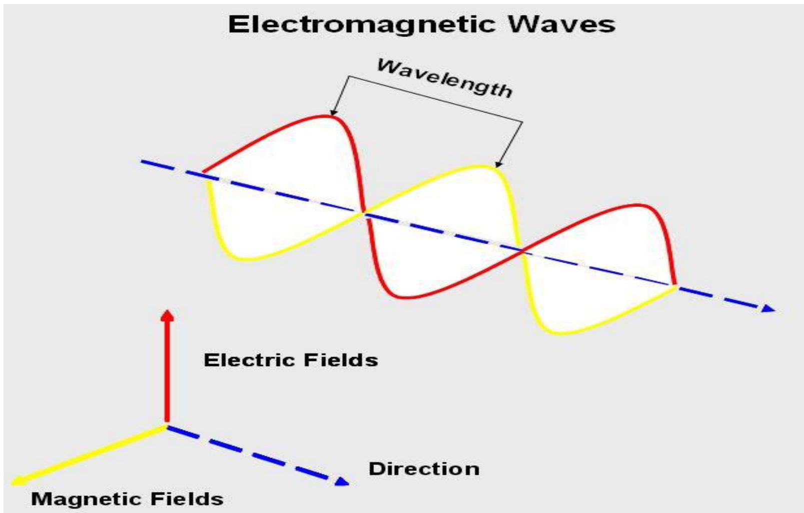


Figure1: Electromagnetic waves (Ogunbadewa, 2022)

The waves are created by acceleration of an electrical charge and the wavelength is determined by the duration of the acceleration. Electromagnetic wave is very interesting in the sense that when it passes sequentially from one medium to the subsequent one, the speed of light and wavelength will change but the frequency will not change. The higher the temperature of the object, the higher the emission of electromagnetic radiation from the object, based on the principle that the sun is the major source of electromagnetic radiation.

Electromagnetic spectrum and remote sensing applications

The sun can produce a wider range of the magnetic spectrum than other entities in the solar system from very shot to very long wavelengths. Hence, the frequency of the wavelength of an electromagnetic wave depends on its source. This wide frequency range of electromagnetic waves constitutes the **Electromagnetic Spectrum**. The electromagnetic spectrum is divided into several wavelength (frequency) regions, among which only a narrow band from about 0.4 to 700 µm is visible to the human eyes. The region of EM spectrum ranges from **short** through **middle** to **long** wavelengths. **Short wavelengths** are: **gamma rays and x-rays** (less than1 nanometer), **ultraviolet** (1 nanometer to about 0.36 µm). **Middle wavelengths** are: **Visible** (Blue: 0.4-0.5; Green: 0.5-0.6 and Red 0.6-0.73 µm), **Infrared** (Near: 0.77-0.9, Short waveIR: 1.4-2.4, Middle waveIR: 3-5; Emitted/far/thermal IR: 8-15µm above). **Longer wavelengths** are: **Microwave** (1 mm to 1 m) and **Radio waves systems** (above 1 m). Figure 2 shows the different portions of electromagnetic spectrum while table 2 shows the principal applications of waveband (specific wavelengths in micrometers µm) in remote sensing (Lillesand, et al., 2015).

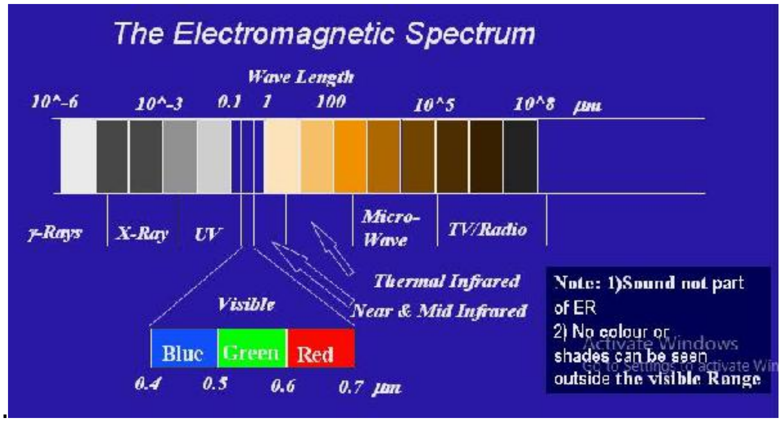


Figure 2. Electromagnetic Spectrum (Ogunbadewa, 2022)

Table 2. Principal applications of wavebands (specific wavelengths) in remote sensing)

Band	Wavelength	Applications
Band 1 - coastal aerosol	0.43-0.45	Coastal and aerosol studies
Band 2 – blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 – green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 – red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.85-0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation; penetrates thin clouds
Band 8 – Panchromatic	0.50-0.68	15 meters resolution, sharper image definition

Source: Adopted from USGS from Landsat 8/9 Operational Land Image (OLI satellite sensors).

RS of the Interactions and processes of electromagnetic radiation

Electromagnetic radiation generated by the sun passes through the vacuum of the space on the top of the atmosphere through to the earth surface and reflected by the earth's surface through the same atmosphere back to the space which is the EMR recorded by the satellite sensor in the space (Zourarakis, 2021). Therefore, it is very important to examine what happens to incoming and outgoing radiation during the interactions including the loss and gain effects on the radiation field and by extension on the quality of remotely sensed data gathered by the satellite sensor. EMR interacts with the atmosphere and earth's surface in the same way except in the refraction process because most radiation within electromagnetic spectrum cannot penetrate solid objects. Therefore, electromagnetic radiation produced by the sun interacts with the atmosphere and earth's surface by refractions (mainly in the atmosphere), scattering, absorption and transmission while the processes involves the source of energy or Illumination, radiation and the atmosphere, interactions with the target, recording of energy by the sensor, transmission, reception and processing, interpretation and analysis and applications. The interactions between the EMR field and the earth-atmosphere systems are very important in RS because these interactions involve modification of incoming and outgoing radiation which determines the intensity of radiation measured by the sensor at different wavelengths. This is the major source of error/noise in remote sensing. Electromagnetic radiation produced by the sun is either refracted (mainly in the atmosphere) or scattered or absorbed or transmitted through the atmosphere and to the earth's surface as shown in figure 3.

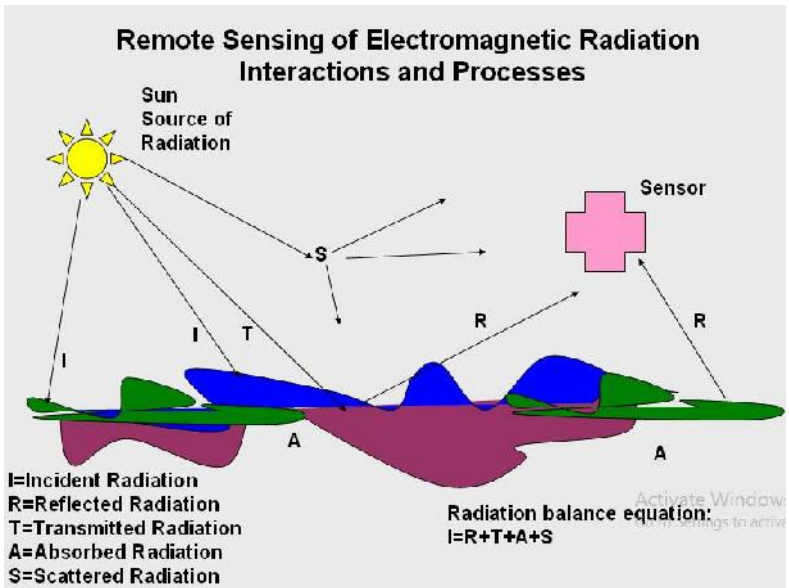


Figure3: Interactions and processes of electromagnetic radiation (Ogunbadewa, 2022)

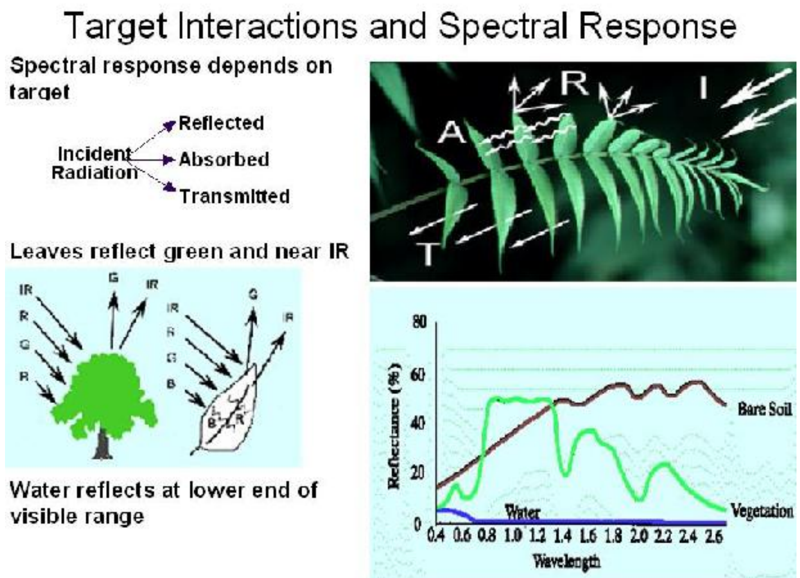
Refracted radiation: This involves the bending of light when it moves from one medium to another caused by the differences in the densities and speed of light of various medium (water and air) resulting deviation of light from original path. This radiation interacts with the surface of the earth in the same way as with the atmosphere with exception of that refraction process rarely take place on the earth's surface as most of the electromagnetic spectrum cannot travel through solid objects. However, the quality of the images is highly degraded by bending of light when the atmospheric humidity is very high.

Scattered radiation: This occurs when the photon of electromagnetic radiation colludes along its path with atmospheric objects/particles. This collusion causes redirection of the electromagnetic radiation leading to three types of scattering: Rayleigh, Mie and Nonselective scatterings. Rayleigh scattering is caused by particles (atmospheric gasses) that are smaller than the wavelength of the radiation. Mie scattering is caused by particles equal (aerosol) size than the radiation wavelength. Nonselective scattering occurs when the particles (water droplets and dust) size are much larger than the wavelength of the radiation. It is nonselective because scatterings are equal across all wavelengths and of equal quantity in the combinations of blue, green and red coloured light, making it visible as white light. Scattering is the most serious effects that the atmosphere has on the electromagnetic radiation. It produces the skylight that allows us to see in shadow, makes images of the target to be recorded with the brightness of the atmosphere, redirects the reflected light away from the sensor causing reduction in spatial details/fuzzy images, decreases the contrasts of the images by making light target darker and dark objects lighter.

Absorbed radiation: Electromagnetic radiation is absorbed by atmospheric gasses (ozone, carbon dioxide and water vapour) as it passes through the atmosphere at the same time. As the energy is absorbed, it is re-emitted by these gas molecules, the re-emission happens at wavelengths typically outside the spectrum considered in optical remote sensing but a major data source for thermal remote sensing. The absorption of EMR is a major obstacle confronting optical remote sensing because the energy absorbed is re-radiated out in another form. The high rate of absorption from water vapour includes its high variability in the concentrations over time, season and across climatic regions and it is responsible for most of the total gas absorption.

Transmitted radiation: This is the radiation that passes directly to the earth's surface without attenuation by the atmosphere.

Reflected radiation This is when the incident radiation on the earth's surface bounces back to the atmosphere. Reflected radiation can either be **Specular** (reflection in a single direction like mirror) or **Diffuse/Lambertian** (reflection in uniform directions), most reflections on the earth's surfaces are in diffuse form. The type of reflections (specular or diffuse) from a target depends on the characteristics of the surface in relation to the wavelength of incoming radiation. For example, if the wavelength is smaller than the variation in the particle sizes of the surface composition like fine grained sand, it will appear rough in visible wavelengths and smooth in the long wavelength of the microwaves. The response of targets to a variety of different wavelengths enables remote sensing systems to distinguish features by means absorption, transmission and reflection therefore each targets/object has gotten its own **Spectral Response Curve** (as shown in figure 4.



. Figure 4: Target Interaction and Spectral Response Curve (Modified from USGS)

Reflection is the main source of remote sensing data, viewing the earth from the above by capturing radiation from the space the dominant atmospheric windows that are mainly utilized are within the reflected visible and radio wavelengths and the Gamma Rays and IR less absorbed while the X-Rays and UV are strongly absorbed. Sensors gather electromagnetic radiation information from reflection of the visible spectrum, particularly the passive sensors because it reflected light from the sun but the active sensor like microwave generates its own reflected radiation.

Sensors

Sensor is the device or instrument that is used to acquire data/measure the reflected/emitted/absorbed radiation that is not only visual to the eye or camera but also what cannot be seen by the eyes, like sound and heat. The detecting and recording instruments using this technology are known as remote sensors. Fortunately, human eyes are natural sensors. The principal parameters measured by a remote sensing system are: Spectral, Spatial and Intensity of the reflected or emitted or absorbed radiation from the object that is targeted. Sensors can be classified as Passive or Active, Imaging or Non-imaging system. Passive systems record energy that is emitted or scattered or reflected from natural sources, that is, from sunlight or emitted energy of the target which is functionally dependent on the temperature of the surface and the atmospheric conditions during the sensing. Active systems provide their own source of EM radiation which is reflected or scattered while the signal is detected by the system that is not energy from the sun. Energy generated from within the sensor system, beamed outward and the fraction returned is measured. Imaging systems are devices like television, computer monitor, cathode ray tube, oscilloscope or combinations of series of detectors that produces images based on radiation emitted from a particular target in electromagnetic spectrum. Non-imaging system measures the radiation received from target as electric signal with some quantifiable attributes such as radiance for detection (Campbell and Wynne, 2011, Cracknell, 2007 and Ogunbadewa, 2022). Some sensors may fit into more than one classification and in order to avoid overlap the focus of this chapter is on Passive and Active systems as shown in figure 5.

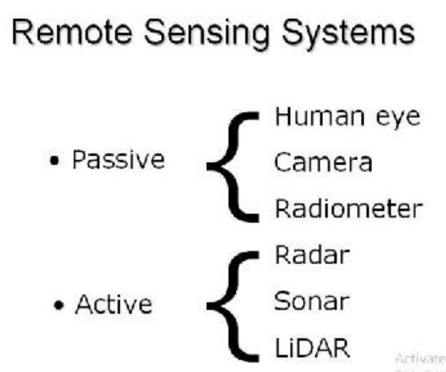


Figure 5: Passive and Active Remote Sensing systems (TRESTE, 2023)

Types of passive remote sensing systems

These are: Gamma-ray spectrometers, Aerial cameras, Thermal infrared video cameras, Multispectral scanner and Imaging Spectrometer. Gamma-ray spectrometers are passive sensors that detect gamma rays. The sources of the radiation are generally from the upper part of soil and rock layers, caused by radioactive decay and used mainly for mineral explorations. Aerial cameras are used in aerial photography. Aircraft serves as a platform and mainly used for topographic mapping and surveying. Thermal infrared video cameras are developed to detect radiation in the near-infrared range. They can be carried by aircraft with some active sensors. Multispectral scanners record information within the visible and infrared range of the electromagnetic spectrum. Earth's surfaces are scanned at various wavelength bands. Satellites act as platforms for these passive sensors. Imaging Spectrometers are used for scanning at a very narrow wavelength bands of the electromagnetic spectrum carried on satellite platforms.

Types of active remote sensing systems

Types of active remote sensing systems are active optical remote sensing, active thermal remote sensing and active microwave remote sensing systems. Active optical remote sensing/Light Detection and Ranging (LIDAR) involves the use of laser beam to illuminate a target in order to acquire the reflected or backscattered radiation about the target which will give the temperature, velocity, location and material composition from a distance. Active thermal remote sensing derives data mainly from infrared spectrum. Most thermal remote sensing uses passive sensors. It is classified under active sensors because the data are acquired during the night when it is dark. Active microwave remote sensing/ Radio Detection and Ranging (RADAR) uses sensors that operate in the microwave region of the electromagnetic spectrum. Microwave signal is transmitted to a specific target while the detection of the target is derived from the reflected or backscattered radiation which is a measurement of round delay time lag to the target allowing calculation of the distance of the sensor to the target.

Remote sensing platforms

These are the vehicles/carrier/service modules for the remote sensing systems. They can be**:** Ground-based or Air-borne or Space-borne platforms or combinations of one or more platforms depending on the purpose of applications**.** Ground-based platforms are remote sensing carried out a close range on the ground**.** It can be static mounted on tripod or mast or dynamic on a moving vehicle and records detailed information about the earth's surface including environmental conditions and natural disasters. Air-borne platforms are stable wing aircraft, although helicopters, balloons and drones are sometimes deployed to collect very detailed images and facilitate the collection of ancillary data. The height of this platform ranges from 100m to 50km. Space-borne platforms are at the height range from 100 km to 36000 km from earth's surface. These are satellites (low level 700-1500 km and high level about 36000 km) but there are some space shuttles, space stations and rockets. The center point of this section will be more on space-borne platforms/satellite remote sensing systems by considering some of its important parameters because of its popularity. However, the choice of any platforms will depend on the purpose of use, cost and time as shown in figure 6.

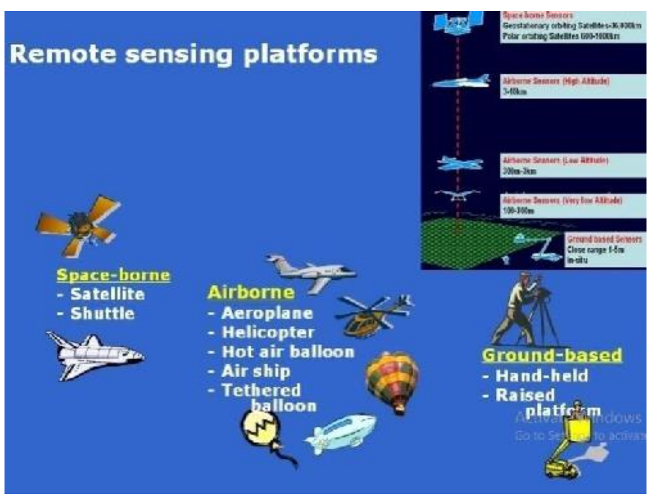


Figure 6: Remote Sensing Platforms (Ogunbadewa, 2022)

Space-borne platforms

Space-borne platforms, also known as satellite platforms, these platforms have been able to overcome some of the challenges faced by sensors mounted on low altitude through its capability of very large area coverage of the earth's surface on an operational basis. Most sensors mounted on satellite platforms are unmanned while the manned satellites like space shuttles, SOYUZ and SKYLAB commute between the earth and the space on short time missions have contributed immensely to the data collections relating to the earth's surface. Apart from using these satellites to carry sensors that gather environmental and land resources information about the earth, there are other satellites that are mounted with sensors that are used in the investigations of the atmosphere, sun, moon, stars and distant planets plus sensors used in telephone, radio, television and navigation network that are collecting data for GPS. Satellite remote sensing system can be classified into two categories: Geostationary satellites and polar-orbiting satellites.

Geostationary satellites

These are satellites that are in a circular orbit used in obtaining remotely sensed data from a specific region and at a relatively fixed position when the earth is rotating. Examples of these satellites are Geostationary Operational Environmental Satellites (GOES), Meteostat, INSAT, Fengyun and Himawari. These satellites are located at an altitude of approximately 36000 kilometres directly over the equator. These satellite sensors are stationary to the position of the earth and constantly viewing the 'same' area of coverage by orbiting at the same speed with the speed of rotation of the earth making the orbital periods to be approximately 24 hours. The coincidence of these satellites with rotation of the earth makes it Geo-synchronous. It is the earth that rotates around these satellites in a fixed position. All geostationary satellites orbit around the earth's equator. The geostationary satellites are used for meteorological purposes. However, some navigation equipment like GPS and non-remote sensing instruments used in communications are also mounted on the satellites in this orbit as shown in figure 7.

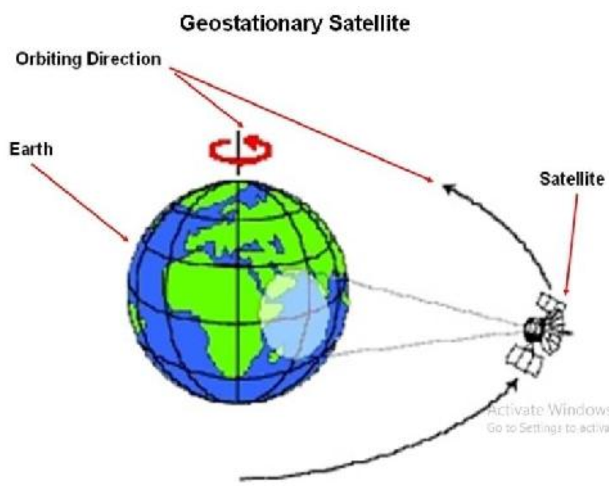


Figure 7: Geostationary Satellites

Polar-orbiting satellites

Polar-orbiting satellites are located near to above of the poles at the height that ranges from 800 to 900 km with an orbital period of 98 to 102 minutes. These satellites are Sun-synchronous because these satellites are permanently exposed to the illumination angle of the sun throughout the day. The acquisition of data by these satellites along its path involves the satellites moving from the North to South/South to North as the earth rotates eastwards. Examples of these satellites are Advanced Very High Resolution Radiometer (AVHRR), Landsat satellite series, "Satellite pour l'Observation de la Terre" (SPOT), Defense Meteorological Satellite Program (DMSP), Moderate Resolution Imaging Spectroradiometer (MODIS), Medium Resolution Imaging Spectrometer (MERIS), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and NigeriaSat series mainly used for earth resources observations, unlike the geostationary satellites, they are very numerous in the space have medium to high spatial and low temporal resolution. Other satellite sensors includeing polar-orbiting satellites are the commercial (RADARSAT, Quickbird, IKONOS and GeoEye) and military/Spy (Cosmos and MIDAS) satellites as shown in figure 8.

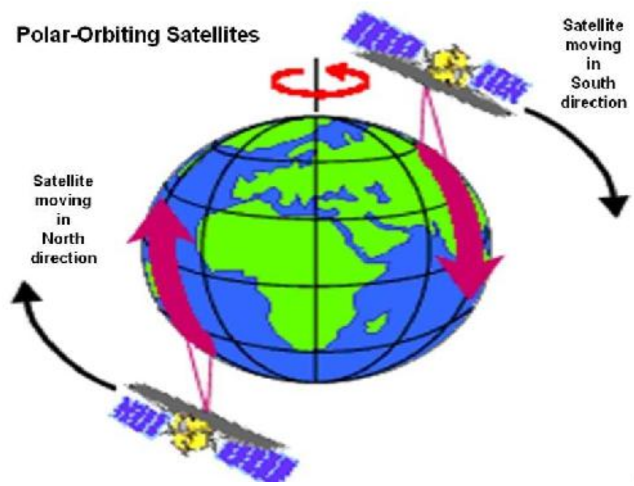


Figure 8: Polar-Orbiting Satellites

Relationship between RS and GIS

The study of remote sensing technique will not be complete without some elements of GIS as the two are not similar but related because both deals with spatially referenced geographic data (Ogunbadewa, 2022). Most times, people have often taken them as synonyms or to be the same subject or one is a subset of another. However, they are independent of each other and they have some differences, these include but not limited to:

1. RS is a data collection technique while GIS is a computer-based data processing system.
2. RS technique has a more complicated user interface that requires the expertise of skilled personnel in data usage while GIS interface is simple and little skill is needed in the data procedures.
3. RS data is limited to the specific area of coverage while GIS allow not only data from RS but data from different sources to be merged into a single format without losing its original attributes when separated.

From the above, it can be inferred that the two fields shared common grounds and overlaps in the area of digital image processing as shown in figure 9.

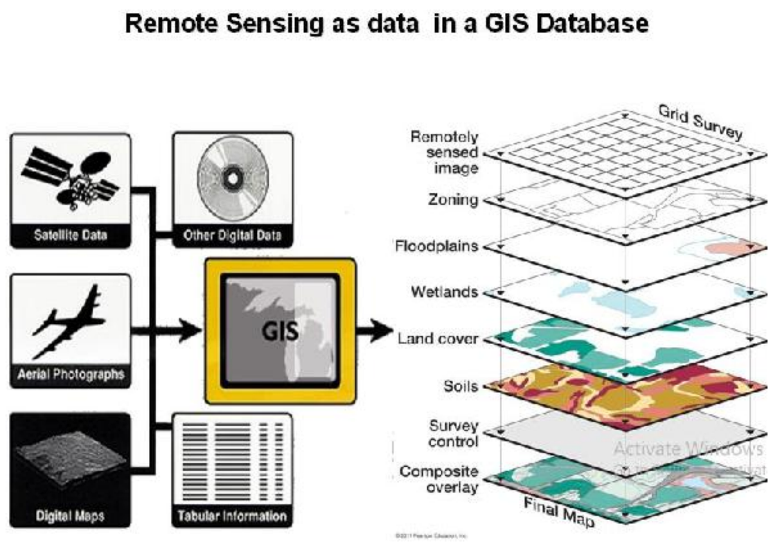


Figure 9: Remote Sensing, as data in a Geographic Information System (Ogunbadewa, 2022)

Digital image processing

In remote sensing, before image processing commences, data has to be acquired depending on the purpose of its applications. Hence, there is need to discuss data acquisition and sensors fundamental capabilities. Human eyes actually do image processing, analyzing shape, size, pattern, shadow, tone/color, texture and context but with computerized image processing allow human to see beyond the limits of our eyes by integrating spectral channels and dividing them by one another. However, the computer cannot know the users' needs. Therefore, human eye can recognize same feature under different illumination levels with the aid of human.

Data acquisition and sensors fundamental capabilities

A sensor capability is called resolution. Resolution of a sensor is the ability of the sensor to detect the smallest objects or differentiate between two objects or the object and its surroundings. There are 4 types of sensors' resolutions which vary according to different remote sensing systems. They are spatial, spectral, temporal and radiometric resolution.

Spatial resolution is the ability of a sensor to detect smallest surface area covered by each pixel in an image. Small area covered by a pixel means high spatial resolution and large area coverage by a pixel is a low spatial resolution sensor. For example, NigeriaSat-1 with pixel size of 32mX32m resolution will show more spatial details than Terra-Modis with size of 250mX250m spatial resolution. Spatial resolution will depend on the numbers of detectors and scanning mirror oscillation cycles. Higher spatial resolution enables information to be more precise.

Spectral resolution is the ability of sensor to separate features into bands according to their spectral signatures. More number of bands in a specified bandwidth means higher spectral resolution and vice versa. The numbers, wavelength position and width of spectral bands a sensor has a band is a region of the EMR to which a set of detectors are sensitive. Multispectral sensors have a few, wide bands. Hyperspectral sensors have a lot of narrow bands. Higher spectral resolution provides increase in data acquisition capability. For example, data sensed in seven spectral bands simultaneously (Landsat Thematic Mapper), as against the four spectral bands (Multispectral scanner). Spectral resolution is the difference between the two numbers at full width at maximum height.

Temporal resolution is the periodicity and revisit frequency at which images of a particular place is captured by a sensor or return period of sensor to image the same place. A satellite sensor like GEOES images is the same spot every 15minutes while Landsat will the same place every 16days.

Radiometric resolution is the sensitivity of the sensor to the magnitude of the signals of electromagnetic energy received. Sensors with finer radiometric resolution are more sensitive in detecting small differences in reflected or emitted energy. The greater the number of digital levels used to express the data collected, the greater the detail of information. For example, a 6-bit sensor can record 2^6 levels of brightness or 64 levels while a 12-bit sensor can record 2^{12} levels of brightness or 4096 levels. There is a "zero" point (zero radiance is received by the sensor), there is no physical limit to the brightness of a pixel but it depends on the purpose of the sensor, Instantaneous Field of View (IFO), sampling time and the narrower bands. As mentioned above the purpose of the applications of data will lead to a trade-off between the types of resolution before image processing.

Digital image processing

Digital image processing in remote sensing is the use of computer and appropriate software (ERDAS IMAGINE, ENVI, ARCGIS, QGIS, IDRISI, MapInfo, Google Earth Engine including computer programming Phyton, R and R Studio) to enhance, restore, rectify and correct remote sensing images by removing noise or artefacts or errors in order to improve the quality information that will be extracted from the images for a better data interpretation and analysis (Chaki and Dey, 2020, Kobernichenkoet al., 2019, Richards and Richards, 2022). The common types of image processing that are usually carried out are Radiometric, Atmospheric, Geometric correction, Image enhancement and classification.

Radiometric correction involves improving the accuracy of surface spectral reflectance, emittance or back-scattered measurements obtained using a remote sensing system. Also, it is to correct for varying factors such as scene illumination, azimuth, elevation, atmospheric conditions (fog or aerosol), viewing geometry and instrument response. Objective is to recover the "true" radiance and/or reflectance of the target of interest /when the emitted or reflected electro-magnetic energy is observed by a sensor on board an aircraft or spacecraft, the observed energy does not coincide with energy emitted or reflected from the same object observed from a short distance. This is due to sun's azimuth and elevation, atmospheric conditions (fog or aerosols), sensor's response. Conversion from radiance (analog signal) to Digital Numbers (DN) follows a calibrated radiometric response function that is unique for channel Inverse relationship permits user to convert from DN back to radiance. Useful in many quantitative applications where you want to know absolute rather than just relative amounts of signal radiance. Calibration parameters available from published sources and image header. We use a calibrated radiometric response function to convert radiance to DN. Of course, we are able to use inverse relationship to convert DN back to radiance.

Atmospheric correction is the steps taken to reduce the atmospheric effects of scattering (increases brightness in the shortwave length visible region) and absorption (decreases brightness in longer wavelength infrared region). The corrections are absolute and relative corrections. It is the total removal of all atmospheric influences using meteorological, ground reference data and sophisticated software based on some assumptions. Relative correction takes one band and/or image as a baseline and transforms the other bands and/or images to match. This is simple method in comparison with the absolute method.

Geometric correction is done to remove geometric distortion caused by sensor system attitude (roll, pitch, and yaw) and/or altitude changes and earth rotation so that individual picture elements (pixels) are in their proper planimetric (x, y) map locations. This allows remote sensing–derived information to be related to other thematic information in geographic information systems (GIS) or spatial decision support systems (SDSS). Geometrically corrected imagery can be used to extract accurate distance, polygon area and direction (bearing) information. Some other techniques used in Geometric

Corrections are Ground Control Point (GCP) Image to Map, Image to Image, Spatial interpolation and appropriate mathematical models.

Image enhancement is point operation change in the value of each individual pixel independent of all other pixels. Local operation changes the value of individual pixels in the context of the values of neighboring pixels. They are image reduction, image magnification, transect extraction, contrast adjustments (linear and non-linear), band ratioing, spatial filtering, fourier transformations, principle components analysis, and texture transformations.

Image Classification is a method of categorizing surface features in image processing into groups for meaningful identification and recognition in image interpretation and analysis. These classifications are two types: Supervised classification involves assignment of spectral values to each pixel for categorization and Unsupervised classifications assignment of spectral values to each pixel based on natural grouping reflectance.

Other procedures involved in image processing are: Information extraction, post-classification, information output, image or enhanced image itself, thematic map, vector map, spatial database, summary statistics and graphs (Piovan et al., 2020)

Image interpretation

This is the process of detecting, identifying and recognizing objects and extraction of from the images using elements discussed below:

Shape cultural features - geometric, distinct boundaries, natural features - irregular shapes and boundaries. Shape helps us distinguish old vs new subdivisions, some tree species, football fields and farmlands. Rectangular features often indicate human influence such as agriculture.

Relative size is an important clue in differentiating built-up area from bare surfaces.

Size and shape information greatly influenced by image resolution. Knowing the scale of the image helps to convert feature dimensions on the image to actual dimensions

Texture coarseness/smoothness caused by variability or uniformity of image tone or color

Varies with image resolution. Often noted by roughness or smoothness. Influenced by shadows.

Pattern: Overall spatial form of related features repeating patterns tends to indicate cultural features and river drainage patterns.

Site is a clue of identification when the feature is related to its environment for example, valleys and hills.

Association helps to differentiate rivers from roads during the dry season due to the presence of gallery forest along the river channels.

Shadows are helpful in relief indication, some tree types, bridges and in the size of a particular feature on an image.

Relative and absolute location in the identification of site of a feature and useful to determination of land use

Once the image processing and interpretation is completed there is need for ground validation by conducting field work which is known as ground “truthing” (Coll et al., 2009)**.**

Remote sensing applications

Remote sensing has been a better option in data collection by providing view for large areas, access of information in inaccessible terrain, geo-referenced data, monitoring of environmental conditions and the advancement in the satellite remote sensing through hyperspectral sensing, multi-sensor, multistage and multi-temporal systems have given the technology a great boost (Camps-Valls et al., 2021). However, there are some challenges facing the applications. These include cloud cover which a major impediment militating against passive systems while data from active systems are difficult to interpret also trade-off between sensors’ resolutions had been an encumbrance factor. Nonetheless, the future of this technology is very bright due to foremost development in geospatial technologies, availability of free data and incorporation of mini-apps, artificial intelligence, machine learning and cloud/web/online computing and networking. Some applications of this technology include precision agriculture, natural hazard mitigation, land-use/cover change detection and population estimation.

Summary

This chapter is written to introduce students to Remote Sensing (RS) and Geographic Information Systems (GIS) by providing them with a solid foundation in this field of study. Relevant concepts and terminologies that will help the students in recognition of the significance of this course in their learning were given deserved attention. The relationship between RS and GIS, in terms of their similarities and differences, were carefully explained. The main portion of the chapter was focused on RS while GIS was taken in association as a component. At the end of the chapter students are given tasks inform of an exercise to test their level of understanding of the course.

Exercise

1. Define RS, GIS and GPS.
2. Discuss the historical development of RS and GIS.
3. Explain the effects of electromagnetic radiation interactions with earth-atmosphere on RS data.
4. Differentiate between active and passive sensors.
5. What are the relationships between RS and GIS?
6. Examine the concept of resolution in RS.
7. Discuss why image processing is important in RS.
8. Make an inventory of the elements involved in image interpretation.

References

Campbell, J. B. and Wynne, R. H. (2011). *Introduction to remote sensing*. Guilford Press.

Camps-Valls, G., Tuia, D., Zhu, X. X. and Reichstein, M. (Eds.). (2021). *Deep learning for the Earth Sciences:*
A comprehensive approach to remote sensing, climate science and geosciences. John Wiley & Sons.

Chaki, J. and Dey, N. (2020). *Texture feature extraction techniques for image recognition*. Springer Singapore.

Cohen, C. J. (2000, October). Early history of remote sensing. In *Proceedings 29th Applied Imagery Pattern*
Recognition Workshop (pp. 3-3). IEEE Computer Society.

Coll, C., Galve, J. M., Sanchez, J. M. and Caselles, V. (2009). Validation of Landsat-7/ETM+ thermal-band calibration and atmospheric correction with ground-based measurements. *IEEE Transactions on*
Geoscience and Remote Sensing, *48*(1), 547-555.

Cracknell, A. P. (2007). *Introduction to remote sensing*. CRC press.

DeBats, D., Gregory, I. and Lafreniere, D. (2018). Introduction: Spatial history, history, and GIS. In *The Routledge Companion to Spatial History* (pp. 1-6). Routledge.

Firehock, K. and Walker, R. A. (2019). *Green infrastructure: map and plan the natural world with GIS*. Redlands, CA, USA: Esri Press.

Flores, G. and Gallardo, C. (2021). Creating Shapefile Files in ArcMap from KML File Generated in My

Maps.
In *Advances in Emerging Trends and Technologies: Proceedings of ICAETT 2020* (pp. 193-204). Springer International Publishing.
Jensen, J. R. (2009). *Remote sensing of the environment: An earth resource perspective 2/e*. Pearson Education India.
Kobernichenko, Victor G., Sergey M. Zraenko, Oleg Yu Ivanov, and Andrey V. Sosnovsky. "Software and methodological support of remote sensing data processing." In *CEUR Workshop Proceedings,*
German, pp. 140-146. 2019.
Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. *Remote sensing and image interpretation*. John Wiley and Sons, 2015.
Ogunbadewa, E.Y. (2022), "Unpublished Lecture Notes"., GPS 309, Geographical Information System.
Ogunbadewa, E.Y. (2022), "Unpublished Lecture Notes"., GPS 317, Airphoto and Remote Sensing.
Ogunbadewa, E.Y. (2022),"Unpublished Lecture Notes"., GPS 311, Fieldwork.
Ogunbadewa, E.Y. (2022),"Unpublished Lecture Notes"., GPS 411, Cartography.
Ogunbadewa, E.Y. (2022),"Unpublished Lecture Notes"., GPS 413, Applied Remote Sensing
Pandey, P. C. and Sharma, L. K. (2021). Introduction to natural resource monitoring using remote sensing technology. *Advances in Remote Sensing for Natural Resource Monitoring*, 1-8.
Piovan, Silvia Elena, and Silvia Elena Piovan. "Remote sensing." *The Geohistorical Approach: Methods and Applications* (2020): 171-197.
Pruitt, E. L. (1979). The office of naval research and geography. *Annals of the Association of American Geographers*, *69*(1), 103-108.
Richards, J. A., & Richards, J. A. (2022). *Remote sensing digital image analysis* (Vol. 5). New York: springer.
Schowengerdt, R. A. (2006). *Remote sensing: models and methods for image processing*. Elsevier.
Sharma, L. K., Gupta, R. and Pandey, P. C. (2021). Future aspects and potential of the remote sensing technology to meet the natural resource needs. *Advances in Remote Sensing for Natural Resource Monitoring*, 445-464.
Xie, Y., Lei, Y., Guo, J. and Meng, B. (2022). *Spacecraft Dynamics and Control*. Singapore: Springer.
Zourarakis, D. P. (2021). Remote Sensing. Principles, Interpretation and Applications,
Fourth. *Photogrammetric engineering & Remote sensing*, *87*(1), 11-12.

Web References

Canada Centre for Mapping and Earth Observation /formerly Canada Centre for Remote Sensing (CCRS: 2023)https://natural-resources.canada.ca/maps-tools-and-publications/21448 (Accessed on April 3, 2023)
National Oceanic and Atmospheric Administration (NOAA: 2023) https://www.noaa.gov/jetstream/satellites/electromagnetic-waves (Accessed on April 3, 2023)
TRibal Earth Science and Technology Education (TRESTE: 2023)https://www.yumpu.com/en/document/view/41700101/tribal-earth-science-and-technology-education-treste-funded-(Accessed on April 3, 2023)
United States Geological Survey (USGS: 2023) https://www.usgs.gov/faqs/what-are-best-landsat-spectral-bands-use-my-research (Accessed on April 3, 2023)

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CHAPTER 11
Introduction to Human Geography
By
AJALA Olayinka Akinsumbo

Overview

Human geography is an indispensable branch of geography that focuses more on man and his relationship with the physical environment. This has manifested in its scope that covers many thematic areas such as population (population geography), settlement (settlement geography), urbanization (urban geography), transportation (transport geography) and health (medical geography) among others. Introducing students to human geography enhances their knowledge of how man relates to their environment and how the environment shapes man's way of life. This chapter attempts to imbibe the students with the pedagogy of world population, human settlement, environmental resources, man's impacts on the environment, sustainable management of resources and the flow of people, goods, energy and ideas with a view to making students identify the link between the physical and human world as well as to contribute to its sustainability.

Objectives

At the end of this chapter, students should be able to:

1. discuss the scope of human geography;
2. compare world population;
3. explain rural and urban settlement;
4. identify different environmental resources; and
5. analyze ways to sustainably manage the population and resources.

Scope of human geography and its relationship to physical geography

Geography is the study of spatiotemporal changes on the surface of the earth. It is to comprehend that the earth is where humans live. Physical geography and human geography are the two main areas of geography at the large-scale stage (Douglas, 2015). The spatial perspective of geography serves as the unifying element in the diversity of information which ranges from landforms to population, climate to settlements and biotic to economic issues. Whether they specialize in human geography or physical geography, almost every geographer is interested in how things are distributed, ordered and organized on the Earth's surface (Famisa, 1999).

As assumptions and viewpoints have changed over time, so has the field of human geography. One of the main subfields of geography, human geography, is concerned with the study of people and their relationships with their social groups, cultures, economies and interactions with the environment from a spatiotemporal viewpoint. Human geography is the study of how people, places and environments interact and change over time and space within and between geographical areas (Douglas, 2015 and Saroha, 2017). The fundamental concepts of human geography, such as location, space, region, distribution, place, migration, diffusion, and the interactions between people and their environment are still relevant today. Modern human geography focuses on the scientific investigation of where people and activities are found on the surface of the world and the factors that influence these distributions

(Saroha, 2017).

Human geographers define and clarify human social interaction patterns, spatial level relationships and how they affect or have an impact on the environment of the planet. Human geographers concentrate on the geographical organization and processes influencing people's lives, activities and interactions with their surroundings. Human geography is the study of the relationship between human societies and the surface of the globe. Also, it is described as the study of how the physical environment and sociocultural environment interact which is a result of how people are related to one another (Douglas, 2015).

The application of several key geographical themes, such as location, place, man-environment interplay, movement and region, set human geography apart from other related disciplines, such as demography, economics, sociology, politics, psychology, etc. The fundamental concepts of human geography, such as location, distribution, space, place, region, migration, diffusion and the interactions between people and their environment, are still relevant today. Modern human geography is the scientific study of where people and activities are located on the surface of the globe and the factors that influence their distribution such as density, concentration and pattern analysis (Saroha, 2017).

The relationship between each aspect of human life and the area in which it takes place is explained by human geography. As a result, human geography assumes a very multidisciplinary aspect. It establishes intimate ties with other sister social science fields in order to comprehend and clarify the human components of the earth's surface. Social geography, behavioural geography, population geography, cultural geography, settlement geography, medical geography, economic geography, urban geography and political geography are only a few of the aspects covered by the study of human geography (Ayeni and Soneye, 2018).

Human geography reflects the development of the social sciences and the need to comprehend the variety of living conditions, human activity, and land use throughout the world and within nations as the result of the operation of social, political, and economic systems. In contrast, physical geography reflects the scientific concern to understand and explain the nature and properties of matter and the universe. While the basic epistemology of physical geography is a wide scientific technique and occasionally, positivist methods; human geography has positivist, humanist and structuralist epistemologies (Douglas, 2015 and Ayeni and Soneye, 2018).

World population

The distribution of people on earth is described by the term "population." The majority of the world's population only occupies a third of the available land area, indicating a severely unequal distribution. Whereas, the quantity of people in a certain area, typically per square kilometer, is referred to as population density (Famisa, 1999 and Nicholas, 2021). This can be computed for a city, a county, a nation or the entire world. It is calculated by dividing a country or region's overall population by its land area (in square km). The population of the globe has increased by more than three times since the middle of the 20th century. In mid-November 2022, there were 8.0 billion people on the planet. The population of the world is projected to rise by almost 2 billion people over the course of the next 30 years, from the present 8 billion to 9.7 billion in 2050, with a potential peak of roughly 10.4 billion in 2100 (United Nations, 2022). Thus, as of early 2023, the most populous nations are China, India, the United States, Pakistan, Nigeria, Brazil, Bangladesh and Indonesia.

Patterns of population distribution in the world

The patterns of population across the globe are not uniform. The patterns of population distribution can be dense, moderate or sparse (World Bank, 2020 and United Nations, 2022). These are summarized as follows:

A. The densely populated areas of the world

1. **Industrial North-Eastern USA:** This area stretches from the shore of the Great Lakes passing through Pittsburg to New York which has abundant coal and iron. These are industrial areas of the United States and Canada.
2. **Industrial North-West Europe:** The presence of mineral resources like coal and iron makes the region have a dense population. The countries in this region are Germany, France, Great Britain, Belgium, Denmark, and so on.
3. **The Nile Valley and Delta:** This area is Egypt where parts of the desert (Sahara Desert) have been converted to an area of high agricultural activities which results in a dense population in the area.
4. Agricultural Monsoon Asia: These are fertile areas coupled with favourable climatic conditions such as warm weather and abundant rainfall that enhance agricultural practices. These are China, India, Japan, Pakistan, Indonesia amongst others.

B. The moderately populated areas of the world

a. These include areas of cool temperate forest in Canada, Asia, and Europe
b. The temperate and tropical grassland of southern continents
c. Many parts of Africa
d. Agricultural USA
e. Most parts of Southeast Asia

C. The sparsely populated areas of the world

i. The hot deserts of the world like the Sahara, Kalahari, the Atacama, among others as a result of hot weather and dryness with no rainfall
ii. The cold polar lands of the Arctic and Antarctica as a result of very cold weather in the areas
iii. The Eurasian and Canadian Tundra and Greenland as a result of very cold weather
iv. Amazon basin in South America, and Congo basin in Africa due to being dense tropical rainforest (South America), Congo (Zaire) basin. They are uninhabited jungles (Central Africa)
v. The areas of rugged and high mountains of the world such as Himalayas, Rockies, Kilimanjaro and Andes.

Factors influencing population distribution and density

About 30% of the earth's surface is made up of land, with the remainder being water. Unfortunately, only about 11% of the land area is suitable for human habitation. There are two categories of factors that influence population distribution and density. These are physical (natural) and human. Climate, water availability, natural resources, relief, natural vegetation and soils are examples of physical (natural) elements that affect the environment. The human elements are those that are caused by human activity and might be either political, social or economic (World Bank, 2020 and Nicholas, 2021). Transport and financial resources (sometimes known as capital to invest in manufacturing) are economic elements. Education, health care and housing are examples of social variables. A political component is the government's investment in a region's infrastructure, like in land reclamation, airport, roads, sea ports and railways (Famisa, 1999 and Nicholas, 2021)

A. The physical/natural factors

1. Climate

The earth is divided into three main climate zones: polar, temperate and tropical. Due to the long winters with subfreezing temperatures and the limited plant-growing seasons, people tend to stay away from polar regions. As a result, these regions have relatively low population densities and are home to people who still hunt and gather traditionally such as in northern Canada, Alaska and Greenland. The Himalayas, Andes and Rockies are only a few examples of the world's mountainous regions with such frosty weather. Again, the population densities in these locations are extremely low. The tropical deserts of the Sahara and Arabian Peninsula are other places with low population densities. Temperate regions with moderate temperatures and sufficient rainfall to ensure a steady supply of water for both people and crops are more likely to have high population densities. Consider Western Europe, the North East of the United States, North East China, and Japan. There are some tropical regions with a high population density such as Bangladesh, where year-round high temperatures, consistent rainfall and fertile soils produce highly productive agricultural areas. However, not all of these tropical regions are accessible such as the rainforests of Central Amazonia and Borneo which are currently very inhospitable. 99.9% of Egypt's 81 million people live on just 4% of the nation's land area with the remaining 95% being desert.

2. Water supply

The majority of people in the world obtain their water for drinking and farming from two sources: aquifers, which are underground reservoirs and rivers and lakes. Water can travel long distances- both above ground and underground- expanding the region where humans can reside. Consider the Nile in Egypt flowing through the desert and Colorado in the South West of the United States. In areas without a steady supply of water, population densities are often low.

3. Soils

When estimating how productive a region will be for growing crops, soil fertility is crucial. Mineral-rich and well-drained soils are the most fruitful types. Fertile soil can support large population densities in regions where water is present, either naturally or through irrigation, like on the Indonesian island of Java. On the other hand, upland regions with thin, stony, unproductive soils may have low population densities since they may only be used for substantial sheep grazing, like in North Wales in the UK and the Atlas Mountain in Morocco.

4. Relief (Topography)

People's densities typically range from the lowest in high, steep terrain to a maximum in low, slightly sloping, or flat terrain. The high terrain located in the world's major mountain ranges typically experiences colder winters, more frosts, and heavier rainfall that frequently turns to snow. Moreover, high ground typically has steeper slopes that are more challenging to farm (though this can be overcome by terracing – as in the rice terraces of Indonesia and southern China). As a result, the majority of the world's population is typically found in lower-lying regions like those along beaches, river floodplains, and deltas.

5. Natural resources

In its broadest sense, the term "natural resource" refers to natural resources which include soil, water, wind and minerals. The major coalfields of Western Europe, particularly the UK and Germany, and the US, saw a significant movement (migration) of people during the Industrial Revolution in the nineteenth century. The iron and steel industries, which created thousands of new employments and had a significant impact on population densities in regions like South Wales in the UK, and the Ruhr in Germany, were large enterprises that used coal as fuel.

B. The human factors

1. Economic factors

In the modern world, economic factors are now crucial in determining where industries are located, which in turn affects where people live or the distribution of the population. Transport is one of the most significant economic aspects. Several sectors will benefit if there is quick, effective, affordable and dependable transportation since it will lower production costs and broaden the market in which they may sell their goods. For instance, modern ports, such as Europort in the Netherlands, Singapore in Southeast Asia, Shanghai in China and New York in the United States. Highways have a similar impact and draw business. These areas frequently serve as natural route centers where other modes of transportation, including road, rail, and air, intersect. Both London and Paris serve as excellent examples because they are at the geographic hub of their respective nations' road, rail, and air networks

2. **Political factors**

Government expenditures on an area's infrastructure, such as roads, railroads, airports, and sea ports, as well as land reclamation, are political factors. Governments at the national and regional levels, as well as the major trading blocs like the European Union, play a significant role in determining the distribution of the population and the locations of businesses, employment opportunities, transportation infrastructure, air and sea ports, housing, hospitals, and educational institutions.

It can be inferred that there are places on earth where the population is at a moderate level, overpopulated, and underpopulated. A level of population that is ecologically sustainable is the moderate population for a region or nation. It is connected to the nation's or region's carrying capacity. There will be issues with the food supply and water supply, for example, if there is overpopulation in an area. This connotes that the population exceeds the carrying capacity of an area which results in a decline in standards of living in an area. And if the carrying capacity, especially in terms of available resources, is above the population of an area, it is termed underpopulation.

Human settlements

A settlement is a place where people live. It can consist of towns, villages or a collection of huts or houses. Human settlements reflect man's adaptation to his environment. Historically, most of the population lived in rural areas, but nowadays more than half of the world's population lives in urban areas (World Bank, 2020). In 1970, thirty-seven (37%) per cent of people lived in cities, compared to 63% who lived in rural areas. In 2000, the proportion of people living in rural areas fell to 53% while that in urban areas rose to 47%. In 2015, the percentage of persons living in urban regions (53%) surpassed that in rural areas (47%). According to the projection, 40% of the global population will be in rural areas while 60% will be in urban areas by 2030. This number is anticipated to increase in the future (World Bank 2020 and Sakketa, 2022).

Rural and urban communities differ from one another in more ways than merely the number of homes or population density. This is due to the fact that some rural communities, such as those in China and South-East Asia, have villages that are frequently just as big and as densely populated as some towns. In Spain, a community is referred to as a city or urban settlement if it has more than 10,000 residents. In other nations, like Japan and Nigeria, a community with more than 20,000 residents is regarded as a city, however, in the United States, a community with more than 2500 residents is regarded as a city (Famisa, 1999, Chigu and Antonio, 2019). The difference between an urban and rural settlement has mainly to do with occupations. In rural settlements, the people engage in primary occupations such as farming, fishing, hunting, and forestry. Whereas in urban settlements the people engage in occupations such as manufacturing or tertiary occupations such as administration, education, banking, and other services. In Africa, about 60% of the population still lives in rural areas (Delgado-Vinas and Gomes-Moreno, 2022 and Sakketa, 2022).

Classification of settlements

There are many different types of settlements, each having a wide range of geographic arrangements. From the remote farmhouse to the hamlet, village, town, city, and megalopolis, each of these entities is distinct and has its own identity. On a general note, there are two types of settlements; rural and urban settlements. While farmsteads, hamlets, and villages are considered rural settlements, while towns, cities, metropolis, and megalopolis are classed as urban centers. People's definitions of "urban" and "rural" vary, and they frequently have multiple meanings depending on the context in which they are used. The fundamental differences between urban and rural settlements are that the former is thought to have dense development patterns, whereas the latter is thought to have sparse development patterns (UN-HABITAT, 2019, Chigu and Antonio, 2019). Rural regions are human settlements that differ from major metropolitan centres in that they have a dispersed population, use a lot of land for agriculture or other purposes, and are farther away from them. Since the national urban structure heavily influences the definition of urban centres, there is no one, universal definition. However, when assigning urban features to settlements, three factors are typically seen to be important: population size, population density, and service availability (UN HABITAT, 2019 and Sakketa, 2022). A small town may have a population of several tens of thousands in huge cities like India, and an intermediate center may have as many as 500,000 people living there. The largest city in minor countries may have a population of fewer than 500,000. Consideration of small and intermediate urban centers should be made in light of their roles in providing infrastructure, facilities, and services to both their residents and those in the area. In some nations, the size requirement is ignored, particularly when it appears to be unimportant in local settings and due to wide variances in the chosen values from one nation to another. In one country, a settlement's population might be deemed large enough to qualify as an urban center, whereas, in another, it might be deemed too high or too low (Chigbu and Antonio, 2019 and Sakketa, 2022). Urban centers are typically defined by population thresholds, although while many countries in South America and Europe employ the relatively low barrier of 2,000 to 2,500 residents, other countries utilize significantly higher thresholds. More specifically, the number is 2,500 in the USA, 5,000 in Ghana, 10,000 in Greece, Spain, and Switzerland city (Chigu and Antonio, 2019 and Delgado-Vinas and Gomes-Moreno, 2022). Any community with at least 20,000 inhabitants is considered an urban center in Nigeria, according to the National Population Commission of Nigeria. These numbers provide a clear picture of the demographic importance of urban areas. It's crucial to keep in mind, though, that different countries may have very different definitions of what constitutes an urban center. Rural and urban settlements are the two categories of human settlement.

Hierarchy of Settlements

In order for students to comprehend the status of any settlement, it is typically necessary to explicitly educate them on the hierarchy of settlements when studying settlements. Homesteads, hamlets, and villages are examples of rural settlements, while towns, cities, and megacities are examples of urban communities. Based on population growth, the hierarchy will move up or down (Sakketa, 2022). A settlement hierarchy results from classifying and grouping communities based on their size and shape. The size of the settlement, the distance between communities of similar size, the population, and the variety of services available all increase as you advance up the hierarchy. Figure 1 shows that there are more towns than cities, more villages than towns, and more cities than conurbations. The pyramid also demonstrates that the number of services a settlement offers rises with settlement size; tiny settlements will only offer low-order services, whereas big towns, cities, and conurbations will offer both low- and high-order services (Nicholas, 2021 and Delgado-Vinas and Gomes-Moreno, 2022).

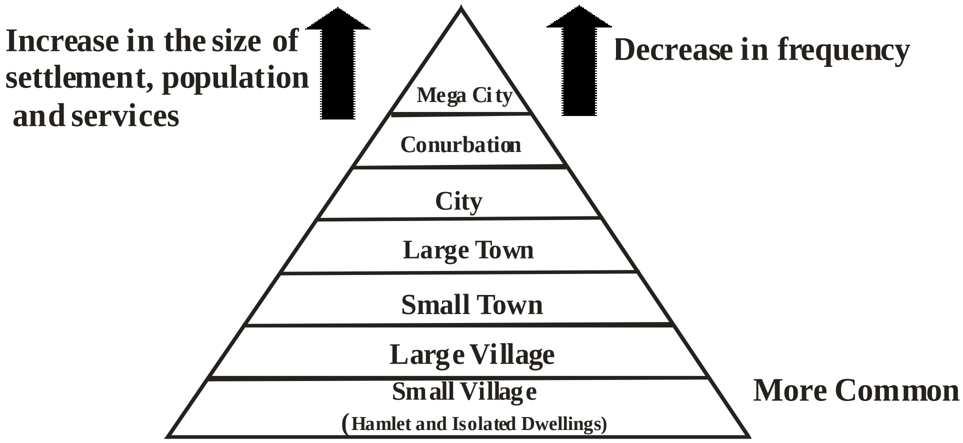

Figure 1: Hierarchy of Settlements

Patterns of Settlements

The distribution of humans throughout a landscape reveals details about how people use the area, trends in economic growth, and social relationships between different human groups. When the distributions are evaluated across a number of years, it is easy to learn how the people and their cultural traditions have evolved, as well as how the physical landscape has changed. Settlement patterns are the shape, density and distribution of human habitations, as well as how these evolve through time. The way populations use resources and generate waste, as well as how they affect social and economic prosperity, are all influenced by settlement patterns (Famisa, 1999 and Sakketa, 2022). Settlement patterns change with time, but they also have a variety of spatial locations. There will be severe consequences for biodiversity if current patterns and rates of urban expansion continue. Ecological communities will be in danger when pressures on already-stressed ecosystems intensify and lead to the degradation or removal of natural plants. The settlement pattern can be dispersed, clustered, or linear (Famisa, 1999; Delgado-Vinas and Gomes-Moreno, 2022 and Sakketa, 2022).

Functions of Settlements

Some communities have a predominant purpose, while others have multiple functions. The needs of many settlements around the world have required them to adapt over time. For instance, rural farming communities that discover that their younger members are departing to find work in the city, leaving only the older population, may turn into retirement communities or commuter villages as commuters move in. Major roles that settlements play include, among others (Famisa, 1999, Chigu and Antonio, 2019; Nicholas, 2021 and Delgado-Vinas and Gomes-Moreno, 2022):

Market - refers to a town that regularly holds a market and it is usually more community orientated than regular towns. A market town is a collection and distribution center for local products. It is more common in agricultural regions and some densely-populated areas. Examples of market towns are Norwich, Accra and Kumasi (Ghana), Lagos, Onitsha, Kano and Ibadan (Nigeria).

Port - A port is a place on a seashore or coast which consist of one or more docks where goods are loaded and unloaded. There are ports with a deep amount of water. However, these deep-water ports are able to handle more massive, economical ships. Some ports also have an important role in military bases. Port settlements include Marseilles, Auckland, Southampton, and Hong Kong (seaports); Singapore, Colombo, Lagos and Rotterdam (entreports- for receiving and redistributing goods to the neighbouring countries); Belgium, Calais and Folkestone (packet stations- ferry terminals on the international scale); and river ports like Port Harcourt, Warri and Sapele in Nigeria.

Industrial/Manufacturing – is where most of the activities are manufacturing. A manufacturing area requires a nearby source of materials, transportation, and working force. This is why the main manufacturing cities are usually located near a waterway. Major industrial towns are Pittsburgh (U.S.A.), and Leeds (U.K.). Sheffield developed as an important iron and steel industrial center.

Resort –is a place where tourists visit to enjoy themselves. There are many tourist resorts in the world. Some people seek places where they can rest and relax in peace. For those people, places like tropical islands and beaches might be suitable. There are those who seek adventures and sports for tourism e.g., ski resorts, mountain resorts, rainforests, etc. Holiday resort centers include Brighton (U.K.), Miami (U.S.A.), Cameron Highlands (Malaysia), health resorts in Baden (Germany) and Bath (U.K.).

Administration - The most common administration is the government. They set businesses and laws for the people of their nation. National capitals perform this function e.g., Washington D.C. (U.S.A.), Brasilia (Brazil), and Abuja (Nigeria) among others.

Education – These are settlements of world-renowned educational institutions e.g., Oxford, Cambridge and London (U.K.), Lund (Sweden) and Heidelberg (Germany). In Nigeria, there are Ibadan, Ile-Ife, Zaria, Akure and so on in Nigeria (Ajala, Akingbade, Olabamiji and Folorunsho, 2022).

Residential/Satellite – These are settlements that provide accommodation for urban people and often include industrial estates for light industries e.g., Crawley serving congested London; Petalling Jaya near Kuala Lumpur; Mushin, Shomolu, Ajegunle and Ojo Apapa, etc. are residential settlements serving Lagos while Diobu serves Port Harcourt.

Mining - refers to a town located next to a mine or mines. They usually arose quickly after a mineral deposit was discovered, especially with gold and silver. Mining towns became famous for working-class struggles and militant unionism. There are many mining towns across the world e.g., Lubumbashi (Zaire), Enugu and Jos (Nigeria), Newcastle (U.K.), Kalgoorlie (Australia), and Johannesburg (S. Africa).

Commercial – This is a center of commerce and finance. By this, it is central to the economy of the nation. A commercial town is a major trading center consisting, largely, of shopping malls, good transportation, a safe environment, and technology. Examples are London, New York, Zurich, Frankfort, and Lagos.

Route Center – This may be a route center for airplane, automobiles, ocean-liners, or trains. The function of a route center is basically center of the materials. It is a crucial settlement because if it falls, there is a high chance of messing up the economical flow. An example of a Route Centre is Inchon Airport in East Asia. If the Inchon airports route system is malfunctioning, then economically and politically Korea will become devastated.

Cultural Town - A culture is developed based on beliefs, faith, practices, customs, lifestyle, language, intelligence, art, food habits, economy, etc. The differences in these factors gave cultural identities to different parts of the world. For instance, Ile-Ife in Nigeria

Religious Town – This is also known as 'Ecclesiastical Town'**.** Different religions have different cultures such as Jerusalem (Christian), Mecca and Medina (Muslim), Benares (Hindu), Jewish, etc. Canterbury and Lourdes in France serve as religious centers.

Urban centers are unique because they perform a series of functions that make them attract more people. These include the concentration of various forms of capital- human, economic, social, and political. Also, they are centers of artistic, scientific, and technological innovations culture and education. They also perform great roles in social transformation. The provision of basic urban services had not kept pace with the rapid increase in the urban population (Sakketa, 2022 and Delgado-Vinas and Gomes-Moreno, 2022). Now and in the nearest future, innovative, responsive and effective policies and institutions are required in order to meet fully the future needs and potentials of the urban centers. Some of these policies include the sustainable cities programme, cost-recovery strategies, inclusive cities network, good urban governance and population migration policies.

Urban and rural settlements inter-relationship

A rural-urban relationship can be social, economic, and cultural. It includes the flow of manufactured and imported goods from urban centers to rural settlements, as well as the flow of agricultural and other commodities from rural-based producers to urban markets, both for local consumers and for forwarding to regional, national, and international markets. They also include the flows of people who commute often, make sporadic trips to metropolitan services and administrative hubs, or migrate either temporarily or permanently between rural and urban populations. Information on market mechanisms, such as price changes and customer preferences, as well as information on job prospects for possible migrants, are exchanged between rural and urban areas (UN-HABITAT, 2019 and Delgado-Vinas and Gomes-Moreno, 2022).

1. **Agricultural inter-relationship**: This includes any effects that urbanization has on agricultural productivity and output, the processing and trade of agricultural inputs, as well as the services that urban regions offer to rural areas.
2. **Consumption inter-relationship**: There are inherent connections between rural and urban places. For instance, while rural populations depend on metropolitan services, urban residents depend on food and other natural resources in rural areas.
3. **Flows of people or labour inter-relationship:** The movement of people or labour between rural and urban areas is referred to as human mobility. This can happen in a number of ways, including commuting or moving about continuously. Expanding urban regions, therefore, provides the chance to diversify rural economic activity away from agriculture in rural areas, and improves their incomes.
4. **Financial inter-relationship:** One of the most important sources of funding for maximizing the economic potential of rural communities comes from urban areas. Remittances, loans, and investments made by urban inhabitants as well as government and aid agency investments in the socio-economic and infrastructure development of rural areas are all examples of financial inflows from urban to rural areas.
5. **Land market inter-relationship:** Despite the fact that rural communities depend on agriculture, urbanization competes with agricultural land (Akingbade & Ajala, 201). There are three methods to look at how urbanization has an impact on rural economies' land links. First, when agricultural land in peri-urban areas is converted to developed land as a result of horizontal urbanization. Second, the availability of land per person in rural hinterlands rises when more people migrate from agricultural to urban regions, which in turn boosts labor productivity in agriculture. Thirdly, the growth of urban regions may drive up the price of agricultural land in peri-urban areas.
6. **Information and knowledge inter-relationship:** Cities and towns hasten human interaction, which in turn hastens knowledge transfer and accumulation. One of the ways that urbanization affects rural development is through the interchange of information or ideas between urban and rural populations. For instance, information about population needs, employment opportunities, extension services, market information, innovations, and new technology that are essential for boosting farm productivity and, consequently, rural development are transferred from urban to rural areas.
7. **Social interaction inter-relationship:** The social structure may change as a result of urbanization, including a decline in culture and identity as well as a shift in social capital. This change may undermine social cohesiveness and/or heighten social conflicts, both of which have an impact on economic outcomes. Rural-urban linkages offer convenient spaces for social interaction.

Environmental resources

The elements of the earth's biophysical environment, both living and non-living, that can be useful to humans are called environmental resources. Subsoil resources (mineral and energy), soil resources, biological resources, water resources, and land resources are all examples of environmental resources. Environmental resources can be naturally grouped into renewable (timber, water) or non-renewable (minerals) resources African Development Bank Group (2016).

Renewable and non-renewable resources

Environmental resources that can be renewed as they are utilized include trees, water, the sun, and wind. But, if they are not adequately managed or maintained, renewable resources might become exhausted. Environmental resources classified as nonrenewable are those that run out more quickly than they can replenish. Nonrenewable resources are permanently depleted after they are mined and used up. Africa has a wealth of natural resources, including forests, water, oil, natural gas, minerals, and arable land. A significant amount of the world's natural resources, both renewable and non-renewable, are found on this continent. About thirty (30) percent of the world's mineral reserves, eight percent of its natural gas, and twelve percent of its oil reserves are found in Africa. Land is both a socio-cultural resource and a resource for economic growth. Yet, a sizeable portion of these resources are exploited in an unsustainable manner, and some are lost due to criminal activity, which means that the benefits that can be obtained over time are diminishing in (Africa African Development Bank Group, 2016). Some of the aforementioned environmental resources are discussed below:

1. **Climate and vegetation as environmental resources**

Both climate and vegetation are renewable resources. Renewable resources are those resources that are being replenished, after use (by man) and natural factors. In general, a natural resource is anything that can be used by man. As a resource, solar energy acts as the life spring of virtually all the processes that take place on the earth's surface, and it is increasingly being put to use at the present time. It is also being harnessed as a source of power. Vegetation as a natural resource, serves as a source of fuel and materials for industrial use. The industrial uses of vegetation include medicinal uses, furniture, paper making, and various construction works such as house roofing, canoe building, etc.

2. **Soil as environmental resources**

Soil is a medium in which plants grow. Soil is found distributed over the earth's surface showing distinct spatial relationships with other factors of the environment whose character, development, and distribution in space are governed by the general laws of nature. When a lump of soil is collected, it is expected that it will be made up of four main constituents. These are mineral matter, organic matter, air and water. While mineral matter and organic matter are known as solid matter, air, and water are known as pore spaces.

3. **Water as environmental resources**

The percentage of the earth covered by water is over 70%. Hence, it should be expected that the earth must have a lot of resources restored in this water surface. The water of the earth is found in the oceans, seas, lakes and pond, rivers and streams. Ocean and sea waters are characteristically salty, while water in lakes, ponds, rivers, and streams subject to tidal waters are also salty. The resources in these waters are limitless. There are solid and liquid minerals, numerous animals of varying sizes, countless fishes and reptiles. Water bodies provide means of transport, and energy for electricity supply. It also serves as a medium of transportation, and for agricultural purposes.

4. **Minerals as Environmental Resources**

Minerals are naturally formed chemical substances which possess a definite chemical composition and a definite atomic structure. Minerals occur in various concentrations and quality and are unevenly scattered on the earth's surface. As many as over 2000 minerals are known to man. Common minerals can be grouped into mineral fuels for power (coal, petroleum, gas), iron, non-ferrous metals (copper, tin, aluminum, lead, zinc), ferro-alloy metals (nickel, molybdenum, manganese, chromium, tungsten, cobalt, vanadium), the noble metals (gold, silver, platinum, titanium), and some other metals and minerals like mercury, osmium, radium, plutonium, graphite, mica, asbestos, pyrites, sulphur, potash, phosphate, borate, diamond among others. Minerals serve as a source of fuel, provision of employment opportunities, industrial development, construction purpose, and source of ornamentals.

These environmental resources are, in most parts of Africa, being degraded. In order to avoid extinction/depletion of these resources, there should be environmental management of these resources, especially, through judicious use and conservation of these resources (African Development Bank Group, 2016). All important aspects of environmental resource management such as economic, ethical, social, and technological must be taken into consideration.

The roles of movement and flow of people, goods, energy and ideas

It is pertinent to state that the facilities of transport and communication (movement and flow of people, goods, energy, and ideas) are not developed autonomously for their own sake. They are normally developed to serve certain purposes including political cohesion, administrative purposes, military movement and for the enhancement of economic development. Therefore, transport and communications are part of development processes (Famisa, 1999). The distinction between transportation and communication is not always clearly defined, but Transportation could be viewed as mechanical movements of physical entities (people and goods), while communication is the movement of messages (information, ideas, knowledge). The latter could be sent through printed media or transmitted via electronic devices. Transportation and communication are required to facilitate movements. The functioning or otherwise of an economy is inextricably linked with transportation and communication facilities (Sakketa, 2022). By implication, the development of the whole economy of a country, and the world in general is linked to the network of transportation and communication systems available to mankind. Transportation and communication respond to the needs of the economy, but at the same time could transform the economy from a low to high status. Conventional modes of transportation are recognized as Pedestrians, pack animals, bicycles, cars and trucks which use the roads (ordinary and express/freeways); surface trains, sub-way trains and elevated trains which use the rail-lines. Boats, ships and tankers use the waterways and the open seas/oceans. Helicopters and aircrafts ply the air-routes. Pipes are laid (over or underground) to move oil, gas, and goods. These modes of transport improve in capacity, safety, and speed as new technologies continue to be introduced. These have brought about location interaction among different parts of the world (Famisa, 1999 and UN-HABITAT, 2019).

Transferability, among others, such as complementarity and absence of intervening opportunities is an essential component of locational interaction. Location interaction is either over a short or long distance is made possible by either the provision of transport and communication facilities namely routeways, the media or modes and the terminal. The roles of transportation and communication are indispensable to any economic system either developed or underdeveloped.

The role of transport

In very simple terms, transport is said to provide place and time utilities. For instance, transport enables people, goods and services to move from areas where they are not needed to places where they are needed. For instance, raw materials are shipped to factories that may be located several kilometers from the sources of such raw materials. People move with the help of transport into specific locations where they perform various functions which are of immense benefit to themselves and the surrounding areas. This is a place utility. In terms of time, transport helps in one way or the other to get people, goods and services to their destinations as fast as possible, particularly, with a view to making time available for other purposes. The whole history and the continuous technological improvement in transport are, among other things, to shorten the time spent in transit while overcoming the friction of distance. For instance, commuters between Lagos and Kano using such means of transport as foot, bicycle, motorcycle, lorries, cars, or helicopters would spend different times in transit between the two cities. One can similarly recall that until the construction of an express way linking Ibadan with Lagos, the journey between the two cities in southwestern Nigeria took several hours (Famisa, 1999). The development of e-mail and the internet is meant to convey information at very high speed to where they are required which ordinarily would have taken many hours or days if such messages were to be conveyed through traditional means of transport. The forgoing helps to explain the function of transport as time safer otherwise known as time utility (UN-HABITAT, 2019 and Delgado-Vinas and Gomez-Moreno, 2022). Transportation also enables regional specialization to take place in any space economy. Where adequate transportation infrastructure is in place, farmers, and industries are known to have increased the level of their agricultural and industrial outputs since the constraint usually imposed on mobility due to the absence of transport are not there in the first place. On the other hand, all necessary inputs from outside which are needed on either the farms or factories would usually reach them with relative ease and perhaps at a cheaper cost. In this regard, in the development of all agricultural and industrial theories in geographic research, the availability or unavailability of transport constitutes a critical factor in shaping the spatial location or spatial pattern of either phenomenon in space. Likewise, in the development of theories of the internal structure of cities, transport is regarded as a “city breaker”. In that, the expansion of cities beyond their traditional boundaries and the resultant land use differentiation and their connectivity are made possible by the provision of transport (UN-HABITAT, 2019 and Sakketa, 2022). In a rural economy, adequate provision of transport usually permits better use of land. People living in rural areas depend on the exploitation of land, either in agriculture, lumbering, mining, or in tourist potential. Where transport is not available or when expensively provided in rural areas, rural land use is generally confined to a narrow belt around settlements. There is therefore a strong relationship between transportation and economic development. Thus, the constraints in the standard of the well-being of rural and urban areas can be ascribed to the difference in the level of facilities as well as the possibilities for movement and interaction in both places (Delgado-Vinas & Gomez-Moreno, 2022). Transport has a transformative power as exhibited in the economies of both developed and developing countries since the beginning of this century that scholars have identified three important possible impacts of transport in any economy (UN-HABITAT, 2019 and Sakketa, 2022). The provision of transport facilities could lead to a corresponding positive development. One of the constraints to rural development is the inadequacy of transport infrastructure organization and management. Either within or between urban centers, additional functioning telephone lines or phones may help to improve intra- or inter-urban interaction by decongesting the volume of vehicular transport on the roads linking such various centers. Also, the provision of additional transport facilities may not bring about the desired goal or multiplier effect. It is possible to observe a negative impact on the provision of transport infrastructure either regionally or nationally. This negative impact may be envisaged in two ways, namely through budgetary allocation and spatial diversion of traffic. In the former, more investments in transport infrastructure such as sea ports, airports, roads, and rail roads may be translated to mean a reduction in the funds that would be available to other sectors of the economy like education, health, agriculture, and industrial development. Furthermore, it is possible that additional transport infrastructure may lead to neither positive nor negative impact in the region where they are provided. This observation has been termed the permissive role of transport. This is the case with the transport sector of most developed countries where certain routes are eliminated for redundancy.

The roles of communication

The forms and technologies of communications are varied and complex. The different modes of effecting communications include face-to-face, telephone, hand phone, radio, television, and printed word by postage, fax, e-mail, and internet. Although these modes are different types, they are used complementarily to achieve communications, which play very significant roles in economic development. Communications by broadcasting on radio and television are commonplace in many countries. Phone or telephone as a communication facility is not only a promoter of economic development but, in fact, a variable in the computation of an index of development in an economy. An efficient phone/telephone system engenders effective communications that could prove invaluable in local and international contacts. Effective communications tend to enhance efficiency in all sectors of the economy including agriculture, industrialization, transportation, commerce and trade, fishing activities, and personal services, among others. Telephone facilitates quick contact between rural and urban centers and between national capitals, which are usually the location of headquarters of multinational corporations operating transnational enterprises in manufacturing and commerce. Phones save time by reducing personal visits (UN-HABITAT, 2019 and Delgado-Vinas and Gomez-Moreno, 2022). Some telecommunication technologies can provide worldwide information on a daily basis to enhance trade transactions on various commodities among various countries of the world. Services to match supply and demand are offered on some worldwide communication networks. Some companies use telecommunication technologies to keep records of offers and requests among companies in the world on daily basis. Some produce daily bulletins on trade transactions. A computer is a versatile communication facility. Its capacity to store, retrieve and transmit information is astonishingly high. Computers can link branches of the same company and in many other companies and it tends to create global networks of communication. Internet to which computers and telephones can be linked is such a prolific communications system that it has been likened to the steam engine that gave rise to the industrial revolution of the 18th century in Europe. It is going to revolutionize the way information is obtained, how people communicate with others, and how goods and services are bought (UN-HABITAT, 2019 and Delgado-Vinas and Gomez-Moreno, 2022).

From the foregoing, the roles of transportation and communication at all levels of any economy have been articulated. Starting from a personal level to an international level, transportation and communications have been able to bring people, goods, services, and ideas located in different parts of a country or the world together, to the extent that the world is now being regarded as a global village. Although road accidents, air disasters, shipwrecks, and derailments are menacingly staying with us, man continues to perfect and improve the modes of transportation and communication and the handling of cargoes with a view to meeting the increasing demand for faster mobility of people, goods, services, energy, and ideas. The developed countries of North America, Europe and the Far East are more mobile than the underdeveloped countries of Latin America, Africa, and Asia whose transportation and communication systems are relatively underdeveloped.

Summary

Human geography is a very broad subject that cannot be adequately covered within the scope of this chapter. Hence, this chapter gives a background knowledge that will usher the students into full pedagogy of different aspects of human geography, be it urban geography, population geography, economic geography or social geography among others. This chapter thus introduces the students to the scope of human geography which include world population, human settlements, environmental resources and flow of people, goods, energy and ideas.

Exercise

1. Explain the scope of human geography.
2. Describes the spatial distribution of population across the world.
3. Compare rural settlements and urban settlements within the context of their functions.
4. With specific examples, discuss different types of environmental resources.
5. Highlight the roles of transportation and communication in the economic development of a nation.

References

African Development Bank Group (2016). African Natural Resources Center: Catalyzing Growth and Development through Effective Natural Resources Management.

Ajala, O., Akingbade, A., Olabamiji, A. and Folorunsho, E. (2022). The Quality of Students' Accommodation in Nigeria's Tertiary Institutions. *Interdisciplinary Journal of Education Research*, *4*, 60-74. https://doi.org/10.51986/ijer-2022.vol4.05

Akingbade, A. O. and Ajala, O. A. (2021) Land Administration Reform in Africa: Lesson from Southwestern Nigeria. AFRIGIST Academic Output Series 1. Ibadan, Nigeria: Impeccable.

Ayeni, A. O. and Soneye, A. S. O. (2018). Does Geography Duplicate other Disciplines? Nigerian Geographical Journal, 12(1), 88-97.

Chigbu, U. E., and Antonio, D. (2019). Rural-Urban Inter-Relationship in an Urbanising World: The Literature Perspective of Nigeria (UN-HABITAT GLTN). FIG Working Week 2019 Geospatial information for a smarter life and environmental resilience Hanoi, Vietnam, April 22–26, 2019

Delgado-Vinas, C. and Gómez-Moreno, M.L (2022). The Interaction between Urban and Rural Areas: An Updated Paradigmatic, Methodological and Bibliographic Review. Land 2022, 11, 1298. https:// doi.org/10.3390/land11081298

Department of Geography, OAU (2004). Readings in Man-Environment Relations. Babs -Adedeji and Sons Press, Ile-Ife.

Douglas, I. (2015). The Influence of Human Geography on Physical Geography. Interface, pp 517- 540

Famisa, Z.S. (1999). An Introduction to Economic Geography. Trankhei and Co, Ile-Ife

Nicolas Schneider (2021): Population growth, electricity demand and environmental sustainability in Nigeria: insights from a vector auto-regressive approach, International Journal of Environmental Studies, DOI: 10.1080/00207233.2021.1905317

Sakketa, T. G. (2022). Urbanisation and Rural Development in Developing Countries: A Review of Pathways and Impacts. Discussion Paper, German Development Institute. https://doi.org/10.23661/dp5.2022

Saroha, J. (2017). Scope and Contemporary Relevance of Human Geography. International Journal of Research and Analytical Reviews, 5 (1), 129-134

UN-HABITAT (2019). Urban-Rural Linkages: Guiding Principles. Framework for Action to Advance Integrated Territorial Development, UN-HABITAT

United Nations Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022: Summary of Results. UN DESA/POP/2022/TR/NO. 3.

United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Data Sources. UN DESA/POP/2022/DC/NO. 9

World Bank (2020). Demographic trends and urbanization. International Bank for Reconstruction and Development / The World Bank.

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CHAPTER 12

Basic Elements and Applications of Photogrammetry and Remote Sensing

By

OGUNLADE Simeon Oluwole

Overview

Monitoring our environment is a very important task in science, engineering and technology. Our environment is dynamic (Ogunlade, 2021). It keeps changing daily. These changes come with both positive and negative effects. Man needs to observe and measure these changes in order to obtain relevant information that will help him enjoy the positive effects and manage the negative effects. A branch of science that focuses on this aspect of observing and measuring these changes in the environment is called geospatial technology. Geospatial technology is a branch of science that is concerned with gathering, manipulating, storing, retrieving and classifying recorded information on, above or below the earth surface (Gomorrasca, 2009). Also, it is referred to as surveying or geomatics. The recorded information is called geospatial data (geo-earth, spatial –of space) (Science Direct, 2023). There are many techniques in geospatial technology that are used to record earth surface information or acquire geospatial data. There are those techniques in which the equipment used to record the information must have physical contact with the part of the environment measured or monitored. These are called the contact techniques. Also, there are those techniques in which the equipment does not have any physical contacts with the part of the environment measured or monitored. These are called the non-contact techniques. Photogrammetry and remote sensing belong to the non-contact techniques. That is, the equipment used in them to acquire geospatial data do not have physical contact with the earth surface (or part thereof) being observed or measured. In their applications, both of them belongs to the branch of geospatial technology known as Surveying (Science Direct, 2023). This chapter attempts to take the readers through the basic knowledge of the techniques of photogrammetry and remote sensing

Objectives

At the end of the chapter, students should be able to:

1. define photogrammetry and remote sensing;
2. describe the equipment used in photogrammetry and remote sensing;
3. explain the branches of photogrammetry and remote sensing;
4. explain the applications of photogrammetry and remote sensing;
5. describe the procedures in photogrammetry and remote sensing; and
6. differentiate between photogrammetry and remote sensing.

Photogrammetry

Photogrammetry came from three Greek words, 'Photo' – light, ’Gram' – drawing, 'Metry' – Measurement. Thus, it means making measurement from drawings (images) obtained through light (Geodetic Systems, 2022). Campbell and Whyne (2011) defined photogrammetry as the science of making accurate measurements from photographs, Konecny (2003) viewed it as a technique used to derive geometric (shape and size) information of objects by measuring their images while Schenk (2005) defined it as a technique that helps to obtain reliable information about the properties of surfaces and objects without physical contact with the objects and the information obtained are measured and interpreted. Therefore, generally defined, photogrammetry is the science, art and technology of obtaining information from measurement performed on photographs. The process of collection of photographs is called photography. Thus, photogrammetry is also called aerial photography (Koert Sijmons, 2021). In surveying/geomatics, photogrammetry, also called aerial photography, is the branch that deals with production of maps such as planimetric or topographic maps by compiling number of photographs taken in an area (The constructor, 2023).

Branches of photogrammetry

Photogrammetry consists of two branches (Martin and Getachew, 2021). According to the position of operation, as observed by Koert Sijmons (2021), it can be terrestrial or aerial.

1. **Terrestrial or ground photogrammetry:** This is the situation where photographs are taken from a fixed position on ground
2. **Aerial photogrammetry:** This is where an aircraft, helicopter or drone with camera setup is used to take photographs from the air flying over the ground as shown in figure 1. This is the most used in the field of geospatial technology (Pix-Pro, 2022).

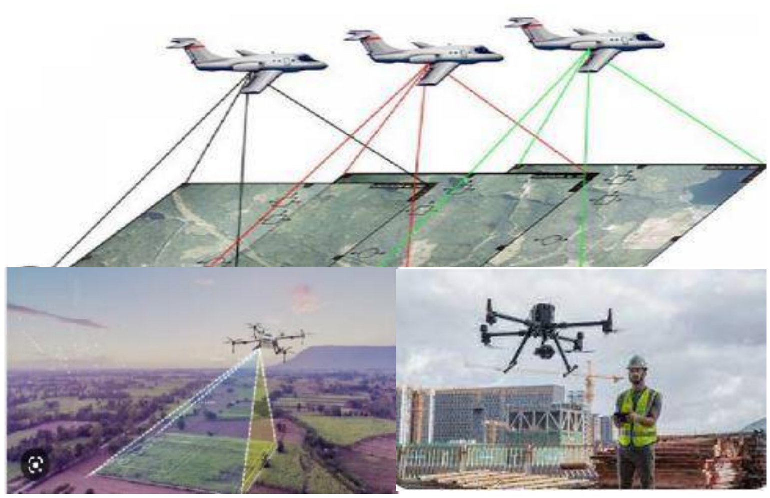


Figure 1: Aircraft and drones in operation.

As the science of surface exploration, photogrammetry can basically be divided into two main branches as (Pix-pro 2022):

1. **Metric photogrammetry:** This deals with the calculations from which we get precise size, shape, volume, and position measurements on the earth's surface or in a definite space. It is used for digital analysis of the object's change, progress or dynamics.
2. **Interpretive photogrammetry:** This is more targeted at the reconstruction of neat patterns, shadings,

surface structures, reliefs and colors to reveal the object's complete visual semblance. The science of
photogrammetry covers many different fields of human activity.

Phases of aerial photogrammetry

There are two phases of operation in photogrammetry (Pix-Pro, 2022). These are:

1. **Production of aerial photographs:** Aerial photographs are obtained with dedicated cameras that are placed on aircraft or drones as shown in figure 2. The cameras are equipped with capabilities that are made to record images of part of the earth's surface on which the platforms fly over.

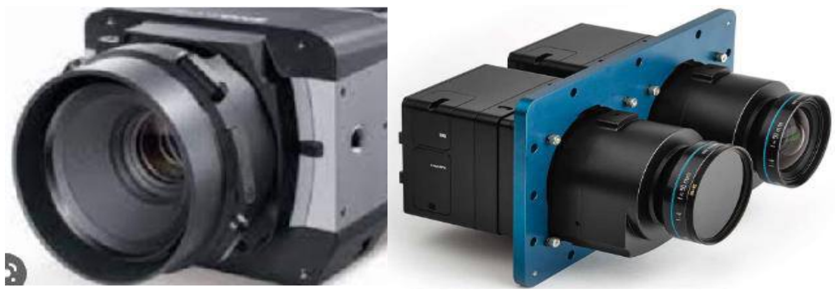


Figure 2: Photogrammetry and Drone camera

The aircrafts are made to fly in pre-planned flight lines over an area of interest and the cameras record the characteristics of the area inform of electromagnetic radiant energy on dedicated films. These films are then processed to generate aerial photographs. The aerial photographs are later presented in hard copy prints or used as soft copy (digital version). A modern way of collecting aerial photograph is the use of drones, also called Unmanned Aerial Vehicle (UAV). UAV is a drone shown in figure 3, equipped with cameras that record the image of an area as it flies over in digital form. The records are then produced in hard copy or used as soft copy.

Figure 3: Drone

2. Measurements/observation on aerial photographs

After the aerial photographs are obtained, they are subjected to two treatments: measurements and observation (metric and interpretation).

a. **Measurement:** Various measurements like Distances, Area, Elevation (Height and Depth) are performed on the photographs to determine some characteristics of the environment such as the digital
analysis of the object's size, shape, coverage, change, progress or dynamics. The results of such measurements are presented as maps. Examples of such maps is the topographic map that shows

the
relative positions of features and points in an environment and the undulations which are presented as
contour lines on map, of its ground surface.

b. Observation: Aerial photographs are also subjected to visual observation. From the observations,
some properties are interpreted to infer some characteristics of the environment. Thereafter, the inferences are presented in various formats for quality decision makings. Properties interpreted includes tone, texture, size, shape, resolution, shadow, pattern and association.

Figure 4: Aerial photograph of Lagos, Nigeria
(Source: British Library)

Applications of photogrammetry

Photogrammetry or aerial photography is used in the following fields (ScienceDirect, 2023):

1. Surveying, architecture, engineering and geology for topographic mapping and several other relevant mappings;
2. Archaeology for quick production of plans for large or complex sites;
3. Meteorology to determine the wind speed of tornadoes when objective weather data cannot be obtained;
4. Combine live action with computer-generated imagery in movies post-production;
5. Creation of photorealistic environmental assets for video games;
6. Creation of 3-D imagery using google earth; and
7. Other areas of application include manufacturing, quality control, police investigation and cultural heritage.

Figure 5: Drone photograph of part of Abuja, Nigeria

Remote Sensing (RS)

Remote means, located-far-away spatially, distant, something which is not exactly in contact or in physical contact, something which is far away. This could be something which is slightly away or even very far away. On the other hand, Sensing means, to sense, perceive by a physical sensation, detect some circumstance or entity automatically (Anthony 2023). Remote sensing has been defined severally. Some of these definitions are:

'1. Remote sensing is the science of gathering information from a location that is distant from the data
Source. (Noam, 1999).

2. Remote Sensing is the science of obtaining and interpreting information from a distance, using sensors
that are not in physical contact with the object being observed (Randall, 2012).

3. Remote Sensing is the science, and to some extent, art of acquiring information about the earth's surface without actually being in contact with it. This is done by sensing and recording reflected or
emitted energy and processing, analyzing and applying that information (CCRS 2023).

Thus, we can define remote sensing simply and generally, according to Campbell and Whyne (2011), as the gathering of information at a distance.

These definitions of RS are broad. Summarily, it is the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study. It is the use of any device at a distance (drone, aircraft, spacecraft, or ship) for gathering information like measurements of force fields, electromagnetic radiation or acoustic energy. RS technique employs such devices as the camera, lasers and radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers, and scintillation counters.

The RS of concern, in this chapter, is a specific one that the involves the use of sensors placed on satellite in space as shown in figure 6 for the observation of earth and its resources. This is also known as satellite RS of the environment.

Figure 6: Satellites in space

Components of remote sensing

From the definitions above, it can be inferred that remote sensing is a technique or a practical method or art applied to some particular task or a science (Anthony, 2018). It involves detection, recording and production of information. All these are performed by devices called sensors. The sensors detect and record signals coming from the environment (objects or their properties or phenomenon). Remote sensing consists of: what is sensed, the device that senses, the signals sensed and the products.

1. **What is sensed?** These are the properties or characteristics of objects or phenomenon. These are contained in the electromagnetic radiant energy that has interacted with surface materials and the atmosphere.
2. **The device that senses**: These are called sensors, described as devices that are equipped with special and dedicated lenses and functions to detect, measure and record radiant electromagnetic energy.

Categories of sensors

Sensors are categorized based on so many factors. Some of the factors commonly used are:

a. The sources of the electromagnetic energy;
b. The interactions of the electromagnetic energy with the surface;
c. Specific function it performs; and
d. The spatial resolution.

a. The sources of the electromagnetic energy: Sensors in this category can be active or passive.

1. Active sensors: They are those that generate their own electromagnetic energy released to interact with the environment and detect, measure and record the electromagnetic energy that are radiated from the environment. Active sensors transmit a signal and receive the reflected response (CCRS, 2002).

2. **Passive Sensors:** They are those that depend on external source of electromagnetic energy like the Sun. The earth is naturally illuminated by electromagnetic radiation from the Sun. Passive sensors collect natural radiant energy reflected or emitted from a target (CCRS, 2002).

b. The interactions of electromagnetic energy with the surface.

Sensors, in this category, can be reflected solar radiation sensors, thermal infrared sensors and imaging radar sensors.

1. **Reflected solar radiation sensors**: Sensors that detect solar radiation that has been diffusely reflected (scattered) upward from surface features. Reflected solar remote sensing systems are the most common type used to monitor Earth resources.
2. **Thermal infrared sensors:** These are sensors that detect the thermal infrared radiation emitted by surface features and can reveal information about the thermal properties of these materials.
3. **Imaging radar sensors**: These are active systems that illuminate the surface with broadcast microwave Radiation and measure the energy that is diffusely reflected back to the sensor. The returning energy provides information about the surface roughness and water content of surface materials and the shape of the land surface.

c. The Specific Function it performs and Country of Origin

Sensors, in this category, can be earth observation sensors like Landsat (Land Information Satellite from America, SPOT from France, Sentinel from European Space Agency etc), Niger-Sat from Nigeria.

d. The resolution

Resolution means how clearly a sensor can obtain information about the smallest object from space. Thus, there exist, high, middle and low resolutions sensors (Ezeomedo and Igbokwe, 2012 and 2013).

Sensors, most times, are loosely referred to as satellite images. For instance, someone can say Landsat 7 satellite image.

The platforms on which the sensors are placed: These can be terrestrial, air borne or space borne.

1. **Terrestrial or ground based:** These are the ones held on hand or placed on the ground using equipment such as tripod stands.
2. **Aerial based or airborne:** Those that are located in the air such as balloons, helicopters, drones, aircraft.
3. **Space borne:** Those that are located in space such as the satellites and rockets.

The signals sensed: These are energies radiated (emitted or reflected) from object or surface materials in the environment. The radiant energy is the electromagnetic energy in form of visible light, Infrared, microwaves etc.

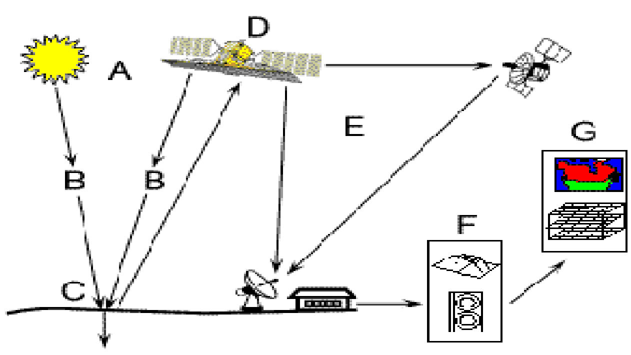
The products: The products of remote sensing are imageries in various formats such as pictorial (images) and digital data etc.

Elements of remote sensing process

There are seven elements that comprise the remote sensing process from the beginning to the end. These are illustrated in steps A-G as shown in figure 7.

Figure 7: Elements of Remote Sensing process

1. **Energy source or illumination (A):** There is always an energy source which illuminates or provides electromagnetic energy to the target of interest. The commonest energy source for the remote sensing of the earth is the Sun.
2. **Radiation and the atmosphere (B):** The energy travels from its source to the target. It comes in contact with and interact with the atmosphere.
3. **Interaction with the target (C):** The energy reaches the target and interacts with the target. The kind of interaction depends on the properties of both the target and the radiation. The energy travels back from the target to the sensor and come in contact with and interact with the atmosphere again (B).
4. **Recording of energy by the sensor (D):** The interaction with the target produces reactions on the energy that makes it carry in it the properties of the target. They are either scattered by or emitted from the target. A sensor (remote - not in contact with the target) collects and record the resultant electromagnetic radiation.



5. **Transmission, reception, and processing (E):** The energy recorded by the sensor is transmitted in electronic form, to a receiving and processing station where the data are processed into an image as shown in figure 8 or an imagery shown in figure 9 either as hard copy and/or digital.

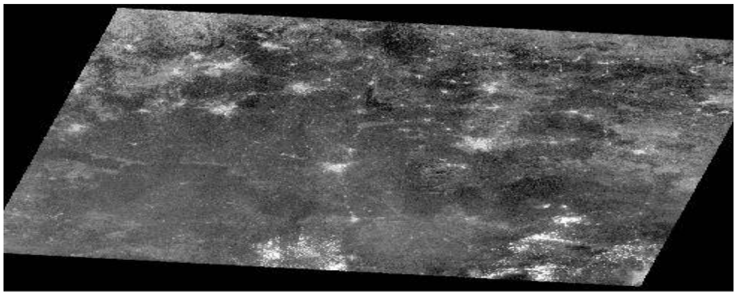


Figure 8: Satellite image of Federal University of Technology Akure, Nigeria
Source: Ogunlade, (2020)

Advantages of remote sensing (Lucas 2000)

1. Remote sensing allows coverage of very large areas which enables regional surveys on a variety of themes and identification of extremely large features.
2. Remote sensing allows repetitive coverage which comes in handy when collecting data on dynamic themes such as water, agricultural fields and so on. Through, this detection of change over times can be done.
3. Remote sensing allows easy collection of data over a variety of scales and resolutions. Through, this variety of an information can be obtained for in-depth and wide analysis.
4. A single image captured through remote sensing can be analyzed and interpreted for use in various applications and purposes. There is no limitation on the extent of information that can be gathered from a single remotely sensed image.
5. Color composite can be obtained or produced from three separate band images which ensure the details of the area are far much more defined than when only a single band image or aerial photograph is being reproduced.
6. Remote sensing is a relatively cheap and constructive method of reconstructing base map in the absence of detailed land survey methods.

Disadvantages of remote sensing (Lucas 2000):

1. Remote sensing is a fairly expensive method of analysis especially when measuring or analyzing smaller areas.
2. Remote sensing requires a special kind of training to analyze the images. Therefore, it is expensive, in the long run, to use remote sensing technology since extra training must be accorded to the users of the technology.
3. It is humans, who select what sensor needs to be used to collect the data, specify the resolution

of the data and calibration of the sensor, select the platform that will carry the sensor and determine when the data will be collected. Because of this, it is easier to introduce human error in this kind of analysis.

4. Powerful active remote sensing systems, such as radars that emit their own electromagnetic radiation, can be intrusive and affect the phenomenon being investigated.
5. The image being analyzed may sometimes be interfered by other phenomena that are not being measured and this should also be accounted for during analysis.
6. Remote sensing technology is sometimes oversold to the point where it feels like it is a panacea that will provide all the solution and information for conducting physical, biological or scientific research.
7. The information provided by remote sensing data may not be complete and may be temporary.
8. Sometimes, large scale engineering maps cannot be prepared from satellite data which makes remote sensing data collection incomplete.

Applications of remote sensing

Generally, remote sensing has been used to gather information about the surfaces and atmosphere of the planets in our solar system. However, the most frequent target of study is the earth (Randall 2012). Remote sensing of the earth has many purposes which include making and updating planimetric maps, weather forecasting and gathering military intelligence. Some other area of application according to Noam (1999) and Ramachandran (2002) include:

1. **Agriculture:** Crop type mapping and crop monitoring;
2. **Forestry:** Clear cut mapping, species identification and burn mapping;
3. **Geology:** Structural mapping and geologic units;
4. **Hydrology:** Flood delineation and soil moisture;
5. **Sea Ice:** Type and concentration and ice motion;
6. **Land Cover:** Rural/ Urban change and biomass mapping
7. Mapping: Planimetry, DEMs, Topographic mapping; and
8. **Oceans and Coastal:** Ocean features, ocean colour and oil spill detection.

Summary

Photogrammetry and remote sensing are closely related techniques of the field of geospatial technology otherwise known as geomatics or surveying. While both are non-contact techniques, photogrammetry operates mostly in the air (near the earth surface) while remote sensing operates in the space thus, in term of coverage, photogrammetry covers smaller area than remote sensing. Since the higher you go the more area you are able to cover. Both uses electromagnetic energy to detect, measure and record the properties of objects and surface material of the environment. Photogrammetry produces aerial photographs while remote sensing produces imageries and images. Both products allow measurement and observation. Photogrammetry consists of two branches according to the position of operation which can be terrestrial or aerial and as the science of surface exploration, in which it is either metric and interpretive drones and aircraft are some common vehicles used in photogrammetry while satellites in space are the vehicles in remote sensing. Photogrammetry can be said to be aerial or terrestrial remote sensing. Remote sensing involves detection, recording and production of information coming from the environment (objects or their properties or phenomenon). These are performed by devices called sensors. The sensors detect and record signals. Sensors are placed on platforms. Remote sensing consists of what is sensed, the device that senses (Sensors), the signals sensed and the products. The elements of remote sensing process include energy source or illumination, radiation and the atmosphere, interaction with the target, recording of energy by the sensor, transmission, reception and processing. The products of photogrammetry and remote sensing are widely applied to our dynamic environment in multiple uses like agriculture, urban and rural planning, mapping, architecture, archaeology, geology and many earth-surface observations and measurements. Photogrammetry and remote sensing are two of the various techniques.

Exercise

1. Define Photogrammetry.
2. Define Remote Sensing.
3. What are the similarities and differences between photogrammetry and remote sensing?
4. Mention the equipment used in photogrammetry and remote sensing
5. What are the branches of photogrammetry?
6. Describe the two phases of operation in photogrammetry.
7. What are the elements of remote sensing operations?
8. What are the end-products of photogrammetry and remote sensing?
9. Mention some applications of photogrammetry and remote sensing
10. What are the advantages and disadvantages of Remote Sensing?

References

Anthony L. (2018). Anthony database. Princeton University. Wordweb.info

Campbell, J. B. and Wynne, R.H., (2011). *Introduction to remote sensing.* 5th ed. The Guilford Press

CCRS : Fundamentals of Remote Sensing . A Canada Centre for Remote Sensing Remote Sensing Tutorial. Natural Resources Ressources naturelles Canada. Prentice-Hall, New Jersey

Ezeomedo, I. C. and Igbokwe, J. I., (2012). Mapping and analysis of landuse and land cover for sustainable Development using medium resolution satellite Images and GIS. *International Journal of Engineering Management Science I.J.E.M.S., Vol.3 (4) 2012-513-519. ISSN 2229-600X*

Ezeomedo, I. C. and Igbokwe, J. I. (2013). Mapping and Analysis of Landuse and Land Cover for a Sustainable Development Using High Resolution Satellite Images and GIS FIG Working Week 2013 Environment for Sustainability Abuja, Nigeria, 6 – 10 May 2013. TS03B - Remote Sensing for Landuse and Planning, 6421

Geodetic Systems (2022). Basics of photogrammetry. Geodetic Services Inc https://www.geodetic.com › basics-of-photogrammetry

Gottfried Konecny (2003): Geoinformation -Remote sensing, photogrammetry and geographic information system. Taylor & Francis Inc

Koert Sijmons (2021): Introduction to photogrammetry. ITC

Lucas L. F. Jansen (2000): Principles of Remote Sensing(ed). ITC Educational training book series; 2). ISBN 90-6164-183-7 ITC Enschede, The Netherlands.

Martin V. and Getachew, T.A (2021) Digital Aerial Mapping. A Hands-On Course. Helsinki

Noam Levin (1999). Fundamentals of Remote Sensing. 1st Hydrographic Data Management course, IMO - International Maritime Academy, Trieste, Italy. *noam71levin@hotmail.com*
Ogunlade, S. O. (2020). Decadal Analysis of Land Cover Trend of Federal University of Technology Akure, Ondo State, Nigeria Using Medium Resolution Multi-Temporal Satellite Images. *International Journal Of Innovative Research & Development. 9(7)* pp 187-192 *ISSN 2278 – 0211 (Online)* DOI No. : 10.24940/ijird/2020/v9/i7/JUL20084.
Ogunlade S. O. (2021): Protection of Ecosystem and Preservation of Biodiversity: The Geospatial Technology Approach. *Nigerian Journal of Environmental Sciences and Technology* (NIJEST). Faculty of Environmental Sciences, University of Benin, Vol 5, No. 1, pp. 67 – 75
Pix-Pro (2022). Photogrammetry Art or Science? https://www.pix-pro.com/about-us
Ramachandran, S. (2002): Application of Remote Sensing and GIS. Madras University
Survey Manual (2013). Chap 7 Photogrammetric Surveys. www.state.nj.us/transportation/eng/documents/surv ey /Chapter7.shtm
Randall, B. S. (2012). Introduction to Remote Sensing of the Environment. ©MicroImages, Inc. http:/www.microimages.com
ScienceDirect (2023). Photogrammetry - an overview | ScienceDirect Topics https://www.sciencedirect.com › topics › photogrammetry
Schenk, T. (2005). Introduction to Photogrammetry. Department of Civil and Environmental Engineering and Geodetic Science. The Ohio State University. 2070 Neil Ave., Columbus, OH 43210. schenk.2@osu.edu
The constructor (2023). Photogrammetry-Aerial Photography and Procedure in Surveying https://theconstructor.org/Surveying

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CHAPTER 13

Basic Computer Applications in Surveying and Geoinformatics

By

MUSA Abubakar Akinyele

Overview

Surveying discipline has come a long way. Satellite and computer technologies have brought so much changes to the techniques used that the name 'Geoinformatics' had to be coined and added to describe its new identity. Drudgery has been reduced to the barest minimum yet accuracy has been elevated to levels that were previously unprecedented. The importance of the computer is ever so visible in this revolution. The knowledge of the computer and how it is applied to the survey and mapping industry can therefore no longer be under estimated. This course has tried to present the rudimentary knowledge (without delving into too much details) of the computer and introduced concepts that will be expatiated upon in future courses in the program. This course introduces the student to the different parts of the computer and its peripherals. It highlights the basic file formats required for mapping and introduces them to the different techniques of data input. It also introduces students to the software packages commonly used in surveying and geoinformatics discipline.

Objectives

At the end of this chapter, students should be able to:

1. identify a computer and its peripherals;
2. explain basic functions of the computer and its peripherals;
3. inculcate rudimentary knowledge of programming.
4. describe the use of computer in surveying and geoinformatics;
5. list and explain the type and functions of software used in surveying and geoinformatics; and
6. identify the digital options and choices available for optimal execution of surveying and geoinformatics projects.

Definition of computer

A computer is an electronic device that accepts data (in the form of digitized data); manipulates it for some results based on a program, software or sequence of instructions on how the data is to be processed and displays the result in an output device.

Computers and maps

Probably the most important use of the computer to the surveyor is in the creation and manipulation of maps. To understand how computer is used to generate maps, a proper understanding of the map file format is necessary. A file format is a standard way that information is encoded for storage in a computer file. Though a number of sophisticated file formats exist for map models, there are basically two types generally in use. These are the vector and the raster file formats.

Vector

The vector file format recognizes only points, lines and polygons. It stores its data in a cartesian coordinate system. Thus, only series of coordinates are stored, with instruction giving the computer added information about the coordinates. A vector file can only contain one of the three file formats. It cannot contain the three at once. Therefore, a typical map will be composed of different vector files overlaid on each other. A point file may be created for bore holes or wells, a line file for roads, and a polygon (area) file for houses. When the vector files are overlaid on each other, the difference between them will not be noticed as shown I figure 1.

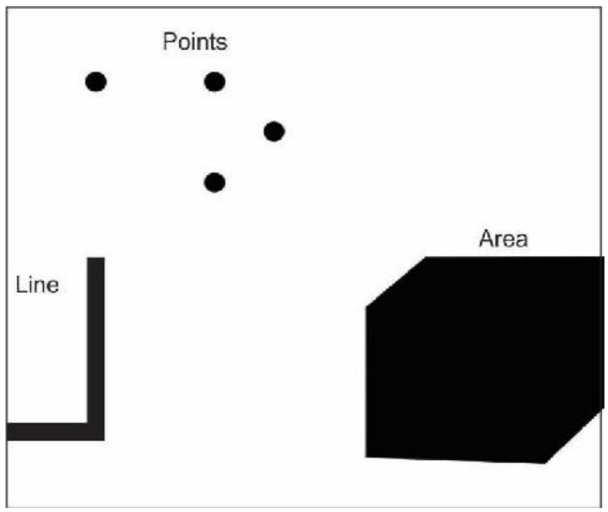


Figure 1: Different file formats

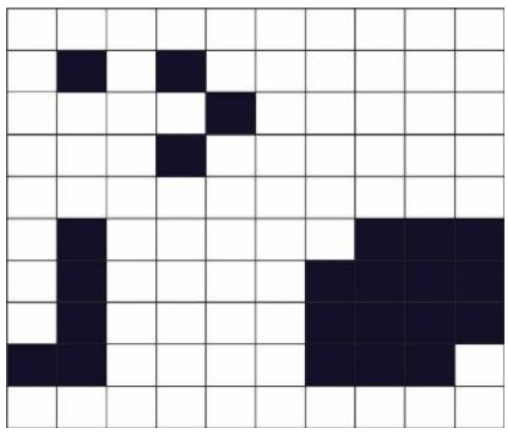
Getting data into a vector file can be done in two ways – either by entering the coordinates directly or by tracing (digitizing). The end product of a field survey is typically a set of coordinates. A surveyor in possession of field data will most likely enter the coordinates into the input dialogue box of the computer. However, before entering the data, the computer must know beforehand if the data is either point, line or polygon. If point vector is specified, points are shown at the coordinates specified. If line data is specified, lines will be drawn to connect the points specified. Lastly, if polygon (area) is specified, in addition to drawing lines to connect the points entered, the first point and the last point will be joined with a line, thus completing the polygon.

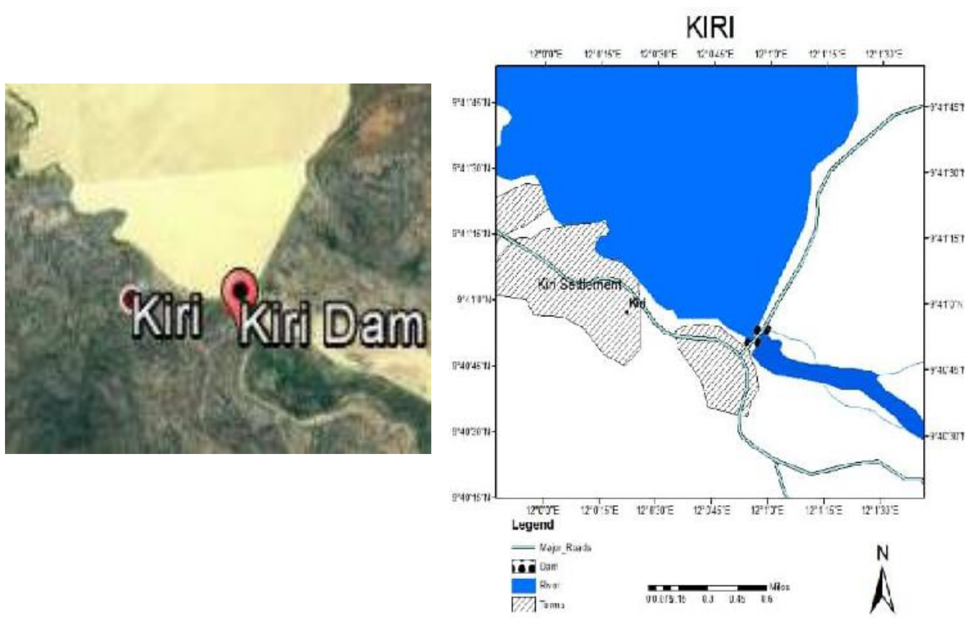
Map updates, for instance, will usually require a combination of field data and existing map of the area of interest. If the existing map is in analogue (paper) form, it will need to be converted into digital form. This is done by tracing the boundaries and other required details of the map using the computer mouse or electronic pen. This process is technically known as digitizing. Digitizing could be either manual or automatic. Manual digitizing means at every turning point on a curve the operator will need to click the mouse so as to store the coordinate. More coordinates are therefore required to store a curve than a straight line. In automatic digitizing, the user merely uses the mouse to trace the various lines making the map, coordinates are stored at specific intervals of time (e.g. every 5 sec). In this case the number of points depicting a line and a curve are the same as long as they are both of the same length.

Raster

The raster file format takes advantage of the computer graphics structure. The graphics screen of a

typical computer consists of a mesh of grids. Each of the grid squares represents a pixel. The number of pixels forming the column and row of a computer screen indicates the resolution of the graphics display. The EGA and VGA adapters have screen modes of 320x200; 640x200 and 640x350.
The data is encoded into the pixels. Thus, isolated pixels with a different digital number from the surrounding pixels depicts points. Group of pixels aligned in a linear form, having the same digital number but different digital numbers from the surrounding form a line. A group of similar pixels clustered together form a polygon or area. The raster file model is very ideal for satellite images.
For the purpose of mapping, the raster format is seen as a collection of grids arranged in rows and columns as shown in figure 2. The rows function as the y-coordinates and column as x-coordinates. Each cell in the raster is explicitly defined by its row and column positions. Unlike the vector format, the raster format can contain points, lines and polygons in the same raster file.





Raster ***Vector***

Figure 2: Raster format

Computer peripherals

A computer peripheral is a piece of computer hardware that is external to but controlled by a computer's central processing unit. Some peripherals like the keyboard comes together with the computer at the point of purchase. The computer is not considered complete without them. There are other peripherals, like printers, that are considered optional. Such peripherals are bought separately.

Input devices:

- **Keyboard**

  The computer keyboard is a device through which text is input into a computer. All the place names; labels, titles etc. printed on maps were written through keyboard. The software used dictates, the size, colour, style and orientation of the text.

- **Mouse**

  The computer mouse is a movable device which controls the cursor (or pointer) on the computer screen. The mouse can be used to control a wide range of things in the computer. In map making it is used to draw boundaries, roads rivers etc.

- **Scanner**

  The scanner, shown in figure 3, is a computer peripheral which converts text or graphics into digital form. Scanners are of different sizes. However, the large scale A0 scanners are often used in the mapping and design industry. Paper maps are inserted into the scanner, and the scanner, using light technology, reads the information on the map and converts it to raster file format.

Figure 3: Scanner

The quality of a scanner is dictated by its resolution. Resolution is the amount of detail a scanner can capture. Resolution is measured in dots per inch. (dpi). A higher dpi means higher resolution and higher quality images. Where maps depict transition zones, the scanner is the preferred means of conversion. Transition boundaries could be marsh land (transition between water bodies and dry land); woodland (transition between forests and grassland); sandy clay (transition between sand and clay) etc.

- **Digitizer**

The digitizer, shown in figure 4, like the scanner, converts graphical designs on paper into digital form but that is where the similarity ends. A paper map is commonly placed on a table wired to a computer (digitizing table). On the table is a stylus (cursor) which is also wired to the computer. The stylus has the capability to send signals to the computer when points, lines or polygons are drawn. In essence, the digitizer is a device for producing vector graphics onto the computer. By tracing the various lines forming a map, the digitizer can reproduce the map accurately on the computer. Where maps depict mainly boundaries, the digitizer is the preferred mode of conversion to digital form.

Output Devices

- **Monitor**

A computer monitor, shown in figure 5, is an output device that displays information in pictorial form. (Wikipedia, 2013). Before the mid-2000s most monitors used cathode ray tubes (CRT), but now a modern monitor is typically a liquid crystal display (LCD) with LED backlight.

Printers/Plotters

A computer printer/plotter, shown in figure 6, is a computer peripheral into which virtual text files and/or images are transferred. The text files and/or images are then converted to hardcopy by creating marks onto pieces of paper. The three most popular printers are laser printers, ink jet printers and thermal printers (Encyclopedia Britannica). Laser printers, just as the name suggests, uses laser beam to direct the toner to different parts of the paper. Ink jet printers creates impression on paper by controlling a jet stream of liquid ink to different portions of the paper. Lastly, thermal printers uses heated pins with wax-based ink to print on paper.

Important printer characteristics includes resolution (in dots per inch); speed (in sheets of paper printed per minute); colour (full colour or black-and-white); and cache memory (which affects the speed at which a file can be printed). The main difference between printers and plotters to a surveyor is the file format. Plotters rely on vector graphics while printers output raster images.

- **Projector**

  A projector is an output device that takes images generated by a computer and reproduce them by projection onto a screen, wall or another surface (Computer Hope, 2021). Projectors are commonly used to show presentation on a large screen so that everyone in a room or hall can see it.

Processor

A processor is an integrated electronic circuit that performs the calculations that run a computer. A processor performs arithmetical logical, input/output (i/o) and other basic instructions that are passed from an operating system (OS), and other basic instruction passed from an operating system (Margaret Rouse, 2020). Every time that an operation is performed on a computer, such as when a file is changed or an application is open, the processor must interpret the operating system or software's instruction. Depending on its capabilities, the processing operations can be quicker or slower (clock speed). The speed of the processor is measured in gigahertz.

Storage Devices

A storage device is any type of computing hardware that is used for storing, porting or extracting data

files and objects. Storage devices can hold and store information both temporarily and permanently. They may be internal or external to a computer, server or computing device (Techpedia).
Storage devices can be grouped into two types, depending on its accessibility to the processor – the primary and the secondary. The primary storage device are designed to hold data temporarily. They also have the fastest access speed. Examples of these type are the random access memory (RAM) and the cache memory. The secondary storage devices are characterized by larger memory space and a permanent storage ability. Storage devices can also be grouped based on their physical characteristics. The following storage devices are commonly in use:

Flash drive

A flash drive (also known as USB drive) is a small, portable device that plugs into the USB on the computer. USB drives are commonly used for storage, data backup, and transferring files between devices.

CD/DVD

The compact disc and the digital versatile disc (CD/DVD) are storage systems based on optical data storage technology. Optical data storage is a method of storing digital information (1s and 0s) by using light to read the information. In terms of its practical usage to the surveyor, the storage capacity of the DVD is much larger than that of the CD.

Hard drive

The hard drive is part of the computer hardware where all permanent computer data are stored. They typically store the operating system, software programs and other files using magnetic disks. They control the reading and writing of the hard disk that provides data storage

Cloud storage

Cloud storage is a service model in which data is transmitted and stored on remote storage systems, where it is maintained, managed, backed up and made available to users over a network – typically the internet. Users will typically pay for cloud storage

A geospatial analyst will choose his storage device based on several factors. A field surveyor, for instance, will need a small, pocket sized device he could attach to his electronic theodolite or GPS unit and record his field measurements. Such measurements do not occupy much memory space since he will be recording vector-based data like coordinates, bearings and distances. Hence, a flash drive will be most appropriate. A remote sensing analyst or a photogrammetrist will be more interested in raster-based data such as aerial photographs and satellite images. For this kind of data, it takes more memory space to depict a unit area than vector. The external hard drive will be more appropriate here. When the raster data is meant to be stored for future use, or its original form is meant to be used over and over again, a compact disk may be considered. In certain cases, the memory space of the CD becomes limiting. When this happens then the next option is to use the DVD. Accumulation of data over several years, presents new challenges – where to store the external hard drives, CDs and DVDs. When such challenges crop up, then it's time to consider cloud storage.

Software packages

While computers are used by a wide range of professionals, software packages used in the surveying and

Geoinformatics discipline are unique to only a narrow spectrum of professional users. Software packages used in the discipline can be categorized into three types – packages that tries to automate traditional survey techniques (Field Survey packages); those that manipulates maps or spatial data in very complex ways to reveal either hidden information or make the maps smart (GIS packages); and those developed by the user.

Geospatial data, is unique in the sense that whatever data one acquires, must also come with its coordinates to be of any meaningful importance. The software used for acquiring, analyzing and displaying spatial data therefore must have the capacity to store and display the coordinates.

Field survey software packages

While there are many different surveying and geoinformatics techniques, there are three fundamental ones that are used the most. These three techniques can either be used in isolation or in combination with each other. The techniques are:

1. **Plane surveying:** This assumes the earth is flat and disregards its curve.
2. **Geodetic survey**ing: This is the method used for large areas, and it takes the curvature of the earth into account.
3. **Aerial surveying:** In this case, data is collected from above via drones, planes and other air borne crafts.

Today, data and measurements collected by surveyors in the field can be fed into surveying software to generate precise calculations, visualizations and more (Autodesk, 2023). Land surveying software assists in the process of evaluating a 3-D landscape to determine the angles and distances between a series of points. Measuring the positioning of these points is typically used to establish maps and boundaries for buildings and other subterranean civic projects.

Geographic Information Systems (GIS) software

The GIS is a computer system for capturing, storing, querying, analyzing, and displaying geospatial data (Kang-tsung, 2008). The GIS software is a very important component of the GIS. It acts as the brain of the GIS, and makes it stand out from other information systems. The storage aspect of the GIS is a sine qua non to the querying aspect. Once geospatial data is stored correctly, a user can query the digital map in ways similar to that of a database. The analysis aspect of the software is probably the most interesting. It is capable of a wide range of analysis, few among which are map algebra, multi-criteria analysis and least cost path analysis. In map algebra, for instance, it allows users use maps like the variables of a formula, thereby creating new maps from the output of an algebraic calculation. Multi-criteria analysis allows users create maps of different criteria. When these criteria maps are merged together, an output map is created with information that were previously hidden. A least cost path analysis allows users create a cost surface of different factors. A cost surface is a raster map representing a feature that is based on some factor that affect travel across an area e.g. gradient or vegetation. When the cost surfaces are merged it provides the GIS with the required data to determine the best route to construct a road, railway etc.

User-developed package

A surveyor might not be satisfied with commercial packages available and might decide to develop his own. Developing a computer program starts with first analyzing the problem and figuring out how it could be solved; then a pseudocode is written on how the computer should solve the problem. This is followed by designing the algorithm. The algorithm can be made using the flowchart. You convert the flow chart into a series of computer codes. Finally, the codes are debugged after testing. The steps are explained thus:

Analyze the problem
The computer user must figure out the problem. Then figure out how the computer will resolve the problem. Usually the problem should be well articulated without any grey areas left. The steps to be taken to resolve it must also be unambiguous.

Pseudocode
In computer science, pseudocode is a plain language description of the steps in an algorithm or another system. Pseudocode often uses structural conventions of a normal programming language, but is intended for human reading rather than machine reading

Algorithm/flowchart
An algorithm is simply an exact list of instructions that conduct specified actions step by step in a computer. They're the building blocks for programming, and they allow things like computers, smartphones, and websites to function and make decisions. One of the popular ways of documenting an algorithm is with a flow chart. A flowchart is a picture of the separate steps of a process in sequential order. It is a generic tool that can be adapted for a wide variety of purposes, and can be used to describe various processes, such as a manufacturing process, an administrative or service process, or an algorithm.

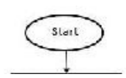
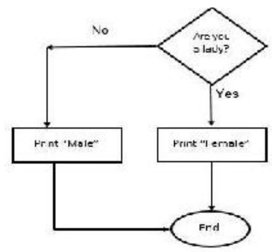
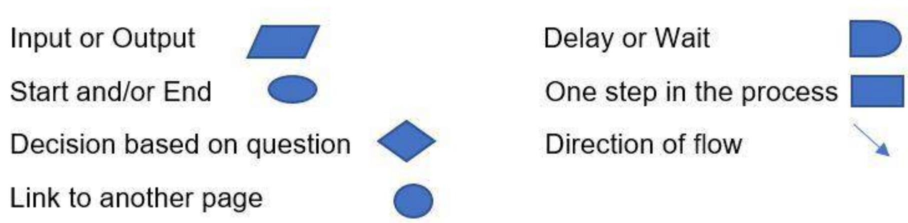


Figure Example of Flow chart.





Computer coding
The computer does not understand the human language. What the computer understand are instructions based on '0s' and '1s'. Unfortunately, such binary languages are difficult for humans to memorize. A compromise is to create a set of instructions that will be easily understood by humans

and yet can be easily translated to the machine language of 0s and 1s. Such instructions are known as computer codes. Computer codes are also known as programming languages since they are used to program the computer. Many different types of programming languages exist. Some of the popular types are BASIC, FORTRAN, JAVA and C++. One needs to study and understand programming languages to use them to instruct the computer. Some of the sophisticated software packages we use are instructed by millions of codes lines.

Basic computer maintenance

The different ways the computer can be maintained can be grouped into four – predictive, preventive, corrective and evolutionary. The user will normally use one or a combination of some of these ways. Usually, the prevailing circumstance dictates which to use.

Predictive Maintenance:

In predictive maintenance, diagnostic tools of the computer are involved. These are tools that test for the general health of the computer. At this point the user is only interested in knowing if he has any issues with the internal workings of the computer. These could include memory space problems, battery issues, over-heating, virus problems etc. User needs to have this information before making the decision to activate preventive maintenance.

Preventive maintenance

These are maintenance techniques that tries to optimize the internal workings of the computer even before they manifest any visible problem. Many of the preventive tools come together with the predictive tools. The antivirus, for instance, not only detects the virus (predictive), but also cleans it (preventive). The 'Defrag & Optimization' tool will detect the level of fragmentation of a drive (predictive), before giving the user the option to defragment (preventive). Preventive maintenance is however not only limited to software. Using low pressure compressors or blowing machines to blow away the dust particles in the computer; cleaning the computer screen to make it clearer etc are all part of preventive maintenance.

Corrective maintenance

Corrective maintenance becomes necessary when a fault is detected. This is the result of a failure in both predictive and preventive maintenance. Overheating of the computer, for instance, may result in a change in the computer fan. Inability to boot properly may be rectified by re-installing the operating system. Power issues may necessitate a replacement of the battery or power supply unit (PSU). In most cases user may need to give it to a professional to correct.

Evolutionary Maintenance

This kind of maintenance involves keeping your computer at par with latest developments and innovations. As computer manufacturers struggle to dominate the market place, developments could come in terms of increase in speed of processor and memory size together with a reduction in the bulk size of the computer. Thus, evolutionary maintenance could range from replacing some parts of the computer, not because they are spoilt but because they have become outdated; to complete replacement of the computer to a latest model. With regards to software packages, as developers create better versions of their software, new versions are often released to replace earlier ones. Users will be compelled to buy latest versions so as to ensure their computer works optimally.

Summary

The computer is used by a large number of professionals. It has brought a lot of ease and perfection to the mapping industry. Unfortunately, for reasons that borders on fear of change, it has not yet been fully accepted. This chapter has tried to introduce computer as simply as possible, laying more emphasis on its use to the surveying and Geoinformatics professionals. Thus, priority was given to computer peripherals mostly used in the mapping industry to those used by other professionals. Some basic digital concepts were introduced, like the graphical file formats and software packages. This is meant to be a foundation for a more thorough exposure to advanced concepts in the discipline.

Exercise

1. What are computers?
2. Explain any three computer peripherals you know.
3. Explain the two graphic file formats used for digital mapping.
4. What is the main difference between a printer and a plotter?
5. What is cloud storage and under which conditions will it be useful?
6. How are GIS software packages different from field survey packages?
7. List and explain four maintenance procedures you will adopt for your computer.
8. Design a flowchart that prints "Good day sir" if the user is a male and prints "Good day madam", if the user is a female.

References

Autodesk (2023) Autodesk Inc; https://www.autodesk.com, *Downloaded 30 March 2023*

Computer Hope (2021), https://www.computerhope.com, *Downloaded 30 March 2023*

Computer Maintenance: https://www.legit.ng/1219266-what-4-types-maintenance-computer.html, *Downloaded 3 April 2023*

Encyclopeadia Britannica: https://www.britannica.com, *Downloaded 30 March 2023*

Kang-tsung Chang (2008). Introduction to Geographic Information Systems (4th Edition), Mc Graw Hill.

Margaret Rouse (2020). Processor In Techpedia, https://www.techpedia.online, *Downloaded 30 March 2023.*

Wikipedia, (2013). https://en.m.wikipedia.org/wiki/computer_monitor, *Downloaded 30 March 2023*

computersciencedegreehub.com https://www.computersciencedegreehub.com/faq/what-is-coding, *Downloaded 30 March 2023 Downloaded 30 March 2023.*

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CHAPTER 14

Fundamentals of Cartography in Environmental Sciences

By

SHUAIBU Muhammed Ade

Overview

This chapter addressed the concept and fundamentals of cartography as a scientific activity that brings together geographic science, techniques and aesthetic skills to map making as communication tool. It briefly reviewed the evolution of cartography as an art and science of mapmaking. Cartographic materials, instruments and techniques were identified. Methods of map compilation, production and reproduction were explained. Photomap and orthophoto, as image maps, were described. Relief types on map were identified. Also, the concepts of change detection and orientation to describe map revision and map creation were explained. An update of the development of Nigerian map series through review was provided. At the end of this chapter are test items to enhance learning.

Objectives

At the conclusion of this chapter, students should be able to:

1. describe basic concept in cartography;
2. review the trends in the evolution of cartography;
3. identify materials, instruments and techniques in cartography;
4. demonstrate map compilation, production and reproduction methods;
5. describe photomaps and orthophoto;
6. identify relief types on a map;
7. describe map revisions, map to map transfer of details and map orientations; and
8. review the Nigerian map series.

Concepts of cartography

The word "cartography" comes from the word cartographie. In order to explain the meaning of cartography better, the French word "cartographie" needs to be examined. Cartographie came from the words carte and graphie as formulated by the French cartographers (mapmakers) between 1700s and 1800s. The word carte refers to map while graphie refers to representation. The word map refers to a graphical representation of an area of land showing spatial information with a constant scale throughout. Apart from scale, it's usually drawn on flat surface with symbolization and generalization representing the spatial data. These are called elements of map and are the major concepts in cartography (map making). Therefore, cartography is simply the assembling of map elements both planimetrically and aesthetically. As a discipline, it can be described as the conception, production, dissemination, study and practice of making maps. The maps are of different types that are usually grouped in to three. These are based on scale (e.g., large, medium and small), function (e.g., general reference maps, thematic maps, and charts) and subject area (e.g., cadastral maps and plans).

Fundamentals of cartography

Cartography, from its concept, can be described as the study and practice of making maps in all their forms. These are tools made by mapmakers for spatial communication to users. Fundamentally, cartography tries to combine together geographic science, techniques and aesthetics skills in the mapmaking process. The aim is to create maps that are attractive and coherent. Therefore, understanding the major concepts and what they stand for with the fundamentals of cartography are crucial to mapmaking.

Elements and content of map

Cartography is simply described as assembling of map elements. The elements are assembled on either map face or as marginal information on the map. Figure 1 shows some of the important elements of map. The first eight are put in an easy to recall acronym (DOGTAILS) then others together with their explanations as follows:

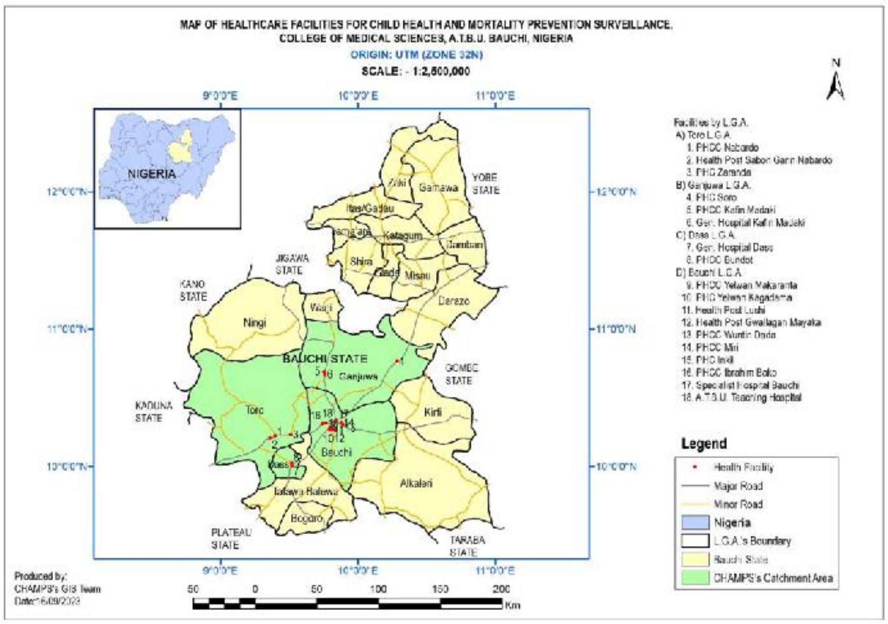

Figure 1: Some Basic Elements of Map

1. Date, in the first place, indicates when the map was made or when it was updated.
2. Orientation (direction) provides north direction to the map pointing to the direction of either true north or compass north. In most cases, the north is assumed to be at the top of a map. The north arrow is used to indicate the direction and it has these properties which include size, style, colour and angle.
3. Grid provides intersecting lines (coordinate system) drawn to find or locate places on the map.
4. Title shows the subject or front matter of a map that usually grabs readers' attention. Short title is more apt than long ones and should address issues like what, where and when of the map? Also, it tells the map reader in few words what is important about the map by simply stating the information portrayed (e.g., percentages of local languages in Bauchi State) or engaged the users with broader and catchier phrase (e.g., the voices of the nation).
5. Author is the cartographer or organization who made the map writing in text form.
6. Inset is a small map set within the main larger map to show that the larger map was from the inset.
7. Legend (key) relates map symbols to the map body as it describes the unknown, unique and

known symbols of a map. Also, it guides in the identification of what the map's symbols and colors represent.

8. Scale relates to the relationship between a distance on a map to actual distance on the ground. The scale based on types (verbal, number and graphic) can be represented as words (e.g., one inch equals one kilometer), number in form of ratio or fraction (e.g., 1: 50,000), and graphic called bar respectively. Scale bar is graphically drawn on a map to show scale with horizontal line divisions; the number which each division represent is the scale of the map. This is divided in to two viz. main scale and secondary scale. There are different styles depending on individuals. Such may include:

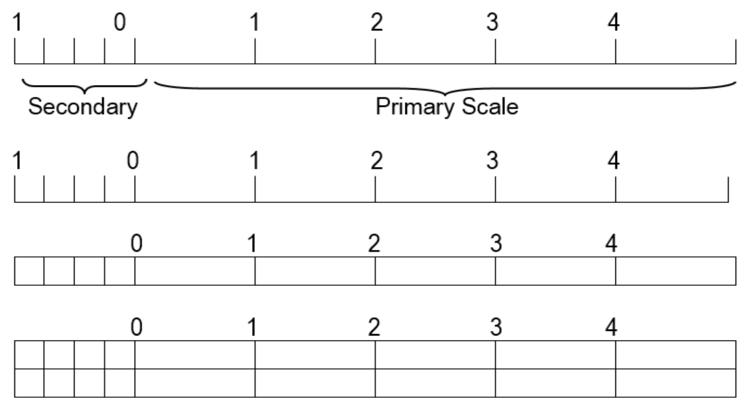

Figure 2: Different ways of constructing scale bar

The scale of the map affects the amount of details that can be shown on the map. Also, this can affect the accuracy of which they can be drawn. It can be calculated using equation 1.

Scale = Map Distance/Ground Distance 1

9. Coordinate system includes the grid reference which is used in cartography because it always seeks to find about what is exactly relatively where, how and when on the earth? To answer such questions with some degree of precision and accuracy, the use of coordinate system become necessary. Also, it is used in identifying geographical feature's location by intersection of two lines from defined origin. In cartography, we have three types of coordinate systems; cartesian, polar, and spherical system. The one that is commonly used is the cartesian because it uses a plane of two perpendicular axes x and y to locate points, lines and polygons on earth surface. This provides a frame of reference for data or features to be located on the surface of the earth. Also, it helps to align data relative to other ones in order to perform spatially accurate analysis from the maps.

   Horizontal coordinate system can be of three types: geographic, projected, or local. Geographic coordinate systems (GCS) are based on a three-dimensional ellipsoidal or spherical surface, and locations are defined using angular measurements, usually in degrees, measuring degrees of longitude (x-coordinates) and degrees of latitude (y-coordinates). The location of data is expressed as positive or negative numbers: positive x- and y-values for north of the equator and east of the prime meridian and negative values for south of the equator and west of the prime meridian.

Vertical coordinate system is either gravity based or ellipsoidal. Gravity-based vertical coordinate systems are more commonly used. They reference a mean sea level calculation (or in some cases, derived from the level of a single point).

Ellipsoidal coordinate system references a mathematically derived spheroidal or ellipsoidal surface. Since they are calculated on a mathematical model, ellipsoidal coordinate systems are simpler than gravity-based vertical coordinate systems, but they may lack significant accuracy, especially in large-scale applications. When using an ellipsoidal vertical coordinate system, it must be ensured that it matches the geographic coordinate system. Their units of measurements are in meter or kilometer.

Vertical coordinate system provides a reference for z-coordinates, which are measurements of the height or depth of features. Vertical coordinate systems are always in linear units such as meters. Using a vertical coordinate system improves locational accuracy in analysis and editing. Vertical coordinate systems in a global scene must be ellipsoidal, with one exception. They can be gravity based only if they cover a full-world extent. EGM2008 Geoid and EGM96 Geoid are examples of global gravity-based vertical coordinate systems.

10. Map body as the most important part of the map, it contains or houses the map information. The other elements support the communication process and help the map user to orient himself and understand the map title.
11. Index is a listing of places on the map and where to find them based on coordinates or letter with numbers.
12. Typography refers to the text used on map. It is considered as symbology just like point, line or area symbols. In fact, a map that has no text, it could hardly be understood. The challenges of selecting and placing text on map is how to avoid its interference with map's data or design and to easily locate it such that it is readable. Therefore, to establish clear association between text and map features, different font types, styles, and sizes are to be carefully used to make map pleasant and coherent.
13. Symbology is the study or use of symbols to represent features and attributes of a map layer. Also, it can be described as a means of creating various visual effects through drawing in visual variables. The visual variables are: Signs, shape or form, orientation, Column structure and likeness. There are two major types of symbols viz.: qualitative and quantitative symbols. Qualitative Symbols (Lateral view) refer to the use of symbols to show the mere presence of some features in a certain place e.g. schools, railways, filling station, market and so on. While Quantitative Symbols (Pictorial view) refer to the use of symbols to draw the attention of users to the relative importance of the map features, e.g. state with a population of four million voters in Nigeria.

    The general rule for choosing symbols is to use point, line and polygon symbols for point, line and area for vector data respectively. While for raster data, the point line and polygon all are inside the cell. One important thing that must be noted and considered in the use of such symbols is dimensionality which ranges from one to three dimensions. A point is dimensionless, a line has one dimension, a polygon has two dimension, and a volume has three dimension.
14. Generalisation is the use of symbols or classifications of data to present spatial features on a map. It is an important and unavoidable part of making maps because geographic features cannot be represented on a map without undergoing transformation. The reason for transformation is because of change of scale. An example of generalisation is data classification. Common methods of data classification include; equal interval which divides the range of data into equal intervals and others such as geometric interval that groups data values

into classes of increasingly larger intervals are used.

15. Colour just like symbols are used in presentation of mapped data on the map. Colour has its source from the sun's Electromagnetic Radiation (ER) and has three aspects hue, value and saturation. These colours are used to convey meaning on map. Colour as visual variable include hue, chroma, size, texture shape and pattern are used to communicate on map. Cartographers have combined these colours to develop colour schemes such as single hue, hue and value, diverging, part spectral and full spectral to display information on map. The use of colour as visual variable in symbolisation are classified into two;

    Primary visual variables comprise of ordering and differentiating visual variables. The ordering visual variables include value (colour) and size while the differentiating visual variables include hue (colour), orientation and shape. Secondary visual variables are mainly used for differentiating and they include arrangement (pattern), texture (pattern) and orientation.
16. Neat line is a box drawn around a map to give it a tidy look or appearance.
17. Source/credit is the basic for map information as it provides information in respect of where the map comes from.

Map projection

Since our earth where we live in and carry out measurement is round (i.e. geoidal in shape) and where we draw our map is flat (sheet of paper or computer screen), then projection as a broad set of transformations to be employed to represent the curved three-dimensional surface onto a flat (plane), two-dimensional surface is necessary. Therefore, map projection is the process of transferring spatial information obtained from a three-dimensional surface of the earth (globe) to a two-dimensional surface of a sheet of paper or digitally computer screen.

In a map projection, coordinates, often expressed as latitude and longitude, of locations from the surface of the globe are transformed to coordinates on a plane. The parallel of latitudes and meridian of longitudes divide the earth into various segments as horizontal and vertical lines respectively. The network of the parallels and the meridians formed graticule and it is this graticule that enables the drawing of maps. therefore, the word projection refers to the drawing of graticule on a flat surface.

Also, there are elements of map projection that should be noted which include reduced earth which is a model of the earth represented by the help of a reduced scale on a flat sheet of paper; parallel of latitudes, and meridian of longitudes as explained above. In Cartography, three types of projection based on distance, area or shape and direction were invented. There are; equal-area projection which does not distort the size of areas but does distort their shapes; orthographic projection does not distort shapes; and conformal which has same scale in all directions.

Map Design

Map design is a visual plan to achieve a goal. It is a process of drafting maps to communicate ideas and once is done well, it will enable the transfer of knowledge from cartographer to user with ease. The drafting of map is usually based on purpose and audience because the two determine what map elements are to be included and how data are to be displayed, and the general layout and format of the entire map. Therefore, it is a process that includes scaling and formatting according to the purpose of the map. Both the elements and georeferenced data are presented on the layout so that the map will be clear and useful without overloading the user with information.

It is important to note that success in map design to some extend depends largely on map layout. A layout (planar organization) deals with the composition and the arrangement of map elements and marginal (upper, left, right or lower) information around a map face with major concerns on; focus, order and balance. Also, some principles are expected to be considered when designing a map to ensure that the map produced is aesthetically pleasant, functional, and for successful spatial communication to take place. These principles are legibility, visual contrast, figure-ground, hierarchical organization and balance.

Legibility and visual contrast together can provide the basis for viewing contents on maps. While, the use of figure-ground, hierarchical organization and balance in map design will enable the determination of importance and pattern of things within the contents of a map by a user. These five principles are supposed to be used together as they complement each other in creating map that will successfully communicate geospatial information.

Other factors to be considered in map design are the size and shape of the territory to be mapped, map accuracy and content requirements, map production and use, spatial reference system to be employed and marketing options. It is important to note that, map design and production both depend on the use of the map.

Evolution in cartography

Cartography as an ancient art, its beginning is unknown. This might be because of its long history and multi-cultural nature. Mapmaking was seen to be an instinctive activity shaped by intellect and imagination of the culture depicting its reality (geographical areas and events) through map. This map is then kept as artifacts. Therefore, maps are seen as products of culture and history and among such earliest known maps are the medieval world map, the Garden of Eden and world star-shape map of Babylon scratched on clay tablets around 600 B.C. The science of mathematical principles specifically geometric point based on latitude and longitude were seen to be used to produce map traceable in the work of Claudius Ptolemaeus (Ptolemy) in Greek around 150 A.D. However, one notable attribute in Ptolemy's work was the capturing of Indian Ocean erroneously as sea on map. By 13th century, Byzantine scholars saw merits in Ptolemy's work and began the making of projections using his coordinates. Spatial and attribute data accuracy and volume got increased in the history of mapmaking as found in the work of Al-Idrisi where he used his experience and regional maps as well as projection of known world to produce most accurate and south oriented map in the 12th century.

Size distortions in mapmaking was prominently noticed in 1389. This distortion can be seen in the China's Amalgamated Map of the Ming Empire. In this work, Japan and Korea were shown to be larger than India on the map. Similarly, Africa was presented as a small peninsula on the same map. Style and bearings in the evolution of mapmaking were evidently seen used in the work of Gerardus Mercator in 1569. His work displayed the spherical earth on flat rectangular projection surface and the world map drawn was based on parallel of latitudes spaced increasingly apart as they move far from the equator. This Mercator projection has caused a lot of distortions in mapmaking for navigation purpose. Consequently, modern map such as the Robinson and Winkel Tripel projections to correct for the distortions were used to supplant it. Recently, geospatial technology has greatly advanced mapmaking in terms of availability and affordability of mapping hardware, software and inexpensive volumes of spatial information for making maps. It is now possible and easy to make maps for wide variety of purposes to address different environmental and other related problems. Despite the evolution in mapmaking, the fundamentals of cartography as an art and science remain a key in how maps are designed and what kinds of information could be seen with them.

Techniques in cartography

Map making techniques include map compilation from existing materials, generalization of detail, map production from original surveys and final steps in map preparation.

Map compilation

Map compilation can be described as the process of assembling, evaluating and interpreting cartographic measurements and materials in order to produce a map. The compilation may start from photogrammetric compilation or original survey. There are at least five major steps in the process of map compilation; (a) selection, (b) classification, (c) simplification, (d) exaggeration, and (e) symbolization.

Map production

Map production means arranging map elements on a sheet of paper. Map elements are the title, map body, map border, legend, scale, north arrow and the acknowledgement. Scale represents the ratio of a distance on the map to the actual distance on the earth surface.

Map reproduction

When maps are made, they are usually produced in a number of copies. After some times, some copies may be needed. The printing of a map or the electronic duplication of a map in a digital format. Presently, cartographers have a number of reproduction technologies from which to choose, including offset printing (lithography), plotters, large-format printers, desktop printers and electronic media.

Instruments in cartography

In cartography, there are instruments that are needed to be used to create maps. These are grouped into two as analogue and digital. Analogue instruments include compasses, mylar sheeting, planimeters, and dividers which are used to create analogue maps. Others are drafting equipment which include T-squares, protractors, straightedges, stencils, lettering aids, lighting tables and drafting scales.

Materials in cartography

Cartographic materials are spatial data that represent the earth as a whole or in part including celestial body. Examples of such materials include aerial photographs, remote sensing image, orthophoto or orthoimagery, maps, atlases, globes, three-dimensional maps, terrain, and monographs.

Photomaps and orthophotos

An aerial photograph does not have a constant scale throughout the entire photograph and so it cannot be used as a map. The scale of an aerial photograph is defined as the ratio between the focal length of the camera and the height of the camera above the topography. The scale is correct only somewhere around the center and all other features have different scales due to the perspective nature of the photograph.

However, an orthophoto, orthophotograph, orthoimage or orthoimagery is an aerial photograph that has been rectified so that it possesses characteristics of a line map. Also, it can be described as a picture of the ground prepared in such a manner that all of these scale and shape distortions have been removed through rectification. The rectification process is performed by combining photogrammetric principles with digital elevation model (DEM) data.

In the past, orthophotos were produced with a specially outfitted photogrammetric stereo plotter. With the advent of digital photogrammetric methods, an orthophoto can now be produced, even on a desktop PC, provided that appropriate software and data are available. An orthophoto is produced by computing the scale and position distortions of each pixel of the aerial photograph, re-scaling and repositioning the pixels in a new computer-generated image. This process is called *differential* *rectification*. Orthophotos that are produced from, and saved as, digital images are sometimes called *digital orthophotos*.

Digital orthophotos

The growth of image-processing technology has initiated the emergence of digital orthophotography: computer-rectified aerial photographs that provide raster images of ground features in their true map (geographical) positions. Digital orthophotos—which have come on strong as a new and different base map—offer a complete, accurate foundation for a Geographic Information System (GIS). Digital orthophoto, shown in figure 2, is a proven alternative for applications ranging from infrastructure management to appraisal mapping. A digital orthophoto is simply a computerized version of a conventional orthophoto: a raster image of ground features in their true map positions. A raster image is a grid of computer pixels. Each pixel has a row and column "address" (an *X, Y* value) and an intensity value ranging from 0 to 255.

A digital orthophoto is a continuous-tone raster image; all pixels are "on" but at varying intensities of black, white, and gray (or red, yellow and blue for color). By contrast, binary raster images would produce no gray tones; pixels with a binary value of either 0 or 1 would be either "off" or "on."

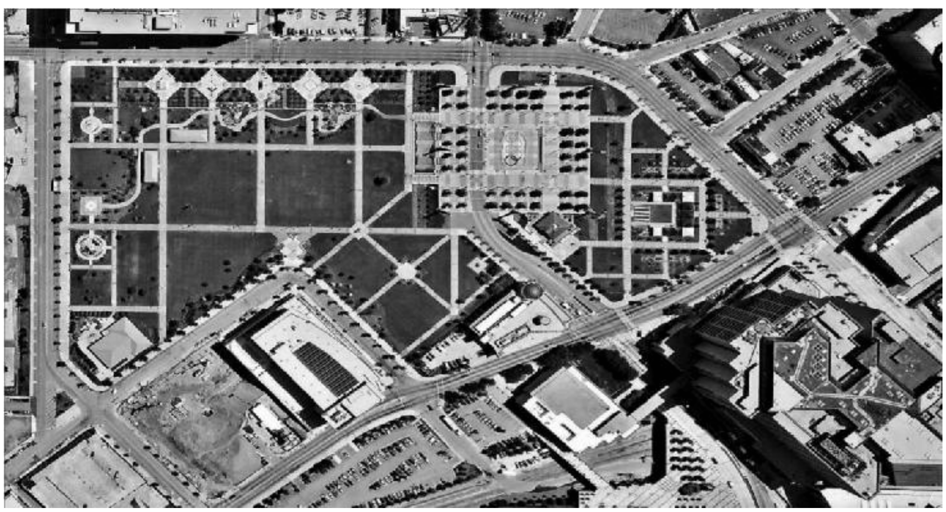

Figure 2: Digital Orthophoto

Advantages and disadvantages of orthophotos

Orthophotos have the following advantages:

1. An orthophoto has map-like characteristics, while preserving the pictorial image;
2. Speed of production, which becomes more evident when maps have to be revised or updated;
3. Compatibility with GIS software and can be integrated digitally into a project;
4. Cartographic overlay can be added to enhance interpretability;
5. Ability to perform change analysis by comparing images from before and after;
6. Use of wider sensing spectrum, such as infrared for special studies; and
7. Mapping inaccessible areas, such as contaminated areas.

Orthophotos have the following disadvantages:

1. To produce accurate orthophoto one needs to know not only the elevation of the surface but also the height of every feature above that surface. Otherwise, these features will be positioned incorrectly on the orthophoto;

2. The needs to search for additional information and somehow blend it into the orthophotos to cover missing images of obstructed features; and
3. While the pictorial images present all the existing features on the ground, their interpretation and classification could be difficult at times. A map with a clear legend is more easily understood and interpreted than a picture. Thus, an added cost of a cartographic enhancement becomes imperative.

Relief on a map

Relief refers to the differences in height from place to place on the earth surface. Also, it can be described as the variations in the elevation of the ground surface. More so, it can be considered as the features of height above a plain or reference datum. On a map, relief is spatially presented using contours or sport heights to show the height of the ground. Relief is measured on a map by contours not by elevation and it differs from other maps such as topographical map due to its emphasis on the three-dimensional elevation of the earth's surface. Relief can be visualized using shading between contours and is called shaded relief. This relief indicates features on the surface with valleys and mountains appearing as rough and smooth for flat areas. A local relief shows variation in elevation or height over a small defined area determined by the difference in height between the highest and lowest points of the area

Map revision

Change is commonly known as the only thing that is constant. This concept of change is more with our spatial environment within a span of time due to natural and manmade factors. These factors include flood, deforestation, construction of roads and buildings among others. To account for the change (difference), maps are made to capture geographical data at time t1 (past) and t2 (present). The change obtained is then used to correct or improve the past map. This is simply called map revision or map update. It involves two procedures change detection and update. To achieve this, three methods are available ground surveying, photogrammetric and remote sensing techniques. These methods can be used to update each of type of maps such as general reference, topographical, thematic, navigation charts, and Cadastral Maps.

Map orientation

Map orientation form the basis upon which maps are created. This directionality property of map gave it an age over other navigation means to be used in viewing features as they are on the earth. Maps are oriented based on the four cardinal points on the earth that is north, east, south and west. However, there exist maps in history that are common and non-uniform. Choosing location for orientating maps varies from top, down, right and left. The most popular or commonly location, used in online and Nigerian maps, is north oriented at the top of the maps. The importance of orienting north at the top is that it will help the user to know the direction of magnetic north. Some maps have their south oriented at the top. This means that north orientation will now be upside down considering the one above. Consequently, east will be facing the left and west facing the right direction. Also, there are few maps that have east oriented at the top as used by Arab cartographers. This happens during the medieval age due to the influence of religious doctrines. More so, there are few maps with no unified orientations as seen in Japan in the 1600s to 1685s. Furthermore, other maps had custom orientation because of political reason to aid navigation instead of directional orientation.

Nigerian map series

The Nigerian topographical map series began in 1938 with the scale of 1:100,000 by the British. In terms of coverage, the whole country was mapped ninety-five percent (95%). The number of sheets obtained from the mapping was 346 out of which 277 were published. The Nigerian topographical map series continuous in 1952 and 1960 (new series) with the same scale of 1:500,000 still by the British. In terms of coverage, the whole country was mapped 100% and 24.24% respectively. The number of sheets obtained from the mapping were 15 and 33 and out of them 16 and 8 were published respectively. In 1965, two mapping series at the scales of 1: 2,000,000 and1: 1,000,000 by same British were carried out respectively. The country coverage achieved for both was 100%. However, the maps were not published and the number of sheets obtained from the two mapping activities were unknown. The most used topographical map series in Nigeria is the one of 1966/1967 made at the scale of 1:50,000. This series has 1352 number of sheets that covered 83.23 % of the country land mass. The number of sheets published were 1122 sheets which are more than the sum of all the published topographical sheets by 752 sheets in the country. The topographical map of 1969 at the scale of 1:250,000 was among the four-mapping series that, in terms of country coverage, was 100%. This map series has 100 sheets more than that of 1952 by 85 sheets due to larger scale factor. The published sheets from the series were 59 in number. The last analogue topographical map series of Nigeria is that of the 1981 made at the scale of 1:25, 000.The country land mass coverage was 5% only. The number of sheets from the mapping were 5408 which is the largest so far obtained due to large scale. No single sheet was published from the work. To locate the topographical map series in Nigeria, and index (list of places on the map and where to find them based on numbers) to them was created. For example, an index to 1: 50,000, 1: 100,000 and 1: 500,000 is shown in figure 3. Other topographical map series that are digital such as vegetation map, relief map and vegetation zones in the country are coming up due to digital technology available for mapping.

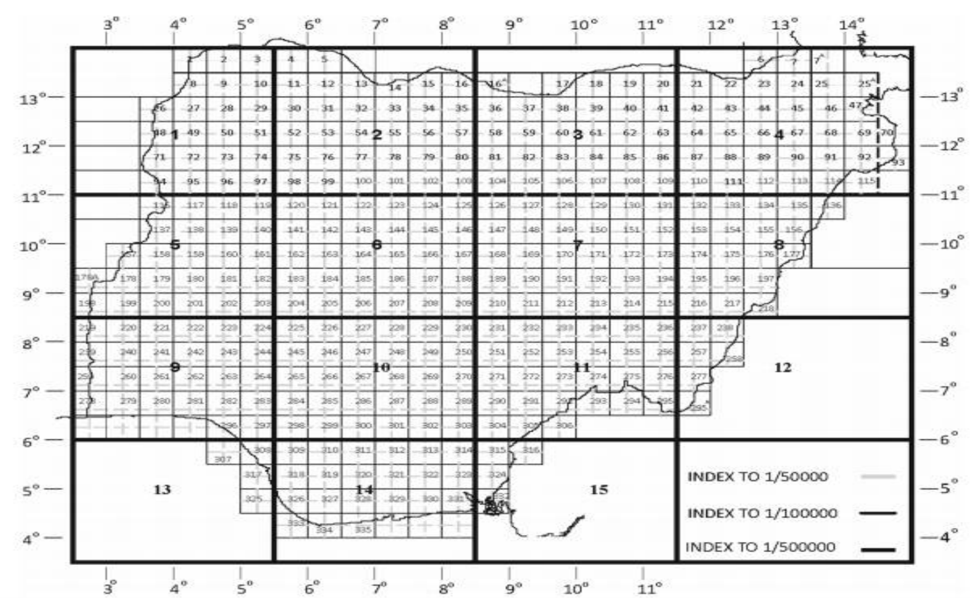

Figure 3: Index to the Nigerian Topographical Map Series

Summary

This chapter has presented the concept of cartography as a scientific activity that brings together geographic science, techniques and skills in creating a tool for spatial communication. It examined map elements within the context of map layout. The concept of orientation as the basis for map creation rather than navigation was explained. The essence of coordinate system and map projection in map making was discussed. Also, the products of cartography to enable environmental study was discussed.

Exercise

1. Briefly explain the concepts and fundamentals of cartography.
2. Trace the trends in the evolution of cartography.
3. Identify the materials, instruments and techniques of cartography.
4. Briefly explain map compilation, map production and map reproduction.
5. Briefly describe photomap and orthophoto.
6 Distinguish between common relief types found on a map.

References

Anson, R. W. (1996). Basic Cartography for Students and Technician. Butter work

Erwin, R. (1989). Principles of Cartography (2nd) Edition. Mc Graw-Hill Book Company. USA.

Misra, R. P. and Ramesh, A. (1989). Fundamentals of Cartography (2nd) Edition. Concept Publishing Company. New Delhi.

Kang-tsung Chang (2014). Introduction to Geographic information System. Mc Graw-hill International Edition. USA.

Shuaibu, M. A. (2022). Lecture notes on Cartography. Abubakar Tafawa Balewa University (ATBU), Bauchi, Nigeria.

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CHAPTER 15

Basic Concepts of Map Reading and Interpretation in Surveying and Geoinformatics

By

IDOWU Timothy Oluwadare and Babalola Ayo

Overview

The end result, mostly, of every surveying and geoinformatics work is to produce a plan or map. In order to achieve this, data are collected with proper care and accuracy through a variety of ways including the use of appropriate equipment and advance data processing techniques that best suit the kind of assignment being carried out. The results obtained are presented, in most cases, in form of plan and map. Accurate reading and interpretation of this map leads to the understanding and recognition of reality of geographical features on the surface of the earth. Therefore, this chapter aims at discussing the concept of map reading and interpretation for the purpose of identifying, understanding, recognizing the earth's surface natural and artificial features which have been represented by symbols on a map.

Objectives

At the conclusion of this chapter, students should be able to:

1. explain the difference between map reading and map interpretation;
2. list the types and functions of map;
3. define map scale, list types of map scale and conversion of one map scale to another;
4. carry out measurement of distance and area on a map;
5. identify, draw and interpret contour lines on map; and
6. demonstrate understanding of the use of symbols to represent features on map.

Map

Map is a graphical representation of part or whole of the earth's surface on a 2-Dimensional surface at a suitable scale. It can be seen as the reflection of the environment which allows us to see a whole scene at a glance, enabling us to understand the spatial relationship of geographical features. A good map is expected to bear the following important parts:

1. **Title:** This shows what the map is all about.
2. **Legend**: It shows identification for interpreting the signs and symbols used in the map.
3. **North direction:** This indicates reference direction on the map.
4. **Scale:** This indicates the relationship between the size of symbol that represent an object on map and the actual size of that object on the surface of the earth.
5. **Map index:** It serve as a map guide to show the features on the map.

Types of maps

1. **General reference planimetric map:** This is a map that contains man-made features such as cities and towns, roads and natural features like lakes, rivers and mountain.
2. **Topographic map:** This map depicts detailed height or elevation (undulation), bearing contour lines for mapping the terrain. On this type of map, features such as buildings, roads

and other locations of objects can easily be identified. Also, hills and valleys can be identified using contour lines which show lines joining points of equal heights or elevations. Figure 1 shows a typical topographic map on a scale of 1:2500.

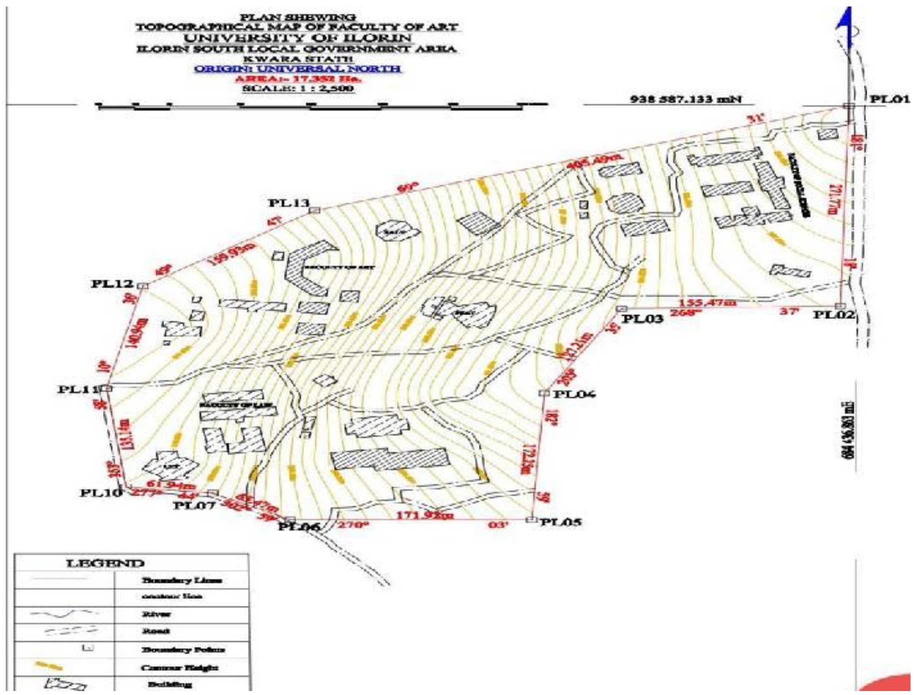

Figure 1: Topographical map (Babalola and Gbemisola, 2020).

3. **Thematic map:** This is generally designed to provide information on specific item aiming at addressing a particular purpose such as temperature, population, rainfall, etc. Figure 2 is an example of thematic map which shows the variation in temperature among different locations in Kwara State of Nigeria.

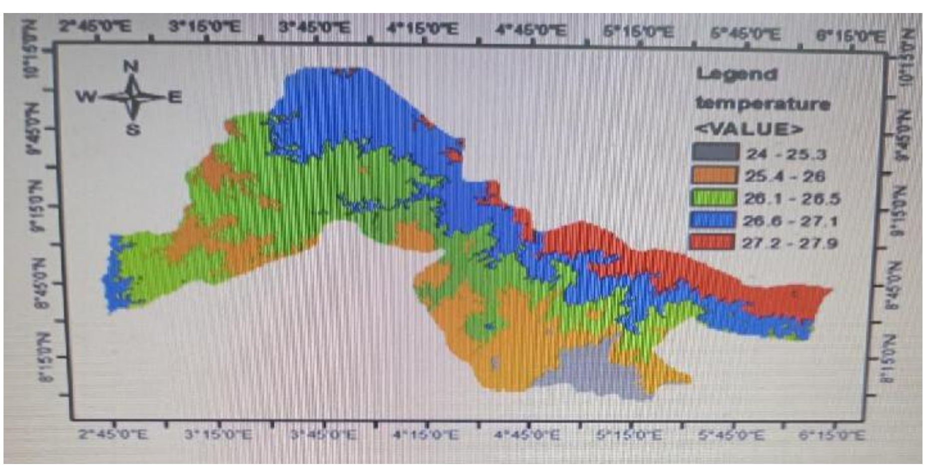

Figure 2: Temperature map of Kwara State of Nigeria (Babalola et al., 2022).

4. **Cadastral map:** cadastral map/plan depicts more specific information such as boundary information resulting from surveying and geoinformatics process of landed properties. It provides ready means of precise description and identification of a particular piece of land with identification number and other legal significances in land registration.
5. **Statistical map:** This presents the difference in values of an event between geographical locations in a geospatial analysis. Examples are Choropleth shown in figures 3a and 3b as well as Cartogram shown in figures 4a and 4b. These maps depict population and population density of the states in Nigeria using the two methods. In the choropleth, the map is shaded according to the population and population density range for all the states while in the cartogram, geographic size of each state is directly altered to be proportional to the population of each state in the country (Babalola and Ogunkunle, 2018).

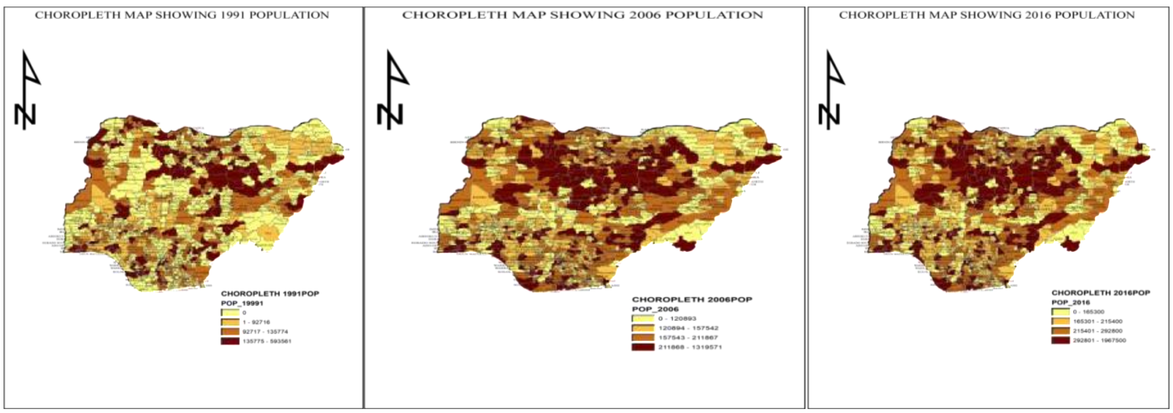

Figure 3a: Choropleth maps of population of Nigeria (1991, 2006 and 2016)

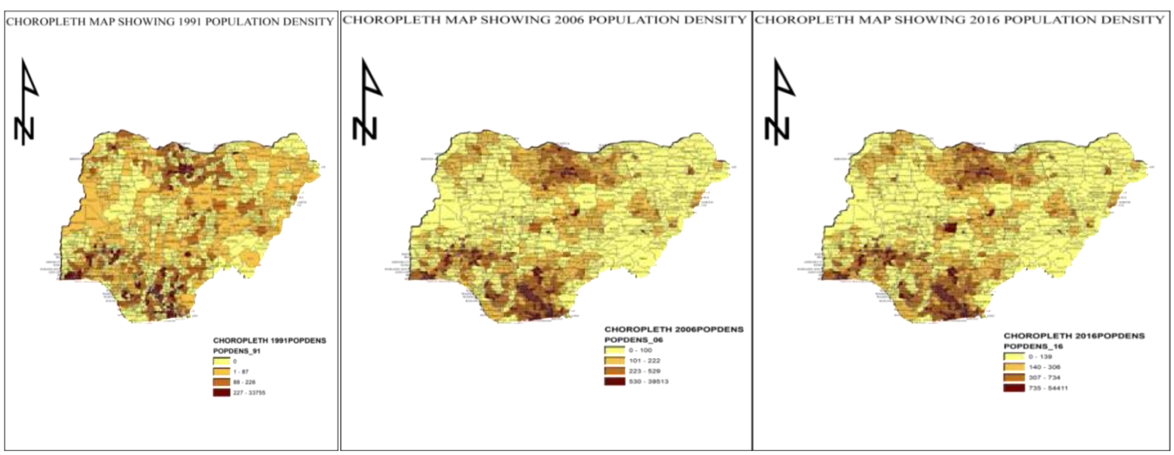

Figure 3b: Choropleth maps of population density of Nigeria (1991, 2006 and 2016)

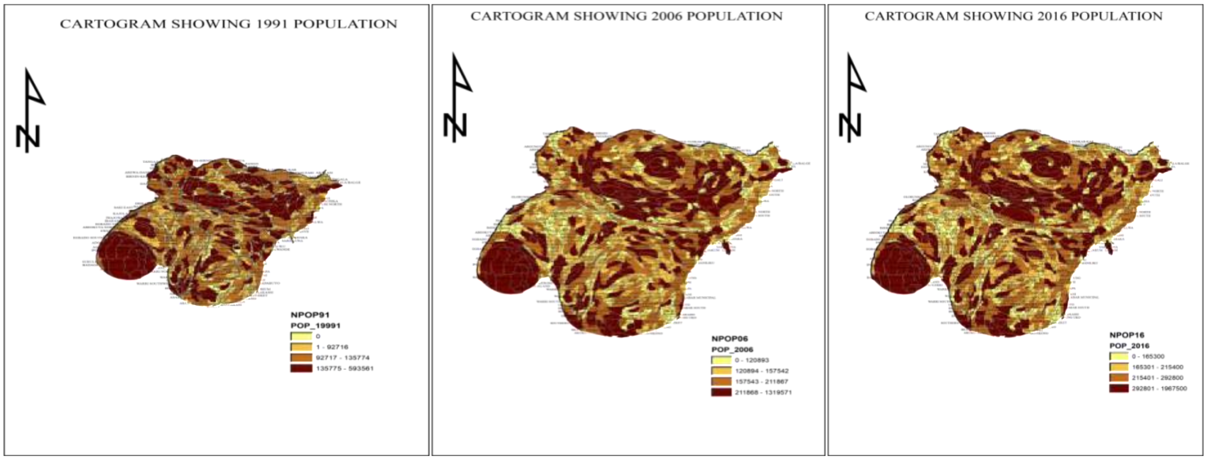

Figure 4a: Cartogram maps of population of Nigeria (1991, 2006 and 2016)

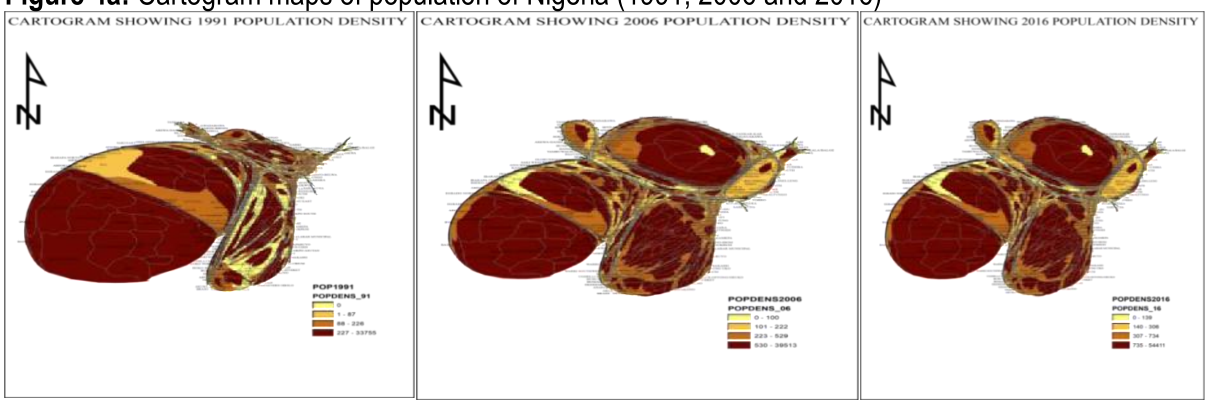

Figure 4b: Cartogram maps of population density of Nigeria (1991, 2006 and 2016)

6. **Route or Itinerary map:** This is the map which serves as aid such as road description information, nautical or aeronautical charts etc. to travelers.
7. **Large, medium and small-scale map**: These maps are so named based on the scales used for their production as shown in the table 1 below.

Table 1: Types of map based on scale

Scale	**Types of maps**
1:50,000	Large Scale Map
1:100,000	Medium Scale Map
1:500,000	Small Scale Map

8. **Information content map:** This is where map can be named based on the combination of more than one types earlier defined. A map can be named based on the combination of scale and general information. Examples of this can be large scale general map, small scale thematic map etc.
9. **Specific geographical content map:** This gives rise to map which could either be made up of physical or cultural features. Examples of this are **population map**, **soil map**, **vegetation map**, and so on.
10. **Method of production map:** This type of map is based on methodology used for the production of map. In this category, we can have **color map**, **monochromic** (black and white) **map**, **digital map, analogue map** and so on.
11. **Isopleths map:** This type of map shows lines joining places of equal values. Examples are **Isohyets map** which shows lines joining places of equal rainfall (Figure 5), **Isotherm map**

shows lines joining places of equal temperature and **Isobar map** shows lines joining places of equal pressure.

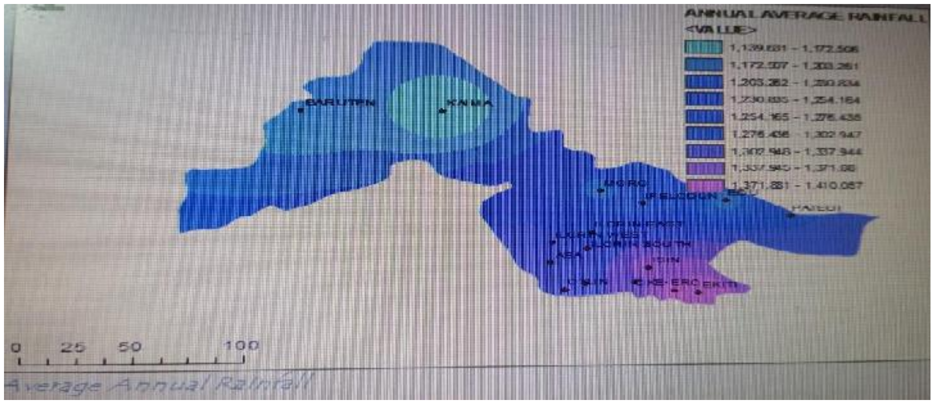

Figure 5: Isohyets map of the Average Annual Rainfall of Kwara State (Babalola and Ogunkunle 2019)

12. **Choropleths maps:** As shown in figures 3a and 3b), are used for the presentation of area density. That is, it shows the population diversity of an area. Population density is the number of persons per square kilometer in a particular study area. It is the ratio of the area in relation to the population of the area. It can be functionally shown as:
    Population density = **Population of the area/total land area.**
    It provides an advantage of being easy to construct and read. However, its disadvantages include giving impression that the population of the study area is evenly distributed. Also, it does not give true details of the population distribution.
13. **Flow-line map**: This is a map in which lines are used to show the movement of the relative amount of goods, traffic and passengers that are carried along communication lines. It shows the direction, frequency and various amount of goods, traffic and passengers along a particular route.
14. **Statistical map:** This aims at achieving analysis of the pattern of distribution that form a spatial trend and spatial relationship.
15. **Dot map:** As shown in figure 6, is used to show discrete unit such as population, crop production, livestock etc. It is drawn based on proportion to the size of object being represented. It is easy to construct and read, visually impressive and informative. Also, comparison among regions using this type of map is easy and it can be used to show values, weight, volumes etc. However, it has a disadvantage which includes difficulties in chosen dot size. Also, dots are spread evenly without taking account of other geographical elements such as relief, vegetation etc. Furthermore, production of the chosen dot size may not be easy.

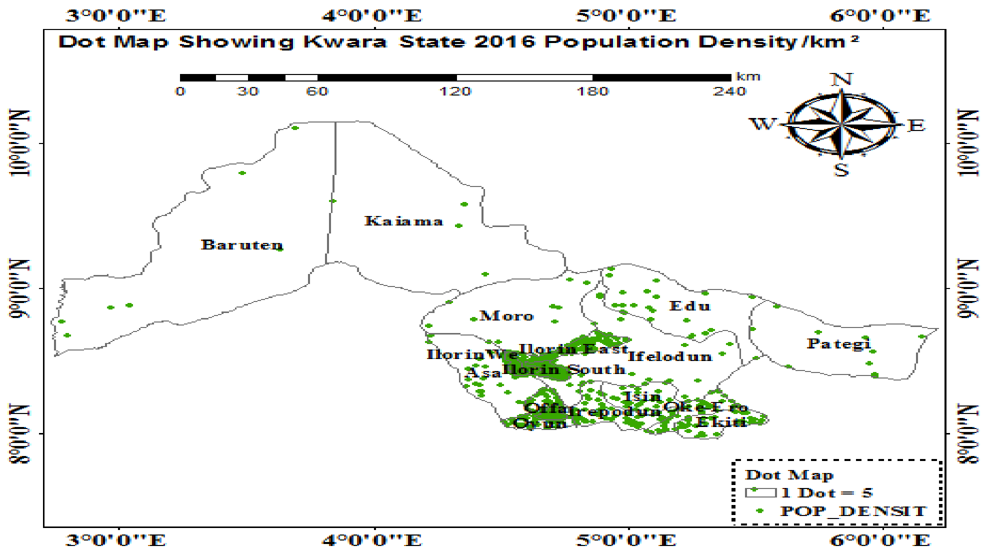

Figure 6: A Dot Map of Kwara State 2016 Population Density/km2 (Babalola et. al. 2021)

16. **Necklace Map:** As shown in figure 7, is a new form of thematic map presented to address the challenges of posed by the cartograms, choropleths and proportional symbol maps (Speckmann and Verbeek 2010). Each enumeration unit is mapped to a contiguous interval on the necklace and is represented by a symbol, usually a symmetrical shape, scaled according to the data.

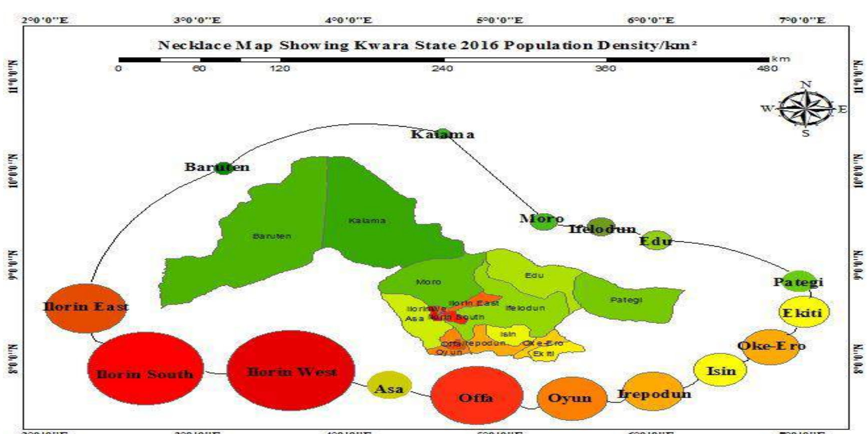

Figure 7: A Necklace map of Kwara State 2016 Population Density/km2 (Babalola et. al. 2021)

Uses of maps

Map are used for accurate description of varied functions. An adage says "what cannot be mapped cannot be described". Some of the uses of maps include:

a. **Generation of hypothesis testing**: Inferences about occurrence of unobserved or unobservable data can be made using maps. As an example, hypothesis of continuous increase in temperature within the next twelve hours can be predicted and tested using maps.

b. **Storage of information**: Map provides means for storing spatially conceive information and also goes further to show the source of such information.
c. **Planning**: Map can help in planning day-to-day activities. This could be used in local, city, national and international planning for pick-nicking, recreation, tourism, excursion, military strategic planning, farming, sporting activities etc.
d. **Inventory of phenomena**: Map gives the actual location of a nation's resources which may include forest, mineral, water, agricultural and human resources.
e. **Communication**: Map is a means of communication using symbols as the only language. That is, if a map is not good in this language, there will be breakdown in communication between the map reader and the map producer.
f. **Instructional means**: Map serves as educational aids as they are used as instructional materials both in the classroom and in the field.
g. **Trace of development**: Map serves as trace of development of places such as the changing pattern of land use and land cover, climate, road network etc.
h. **Visualization of features:** maps are needed to be able to visualize man-made or natural features, identify point locations, directions and their attributes.

Map Scale

The scale of a map shows the relationship between the size on the map and the size on the ground. It is a ratio between map and actual ground physical features. For instance, if the scale on a map is 1cm to 1km, it means a distance of 1cm on the map represents distance of 1km on the ground.

Types of map scale

1. **Statement Scale**: It is the scale given inform of a statement or figures. Examples are: one centimeter represents two kilometers or 1cm to 2km.
2. **Representative Fraction (RF) Scale**: This type of scale is expressed in form of a fraction or ratio where the distance on the map is the numerator and is always one (1) while the denominator represents the distance on ground. Here, both numerator and denominator are of the same unit. Examples are: 1:50,000 or 1/50,000.
3. **Linear scale**: This is a straight line drawn to represent relationship between the distance on map and the actual distance on ground. It is usually divided into primary and secondary parts.

Conversion of map scales

Map scales can be converted from one map scale to another map scale using the following steps:
Write out the statement scale

a. Write the two parts of the scale in the same unit.
b. Write the scale as a fraction with map distance as numerator and ground distance as denominator.
c. Divide out the fraction (numerator and denominator) until the numerator is one.

Examples:

1. Convert statement (1cm to represent 4km) scale to R.F. scale:

Solution:

1cm to 4km
1cm to 400,000cm
Hence, the result is: 1/400,000 or 1: 400,000

2. Convert R. F. (1: 500,000) scale to Statement Scale.

Solution:

1:500,000 means 1cm represents 500,000cm
By dividing the denominator by 100, It becomes 1cm represents 5,000m, if it is further divided by 1000, The final result is 1cm to represent 5km.
Therefore, the statement scale is: 1cm to represent 5km.

3. **Convert Linear scale to Statement and RF scales**

Use ruler or other appropriate instrument to measure the length of only one unit on the linear scale, especially from 0 to the next unit along the right division which can be 1cm or 2cm etc. The measurement on the instrument represents the distance on map. The distance 0 to1 on the map scale is 1cm and the distance on ground is 1km. Therefore, the statement scale is 1cm to 1km and R.F. scale is 1/100,000 or 1:100,000.

It is pertinent to note that:

a. The smaller the denominator of a map scale, the larger the scale of the map. Hence, the map produced with this requirement will be for small area showing much details of important features of the study area.
b. The larger the denominator of a map scale, the smaller the scale of the map. Hence, the map produced with this requirement will be for large area showing much little of important features of the study area.

Distance measurement on map

Distance on a map is the interval between two points which can be straight or curve.

1. **Straight distance:** This includes straight road, air route, straight railway etc.

Procedure:

a. Locate the two points involved on the map;
b. Use ruler to measure the distance;
c. Relate the distance measured on the map to the given scale; and
d. Obtain the equivalent ground distance.

2. **Curve distance:** This is the measurement carried out within a long interval between two points that are not straight such as: river path, foot path, curve road, curve railway etc.

Procedure:

a. Using a pair of dividers, the distance is broken into small sections that the pair of divider can conveniently covers. All the measured sections are added up to obtain total distance on map. Thereafter, the total distance is related to the given map scale to obtain the equivalent distance on the ground.
b. Using a piece of thread, a piece of white thread is carefully laid along the curve or route to be measured. Thereafter, mark the two ends of the distance on the thread with a pen and transfer it to the liner scale to determine the actual distance on map. The total distance is related to the given map scale to obtain the equivalent distance on the ground.
c. **Using straight edge of paper,** a starting point on straight edge of paper is marked and thereafter, twist the edge of the paper along the cause being measured using the pencil at regular intervals as a pivot. Later, the paper is placed against the scale and the distance measured in relation to the given scale of the map to obtain the equivalent ground distance.

Area measurement on map

This contains measurement of areas made of regular and irregular shapes.

1. **Area of regular shape:** This include geometrical shapes such as squares, rectangle, circle etc. The area of rectangular shapes can be measured in relation to their length and breadth while that of circle is taken in relation to its radius.

Procedure for rectangular area:

a. Measure the length and breadth relate them to the scale of the map; and
b. The product of length and breadth equals the area of the rectangle.

2. **Area of irregular shape:** Irregular shapes such as lake, farm land etc. can be measured using square method which requires tracing and graph papers.

Procedure for the irregular shape:

a. Trace the outline of the figure using the tracing paper;
b. Trace the figure from the tracing paper on the graph paper;
c. Count the number of complete squares on the spaces enclosed by the figure from graph paper;
d. Count the number of small boxes that could not form complete squares and approximate them to form certain number of complete squares;
e. Add the number of the total complete figures together;
f. Determine the area of each square and hence the total area on map formed by all squares; and
g. Calculate the equivalent area on ground.

Map reading

Map reading is an act of observation, recognition and understanding geographical features portrayed on a map (Caitlin, 2020). The search for such recognition and understanding of the geographical features may go beyond casual reading of the map but includes the need for consultation of other secondary sources of information such as textbooks, journals, internet, questionnaires etc. It is concerned with how geographical features, which may be natural and/or artificial, are represented with conventional symbols on maps instead of their original shapes. Leilani et al. (2021) opined that a map reader should have understanding of the symbols and the real world (landscapes), hence every symbol or sign on a map must be properly visualized when learning map reading.

Procedures for map reading:

1. Select the right kind of map;
2. Ascertain the orientation of the map;
3. Refer to the legend (Key) to make any meaning of information on map;
4. Identify the coordinate system, either geographical or rectangular, used for mapping; and
5. Understand details of scale of the map.

Figure 8 shows the model which attempts to elucidate the process of map making and map reading. It identifies four levels which includes: data acquisition, results obtained from processed data, production of map and map reading. The process commences with data acquisition from the study area to be mapped. This is followed processing the acquired data to obtain results needed for map production. The results and other relevant information within and around the study area will be used for map production. The generated map can be read and studies by intended users.

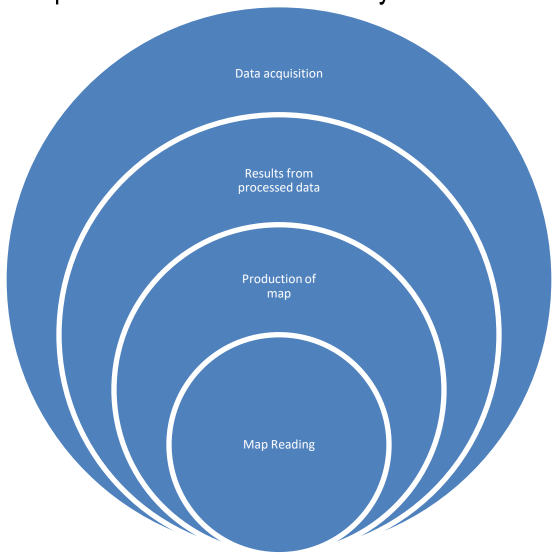

Figure 8: Model for map making and reading (Source: Authors, 2023)

The context upon which a map, be it cultural or spectral, is produced should be properly placed. This is because the information on the map determines the system or process of analysis of its and the interaction with the users. The way and manner upon which the messages on a map are decoded and symbols presented are very important for the successful reading of such map.

Map signs and symbols

Symbols and signs represent different features depicted on a map. These are used to make reading of maps easier and clearer. For instance, color separation is used to make map signs and symbols clearer and sometimes used to classify or group map symbols. Some of the signs and symbols used in map making and reading are shown below.

a. **Lines:** These are used to symbolize railway, road, power and telephone lines amongst others.
b. **Points:** They are used to represent buildings, beacons, trees, etc.
c. **Area:** They are the symbols used to represent cultivation, farmland, wetland, orchards, etc.
d. **Blue color:** This is used to symbolize water bodies such as lakes, dam, swamps, rivers, etc.
e. **Brown color:** It is used to represent land or earth features such as contour lines, sand and dunes areas, etc.
f. **Green color:** It is used for vegetation features such as cultivated land, recreational facilities, etc.
g. **Black color:** It symbolizes construction features like roads, tracks, railway, buildings, etc.
h. **Grey color:** It represents construction features such as built-up areas, cadastral information etc.

Basic tools for map reading

There are required tools for reading as well as interpreting maps. Some of these are:

1. Map
2. Protractor
3. Compass
4. Pencil and paper

5. Lenses to aid eyes
6. Computer

Map Interpretation

Map interpretation provides explanation of the meaning to what has been observed, recognized and understood during map reading. Therefore, it shows that map reading and map interpretation are dependent on each other and they are concerned with how geographical features, which may be natural and/or artificial (man-made cultural and other physical materials), are represented with conventional symbols on maps instead of their original shapes. Hence, map user is left to interpret features shown on map with the aid of the conventional symbols and signs. That is, the success of the interpretation will depend on the ability of the user to understand the language of the map.

Principles of map interpretation

1) Legibility: Features on map should be broad and clear enough to be seen and understood;
2) Visual contrast: There should be ability to distinguish between features and its background;
3) Figure-ground: This presents a distinction between objects of interest (the figure) on the map and on the ground;
4) Hierarchical organization: It represents the order of how the map elements are ranked; and
5) Balance: This shows the balance of interest which represents the visual weight and direction of each of elements of the map (Tait, 2018).

Procedures for map interpretation

1) Determining the index number of the map and the location of the map area;
2) Study the scale and contour interval of the map;
3) Identify the distributional pattern of map features;
4) Study to understand the symbols used and the features they represent;
5) Determine the relationship between the degree of slope and the type of land used.

Importance of map interpretation

a. It assists in the understanding of the earth and how its physical processes and features can shape human activity;
b. The relationship between places on the map can be expressed or understood; and
c. Information about location of places and areas can be easily disseminated.

Contour

This can be referred to as a line on a map representing imaginary line, of the same elevation, on the surface of the earth. The difference in height between two contour lines is called **Contour interval**. Contour line is used to illustrate the shape of a given landform or terrain. Also, it can be used to determine possible visibility between two points.

Characteristics of contour line:

1. All the points on a contour line must have the same height;
2. Flat surface is represented by widely spaced contour lines;
3. Sloppy ground is represented by closely spaced contour lines; and
4. Plane surface is represented by straight parallel equally spaced contour lines.

Observed rules for good contouring:

a. Every point on a contour line must be of the exact same height;
b. Contour line separate points of higher height from points of lower heights;
c. Contour lines must never cross one another; and
d. Contour lines must be continuous.

Methods of contouring

Direct method: The heights of various selected points on a contour line are obtained and their positions are located. Thereafter, the contours are drawn by joining these points. This method looks accurate but very tedious and uneconomical.

Indirect method: This method is suitable for undulated and hilly areas. Here, the points are selected randomly. Their horizontal positions and heights of are not necessarily located on contour lines but the contours are drawn by interpolation technique.

Summary

This chapter has presented definition, types and uses of map. Also, detailed information about the types of map scales and the process for scale conversion, using numerical examples, have been provided. Procedure for map reading, use of symbols/signs and basic tools used for map reading were explained. The chapter further highlighted the principles, procedure and importance of map interpretation. This included designed model which showed the process of map production, reading and interpretation from data acquisition through production of map to reading and interpreting the map.

Exercise

1. Define and list the purposes of a Map.
2. Briefly explain different types of maps.
3. List and explain the uses of 5 symbols used to represent different features on a map.
4. Differentiate between map reading and map interpretation and state the importance of map interpretation.
5. Itemize the principles and procedure of map interpretation
6. Briefly discuss the role of a surveyor in the production, reading and interpretation of map.
7. Explain the process of measuring straight and curve distances on map.
8. Convert R. F (1: 10,000) map scale to Statement map scale.

References

Babalola**, A.** Mohammed O. Idrees, Ruth K. Aniyikaye, Hussein A. Ahmadu, Oyedapo A. Ipadeola (2021). Land suitability for Rice crop Farming in Kwara State using GIS-Based Multi-criteria Decision Analysis. *Journal of Agricultural, Food and Environmental Sciences* Vol. 75. No. 1, pp. 32-47 Original Scientific Paper. 470 available online at https://journals.ukim.mk/index.php/jafes

Babalola Ayo, Adeyemi, M. O., Idrees, M. O., Ahmadu, H., and Maimuna, O. A (2021): Visualizing Population Census Data Using Geographic Information Systems Approach. African Journal of Earth and Environmental Sciences *Volume 3, No. 2, pp. 990-1005 ajees@buk.edu.ng*

Babalola A. and Gbemisola, O. (2020): Topographical Map of Part of the University of Ilorin, An Unpublished Project for the University of Ilorin, Kwara State, Nigeria.

Babalola, A. and Ogunkunle B. T. (2019) Spatial Analysis of Rainfall Variation in Kwara State, Nigeria.

Proceedings of the 54th Nigerian Institution of Surveyors Annual General Conference (NIS). 'National Mapping Infrastructure and Geospatial Technologies in Monitoring Disasters for Sustainable Development'. Anambra 2019, 17-21 June. agm.nisngr.net

Babalola A. and Ogunkunle B. T (2018): Visualizing Population Data using Geographic Information Systems. Journal of Geomatics and Environmental Research (Joger) Vol. 1 No. 1 pp. 46-55. A Publication of the Department of Surveying and Geoinformatics, University of Ilorin.

Caitlin D. (2020): What is Map Reading? Geography Realm https://www.geography realm.com/what is map reading. Accessed 28/03/2023.

Idowu, T. O. (2021): Unpublished lecture notes on map reading and interpretation.

Leilani, A. A., Sarah, P. B., Joel, M. R., and Shelby, D. L. (2021): The Development of Individuals' Map-reading Skills: What research and Theory tells Us. International Journal of Cartography. Doi: 10.1080/23729333.2021.1950318.

Speckmann, B and Verbeek, K. (2010): Introduction to Necklace Map IEEE Trans. Vis. Comput. Graph, pp.1-10

Tait, A. (2018) Visual Hierarchy and Layout. The Geographic Information Science & Technology Body of Knowledge (2nd Quarter 2018 Edition), John P. Wilson (ed.) DOI:10.2222/gistbook/2018.2.4 Accessed March 2023.

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CHAPTER 16

Instrumentation and Tools in Surveying and Geoinformatics

By

OJIGI Lazarus Mustapha

Overview

The rapid technological advances in modern surveying and geoinformatics extend beyond physical measurements to include informatics, computing, communications, software engineering, satellite sensing, spatial observation technologies, land information management, geospatial data science and modelling.

This paper presents a general description and development of instrumentation and tools (old and modern) used in surveying and geoinformatics. Attempts are also made to explain the features and the various platforms where specific instruments and tools are deployed or applied for practical solutions. Examples of results from selected techniques were provided as guides for effective usage, management and applications of relevant surveying and geoinformatics instrumentation and tools by students and professionals for development.

Objectives

At the end of this chapter, students should be able to:

1. identify specific instrumentations and tools (old and modern) used in surveying and geoinformatics;
2. explain the features of various platforms where specific instruments and tools are deployed for effective usage, maintenance and management by students and professionals; and
3. provide some sample products from various equipment, instruments and tools used in surveying and geoinformatics.

Introduction to instrumentation and tools used in surveying and geoinformatics

Definition of instrumentation and tools

Instrumentation and tools can both be referred to as devices or platforms deployed for specific task in surveying and geoinformatics. It is however important to draw a slight boundary between the role of instruments and tools in surveying and geoinformatics. Therefore, it is correct to say that both of them are meant for executing various components of surveying and geoinformatics operations according to standard guidelines for usage and specified technical rules and regulations or instructions. Instruments can be referred to as the entire devices and equipment such as satellites, sensors, total station, theodolites, levels, GPS receivers, echo-sounders, gravimeters, etc. used for earth measurements and data acquisition, storage and monitoring while tools can be referred to as devices, methods and systems such as production hardware, software, programs/suites, techniques/algorithms, database, network, media etc. used for processing, analysis, integration, presentation and management of earth data. However, an instrument becomes a tool where it possesses analytical capability of on-site processing, value addition and representation of survey data in real time or near real time. Therefore, in this paper and for the purpose of simplicity and applications, the term ‘instrumentation and tools’ shall be used together and not differently.

Modernization of instrumentation and tools

Modern science, engineering and technology of surveying and geoinformatics are driven by innovations in the fields of space science and technology, electronics and aerospace engineering, information and communications technology, software and computing technologies as well as data science. To a large extent, the fundamental principles of measurements in surveying and geoinformatics have not changed but the methods and approaches to data acquisition, processing, storage, representation and management have been enhanced, simplified and made robust by the advancements in the instrumentation and tools. It is important to note that the technique or techniques to be adopted for various surveying and geoinformatics projects are determined by the purpose, location and area of coverage of the measurements.

The modernizations of surveying and geoinformatics instrumentation and tools have reduced the conventional time-consuming, tedious and complex field data collection and processing techniques to a much more simplified and user-friendly electronic and digital devices for data acquisition, recording, storage, processing, integration, representation, retrieval and management. The impact of Information and Communication Technology (ICT) evolutions have improved the pace of learning and practice of surveying and geoinformatics across the globe. This has repositioned it in the main stream of sustainable national development and inter-disciplinary relevance globally.

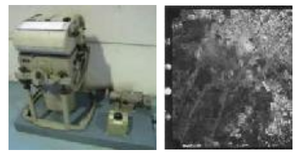
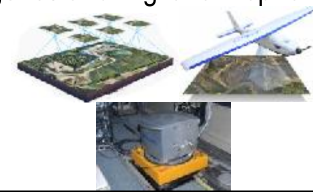
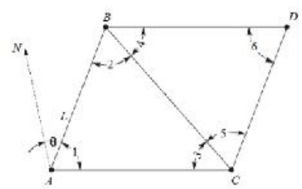
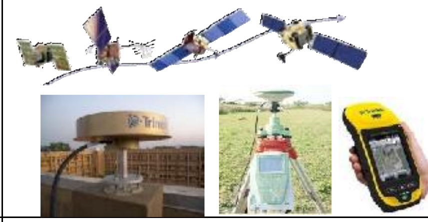
List of instrumentation and tools used in surveying and geoinformatics

The major instrumentation and tools used in surveying and geoinformatics have evolved and are evolving, owing to the growth in electronics and technology. Hitherto, the traditional variables measured using instrumentation and tools included, linear distances, angles/bearing, heights and gravity. However, the boundary of the variables required for mapping the earth surface and its physical dynamics has become very elastic; hence the expansion in the list of instrumentation and tools used in surveying and geoinformatics.

The list of the basic instrumentation and tools used in surveying and geoinformatics include the following, amongst others: measuring tapes (linen, metallic, steel and invar), arrows, wooden pegs, thread, measuring wheel, odometer, planimeter, chains (metric, surveyor's, engineer's and revenue), white cement, ranging poles/rods, offset rods, plumb bob, cross staff (open, French and adjustable**)**, optical square, prism square, site square, tripod, plane table, alidade, plumbing fork, spirit level, trough compass, drawing paper, drawing board, scale rule, 12-figure table, scientific calculator, distance meter, bipods (**aluminum survey bipods, carbon fiber bipods, quick-release bipods),** dot-plumb laser, prism pole, levels (dumpy, Wye/Y, tilting, geodetic and automatic), leveling staff, prismatic compass, sextant, magnetic or surveyor's compass, barometer, altimeter, gyroscope, electromagnetic distance measurement (infrared wave, light wave, and microwave), theodolite, and tacheometer. Other types of instruments used in surveying and geoinformatics include, echo-sounder, sonar scanners, tide gauges, buoy, range meter, lead line, hydrographic survey vessel, boat, gravimeter, radiometer, tiltmeters, strainmeters, magnetometer/magnetic locators**,** aerial camera, airplane, photogrammetric plotters, comparator, computer workstation, digitizers, field data logger/collector and palm computer, reflector, map plotter, total station, 3D scanner, Global Navigation Satellite System (GNSS), Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), Lunar Laser Ranging (LLR) and , and Interferometric Synthetic Aperture Radar (InSAR), Light Detection and Ranging (LiDAR), Laser, ground penetrating radar and Unmanned Aerial System/drones (UAS), etc. Table 1 presents a sample of some activities of the surveyor and technological transition in the instrumentation and tools used.

Table 1: Some activities of the surveyor and technological transition in instrumentations and tools used.

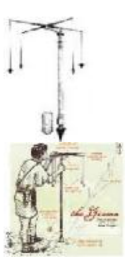
S/ No.	Activities of the Surveyor	Instrumentation and Tools	
		Old	**Modern**
1	Distance/Linear measurement	Chain, Tapes and ranging poles    	EDM, Total Station, SmartPole, GPS, Laser Distance Measurer, etc.    
2	Angular/Directional measurement	Compass, Analog Theodolite and Gyroscope   	Electronic Theodolite, Total and Scan Stations, GPS, Prism, etc     
3	Gravity Surveys	Pendulum, Micro-g LaCoste A10 (Absolute Gravimeter), Micro-g LaCoste FG5 (Abs. Gravimeter),  	Scintrex CG5 (Rel. Gravimeter), and Gravity Satellites (CHAMP, GRACE I/II, & GOCE)  
4	Hydrographic Surveys and Sea Level measurements	River gauges, Echo sounder   	3D Sonar Scanner, Satellite Altimetry (Topex Poseidon), Hyperspectral Satellite Sensors (NOAA AVHRR), etc.  
5	Aerial Surveys	Analog Aerial Camera (Zeiss RB-75 30) and	Digital Airborne Imagery System (DAIS), UAS, Large Format Digital

		Photos 	Cameras (UltraCamD), EOS Imageries and Digital orthophotos 
6	Geodetic Mapping	Triangulation and Trilateration 	GNSS, CORS Network, DGPS/RTK and Rovers Network 
7	Topographic mapping	Dumpy and Tilting/Automatic Levels 	Digital and Laser Levels, DTM with LiDAR, RADAR, 
8	Map data processing Hardware	Lighting Table, Drawing Board, Calculators, Tracing Paper, 12-Figure Table 	Computers, Digitizers, Large Format Scanner, Plotter/Printer 
9	Survey Computations and processing software	Manual Computation by Trigonometric formulae Geometries/Calculus	Specialised/Standard Software: *C++, Visual Basic, MATLAB, SurvCAD, COGO, Kalman Filter, Neural Net, AutoCAD, ArcGIS,other Scientific Software, etc.*
10	Map storage and access	Analog Map Depots	Internet File Transfer Protocol (FTP), Web mapping portal, etc
11	Field Communications	Flags, Waving of hands and Voice	Walkie Talkie, Radio Signal, GPRS, Mobile phone, reflective safty Vest, etc. 
12	Field Transportation	Trekking, Wooden Boats, Bicycles, Trucks and Open vans	Survey Vessels, Airplane, Drone, 4-Wheel Drive with Navigation facilities, etc.

There are key areas of surveying and geoinformatics in which specific instrumentations and tools are deployed to create and manage geospatial data for national development. Some of the areas include, engineering and construction surveying, photogrammetry and aerial mapping, UAS, cadastral and land information system, satellite remote sensing for infrastructure mapping, gravity measurements, geodynamics and plate tectonics, geospatial information system and map digitization, multi-media geospatial data collection tools, space and satellite geodesy (GNSS, VLBI, SLR, DORIS, LLR, and InSAR), environmental geodesy and deformation measurement, underground tunneling and mining surveys, hydrographic and marine measurements (sonar scanning and bathymetry), topographic mapping and terrain analysis with LiDAR/LASER applications, control survey infrastructure and computing hardware and software applications in mapping and land management, etc. The understanding of the physics and the electronics of modern surveying and geoinformatics tools places a lot of demand on each user if there must be optimal use or application of the instruments and tools. The keywords of surveying and geoinformatics are: earth, space, measurement, recording, computation, analyses, integration, representation (drawing, modelling), storing, retrieving, management, assumption and approximation. Each of these keywords suggests the skills, instruments and tools to be deployed in achieving the required results. Currently, data and services from global navigation satellite system, earth observation satellite systems, UAS and a wide-range of geospatial information platforms are more readily available and accessible than ever. Consequently, there is increased emphasis and importance on accuracy, integrity, reliability, continuity and timely availability of geospatial data and information. It is now common to integrate field survey datasets from Total Stations, Bathymetry, GNSS, Laser Scanners, SAR, LiDAR with Earth Observation (EO), Digital Aerial Photographs (DAP) and transmit the end products as spatial information through navigation facilities and related communication technologies in real-time.

Developments of instrumentation and tools used in surveying and geoinformatics

The development of surveying and geoinformatics instruments and tools can be divided into four phases. These are the archaic, the optical, the electro-optical and multi-sensor phases. The archaic phase is simple but crude in nature with the use of the Roman Groma and chains. The introduction of optical phase which led to the invention of optical telescope in 1590 ended the use of the Roman Groma. The production of opto-mechanical components such as telescopes, microscopes, circles and axes allowed and enhanced the measurements of horizontal and vertical angles between 1590 and 1924 (Staiger, 2023). The invention of WILD Heerbrugg T2, a classic opto-mechanical theodolite, made setting up of instruments and observations easier for surveyors and it marked the starting point for the development of modern surveying instrumentation and tools. Other popular optical theodolites that followed T2 are WILDs T3 and T4, KERN DKM2-AE and KERN DKM3 respectively as shown in figure 1.

Development Phase	***Archaic Instruments***	***Optical Instruments***	***Electro-Optical Instruments***	***Satellite-based & Multi-Sensor Instruments***
Instruments & Tools	 Roman Groma	 Wild Heerbrugg T2 & KERN DKM2-AE Theodolites	 Digital Theodolite & Electronic Total Station	  Robotic Total Station & Satellites

Period	Early Roman Civilization	**1590 →1924**	**1924→1990s**	**1990s→2023 (to-date)**

Figure 1: Development phases of surveying and geoinformatics instrumentation and tools

The electro-optical period of surveying instruments was characterized by the arrival of Electronic Distance Measurement (EDM), electronic or digital calculators and digital storage of geodetic measurements and data which lasted till 1990s. Perhaps, the biggest development of surveying theodolites was its integration with EDM which emerged around 1940 and became commercially available in the late 1960s (Lemmens, 2016). The multi-sensor phase, with the current phase of surveying instrumentation and tools, started in 1990 with the rollout of the first digital level, the first usable GPS receivers and digital total stations (Staiger, 2023).
Today, many different sensors and measurement methods are combined in Total Station such as highly accurate angle reading, EDM to reflectors and to any other surface (non-reflector EDM), tilt correction by two-axis inclinometers, different types of motorizations to drive both the horizontal and the vertical motion of the instruments (Paar et al, 2021). The GNSS receivers are now commonly used in combination with Total Stations (TS). The modern TS are multi-sensor systems which can determine the three-dimensional coordinates of target points by combining horizontal angle, vertical angle and distance measurements (Lienhart et al, 2017). Figure 2 shows the advancement in TS technological development.

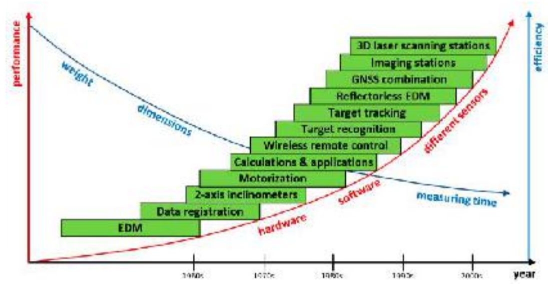


Figure 2: Total station technological development advances (Paar et al, 2021 and Staiger, 2023)

Narratives on instruments and tools

The sets of instruments and tools used in surveying and geoinformatics are largely based on space, aerospace and terrestrial platforms which provide ample opportunities for robust multi-sensor integration and time-series analysis. The power of surveying and geoinformatics instruments and tools is the ability to acquire spatial data, integrate spatial data with non-spatial data (i.e., descriptive information about the spatial data), analyze, create and visualize different scenarios and produce outputs which can be used for understanding earth infrastructure, processes and dynamics, management and decision making (Ojigi, 2023). The following sub-sections provide the narratives of instruments and tools used in space, aerospace and terrestrial platforms for surveying and geoinformatics.

Modern instrumentation and tools in surveying and geoinformatics

Space-based instruments and tools

The space platform is made up of Geostationary Orbit Satellites (GEOS), Medium Earth Orbit Satellites

(MEOS) and Low Earth Orbit Satellites (LEOS) (as shown in table 2 and figure 3). Figure 3 shows the representation of the entire space, aerospace and terrestrial based instruments and tools used in Surveying and Geoinformatics.

Table 2: Space-based Platforms

S/No.	Satellite orbit	Attributes of the orbit	Examples of satellites in the orbit
1	GEOS	average altitude of 36,000 km, equatorial orbits and geostationary/geosynchronous	Communication satellites (e.g., NigComSat-1R. NileSat-1, etc.); Global Weather Satellites (e.g., GOES, MeteoSat, NOAA-AVHRR, EUMESAT, etc.)
2	MEOS	average altitude of 20,000km-22,000km	GNSS (GPS, GLONASS, Galileo, Beidou), Search and Rescue Satellites
3	LEOS	average altitudes of 600-800km and 1000-1400km respectively; polar orbiting/sun-synchronous	GeoEye, Pleiades, SPOT, Landsat, NigeriaSat-X, NigeriaSat-2, Sentinel-1&2, etc.

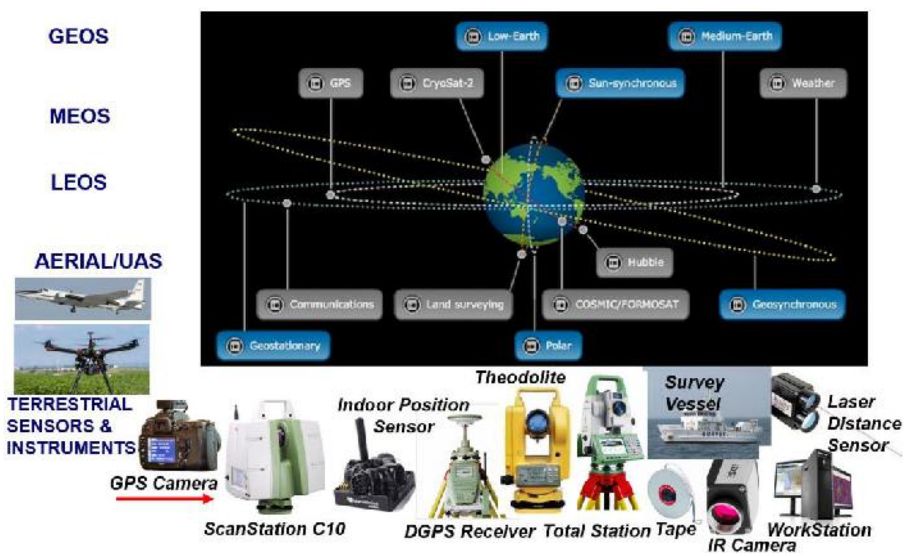


Figure 3: Representation of Space and Terrestrial Platforms, Instruments and Tools (GEOS = Geostationary Orbit Satellites; MEOS = Medium Earth Orbit Satellites; LEOS = Low Earth Orbit Satellites; UAS = Unmanned Aerial System).

Satellite altimetry instruments and tools for sea level rise

Satellite radar altimetry belongs to the class of LEOS. It is a revolutionary technology to measure the height and shape of the sea surface or levels globally from space. It has been used to observe global ocean topography and its changes with unprecedented accuracy (several cm, rms) in Sea Surface Heights (SSH) and resolutions (up to 50km spatial scale) and weekly temporal sampling. It transmits an electromagnetic pulse to the sea surface and measures its two-way travel time when the return reflected from the instantaneous sea surface is received. The altimeter-observed time delay (*t*) can be converted to the range (*R*) from the satellite to ocean surface as:

$$R = vt/2 \qquad 1$$

Where: v = free-space speed of light (~3.0x10⁸m/s⁻²)

Figure 4: Observation Geometry of Satellite Radar Altimetry (part of LEOS)

Due to the favourable reflective properties of water, the satellite radar altimetry observation technique is especially suitable over oceans and open water on land. The ground-based technique to ascertaining sea level changes is the Tide Gauge which are used to measure the level of the sea relative to the height of *'benchmarks'* located in the solid structure or ground on the nearby land. In turn, the height of these benchmarks can be measured relative to the center of earth using advanced geodetic techniques such as the GNSS/GPS receivers. Prior to the advent of satellite technologies for ocean observations and to some extent till date, tide gauges were used along the Nigerian coastal waters by oil prospecting companies such a as Shell Petroleum, Chevron, AGIP Oil, etc. to bench mark the sea levels and tidal phenomena for their exploration and exploitation activities. Tide Gauge readings are now excellent means of validating satellite radar altimetry sea height and level datasets.

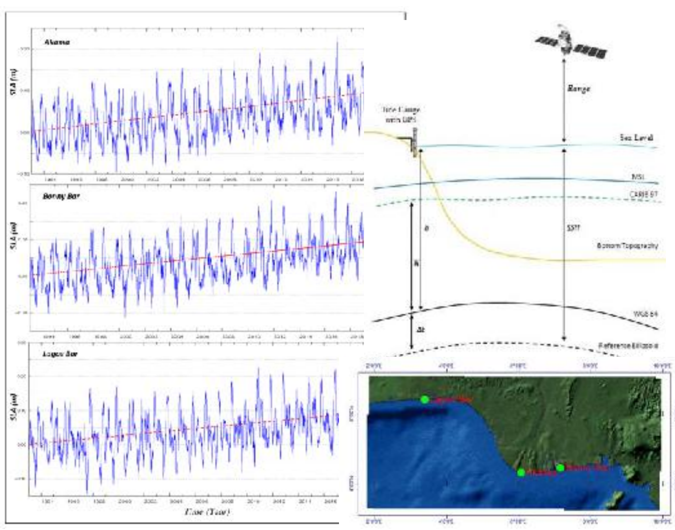


Figure 5: Delay Time SLA Over Selected TG Station in Nigeria (Ojigi and Folaranmi, 2022).

Figure 5 is an example of the use of datasets from satellite altimetry and tide gauge. It shows time series or trend of Sea Level Anomalies (SLA) over three selected Tide Gauge stations (Akassa, Bonny Bar and Lagos Bar) which were analysed for year 1993-2020 (Ojigi and Folaranmi, 2022). SLA is a critical marine geospatial variable for ocean and coastal mapping and management. The results show that the months of October and November of each year marked the periods of highest positive SLA with values ranging between about 0.2m and 0.3m which is an indication of a period of warming sea surface temperature in the study area. However, the months of June and July marked the periods for the highest negative SLA for each station with values ranging between -0.15m and -0.10m, representing a period of cooling sea surface temperature in the study area. The SLA phenomenon is therefore relevant for the investigations of El Nino and La Nina climatic patterns in the study area and by extension, the west coast of the Atlantic Ocean.

Global Navigation Satellite System (GNSS)

The Global Navigation Satellite System (GNSS) is a multi-constellation satellite positioning and navigation system with contributions of satellites from the American Global Positioning System (GPS), Russian Global Navigation Satellite System (GLONASS), Chinese BeiDou and European Galileo and the Indian Compass (Ojigi and Dodo, 2022). GNSS positioning is based on measuring signal travel times to determine distances between satellites and receivers. The satellites continuously emit radio waves as carrier of signals. These waves contain time stamps generated by very precise atomic clocks on board the satellites The receiver on earth or close to the earth captures the satellite signals and registers their time of arrival. The difference between the time of arrival and the time of emission provides the signal travel time which is multiplied by the speed of light ($3.0x10^8$m/s) to provide the distance between the unknown position of the receiver and the known position of the satellite. Figure 6 shows the GNSS architecture (space, control and user segments).

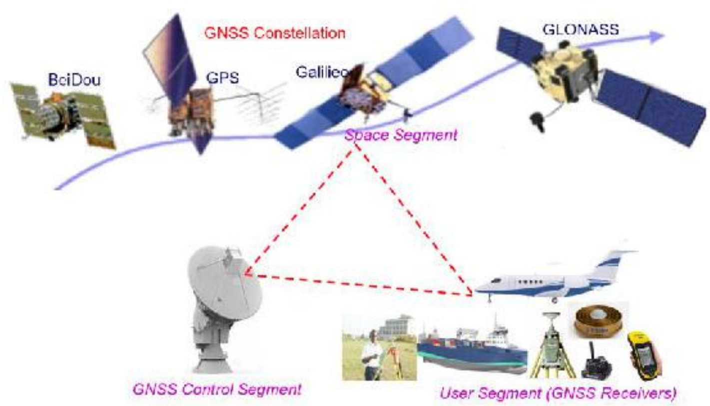


Figure 6: GNSS Architecture (Space, Control and User Segments) (Ojigi, 2023).

The three segments of GNSS (space, control and user segments) are integrated to produce observation and navigation signals that are used for various applications such as positioning and navigation, surveying and mapping, asset tracking, civil aviation (flight operations and landing), search and rescue/safety of life, meteorology (vapour and related atmospheric variables), space weather, logistics and transport management (location-based information system), engineering construction and machine guidance, e-agriculture, etc.

Figure 7: GNSS Centralized Network RTK Data Processing Model for Nigeria (Ojigi, 2022).

Figure 7 shows a proposed centralized network real time kinematic data processing model for Nigeria. The aim of the network RTK for Nigeria is for the Office of the Surveyor General of the Federation to exercise network control over GNSS services at the downstream and provide positional corrections for network users and placing commercial values on the services and products with the highest reliability and performance level of accuracy, integrity, continuity and availability. Figures 8 (i and ii) show GNSS user locations in Akwa Ibom State and Abuja respectively. Both stations were occupied in a GNSS network campaign using the static mode of observation.

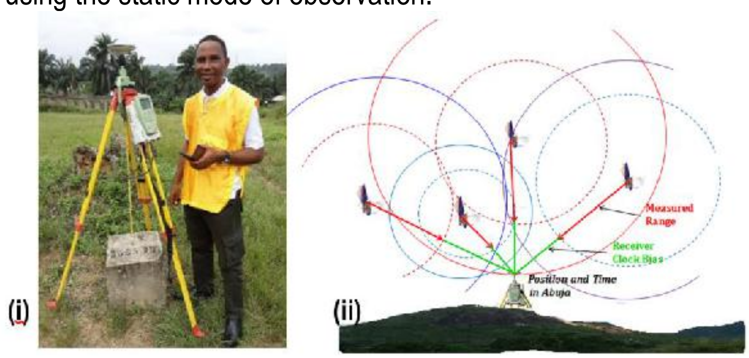


Figure 8: GNSS User locations in Nigeria; (i) A Receiver at Akwa-Ibom State, (ii) A Receiver at Abuja

Remote sensing and earth observation satellites

Remote sensing is the use of electro-mechanical devices and sensors for the acquisition of data about an object from a distance and without physical contact with the object. It relies on electromagnetic energy to capture data from the earth's surface and its surrounding atmosphere or objects. One of the dominant products of the remote sensing technology is imagery (optical or microwave) which is used to investigate specific themes through image and signal processing and interpretations. Earth Observation Satellites (EOS) are used to acquire structural, physical, chemical and biological information about the earth and its land, marine and atmospheric environments for the purpose of sustainable resources inventory and management. UAS and airplanes are equally used to acquire very high-resolution image data of the environment. Figure 9 shows two examples of EOS. These are GeoEye with sub-meter spatial resolution and NigeriaSat-2 with several-meter spatial resolution.

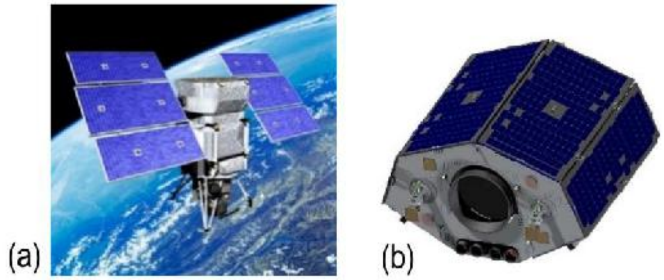


Figure 9 (a and b): Earth Observation Satellites: (a) GeoEye (VHRI); (b) NigeriaSat-2 (MRI)

The Imaging sensors on board NigeriaSat-2 spacecraft are Very High-Resolution Imager (VHRI) and Medium Resolution Imager (MRI). The VHRI provides 2.5m panchromatic and 5m four-band multispectral data (Blue, Green, Red, NIR) on a swath of 20km. The MRI is a 32m medium-resolution multispectral imager to provide data in 4 spectral bands with a swath width of 300 km. NigeriaSat-2 (N-2) is in sun-synchronous orbit at the altitude of 700km. The standard imaging modes for N-2 are the scene and strip modes and then more complex compound modes make use of the high agility to deliver stereo and area modes respectively.

Instruments and tools for gravity measurements

Based on Newton's law of gravitation, the force of attraction (F) between two bodies is proportional to the product of the mases (m_1 and m_2) of the two respective bodies and inversely proportional to the square of the distance (r) between them. The relation is represented by (2), where G is the gravitational constant ($6.6743 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$).

$$F = Gm_1m_2/r^2 \tag{2}$$

Therefore, if a satellite passes above an earth's mass anomaly, its orbit has a perturbation as the satellite position gets closer or further away from the earth. The lower the satellite, the higher its sensitivity to the gravitational effect caused by the mass anomaly. Figures 10 (a, b & c) show gravity measuring instruments and tools.

Figure 10 (a, b & c): Gravity Measuring Instruments and Tools [(a) Micro-g LaCoste FG5 (*Absolute Gravimeter*); (b) Scintrex CG5 (*Relative Gravimeter; (c)* Gravity Satellites (GRACE 1&2)]

Data provided by satellite gravity field surveys and missions are essential for the determination of the earth's gravity field, the computation of geoid, the vertical datum unification and for the establishment of a global unified height system such as the International Height Reference System (IHRS). In Nigeria, gravity measurements, in terms spatio-temporal quality have not been given the required attention over the years. However, the availability of dedicated global gravity field missions such as CHAMP, GRACE (1, 2, and GRACE Follow-On) and GOCE have made huge improvements to the knowledge and data accuracy of the earth's static and time-variable gravity field which are being exploited for national geoid models in Nigeria. These gravity missions have considerably increased the accuracy of the static gravity field by a minimum factor of 100 in terms of resolvable spatial scales compared to pre-CHAMP gravity models which were mainly determined from satellite laser ranging data. Therefore, gravimetry is considered as one of the fundamental instrumentations and tools used in surveying and geoinformatics.

Aerospace and terrestrial instrumentations and tools
Aerial camera, photogrammetric airplane, UAS/drones, airborne LiDAR and Laser are aerospace tools for airborne surveying and geoinformatics. UAS in particular is used for gathering data with high accuracy sensors gathering data from farms for pest management and crop management, roads for traffic congestion and rerouting for congestions, mapping the high-density forests and rivers amongst others. Robots and drones do the survey which makes it more time and resource-efficient**.**

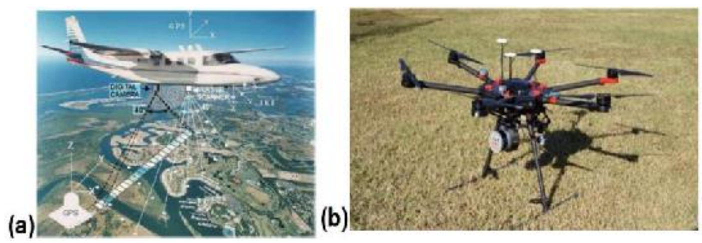


Figure 11 (a & b): Aerospace Technologies for Surveying and Geoinformatics ((a) Photogrammetric Airplane; (b) Unmanned Vehicle Systems)

The suitability of platforms is determined by parameters and criteria such as cost, size and weight of payload, stability and vibration, number of people needed for launch and control, level of piloting skills, flight time and range, minimum airspeed (the lower, the less blurring of images), minimum size of take-off and landing area, purpose and safety. The terrestrial instrumentations and tools include, theodolite, levels, tacheometer, echo-sounder, sonar scanners, tide gauges, buoy, range meter, lead line, hydrographic survey vessel, boat, gravimeter, radiometer, tiltmeters, strainmeters, magnetometer/magnetic locators, total station, etc. Topographic mapping and terrain analyses are made easy with the integration of the terrestrial and aerospace techniques.

Topographic mapping and terrain analysis with DTM and LiDAR
A topographic surface is that physical and visible portion of the earth which can be described as comprising two (random and systematic) elements. The random elements are the continuous surface with continuously varying relief. It would take an endless number of points to describe exactly the random terrain shapes of the topography. It is best exemplified by the use of network of points such Triangulated Irregular Networks (TIN) or Regular Grids Network (RGN). The systematic elements of the terrain surface are characterized either by sharp cracks or break lines in the terrain such as the top or bottom of a road cut, depressions, break lines and spot heights. It is best represented by lines and typical single points. An elevation model created from LiDAR measurements or terrain heights obtained from topographic maps are effective means of rendering Digital Terrain Model (DTM) upon which new topographic maps can be based. The DTM technique provides the flexible approach to different

classes of topographic analyses. It is a computerized way of representing and visualizing the topographic structure of a given portion of the earth surface from raster elevation data with respect to the mean sea level or any other datum, generated from topographic map data (ellipsoidal and orthometric heights), satellite and radar imageries (Ojigi, 2012). Figure 12 shows the 2.5D visualization of high-resolution Pleiades image of a part of FCC, Abuja.

Figure 12: A 2.5D Visualisation of Pleiades Image of Northern Part of Phase II, FCC, Abuja, Nigeria

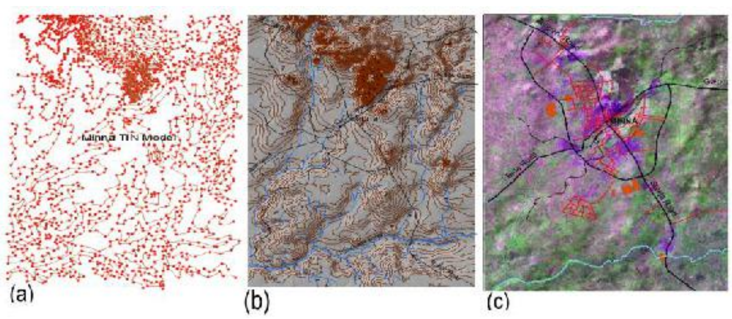


Figure 13: Topographic and relief maps of Minna and Environs, Niger State, Nigeria (a) Minna TIN Point
Cloud Model; (b) Minna Contour-Based Raster DTM; (c) Spatial-Relief Map (Ojigi, 2012).

In order to sufficiently represent the earth topography, point cloud measurement techniques of surveying and geoinformatics are required. In modern times, some of the techniques and tools for generating point cloud data for topographic analysis include:

i. Light Detection and Ranging (LiDAR),
ii. Light Amplification, Simulation Emission and Radiation (LASER) and
iii. Interferometric Synthetic Aperture Radar (InSAR)

In this chapter, only the LiDAR will be described. Readers are advised to cross-check other relevant sources for a fair description of LASER and InSAR.

LiDAR technique and tools

Light Detection and Ranging (LiDAR) is an active remote sensing technology that collects 3D point clouds of the Earth's surface. This technology and tool are being used for a wide range of applications including high-resolution topographic mapping and 3-dimensional surface modelling as well as infrastructure, forestry and biomass studies. The LiDAR sensor *transmits pulses and records the time delay between a light pulse transmission and reception to calculate elevation values*

$$T_d = P_{tt} - P_{rt} = Elevation\ (m) \quad (3)$$

Where: T_d = time delay, P_{tt} = *light pulse transmission time and* P_{rt} = *light pulse reception time*

These values are integrated with information from the aircraft's Global Positioning System (GPS) and orientation (pitch, roll, and yaw) data from inertial measurement technology to produce point cloud data. Each data point is recorded with precise horizontal position, vertical elevation and other attribute values. Point cloud data represent the elevation of landscape features including bare earth, crops, forests, roads, buildings, railways, airports, mountains, valleys, lakes, rivers, glaciers and other environmental features. Since LiDAR pulses can be reflected from any object (buildings, roads, vegetations, bare surface, water surface, etc.), it strikes, up to five returns are collected per pulse hence the multiple returns are recorded and each point is assigned a classification to identify landscape features and other additional information on terrain characteristics.

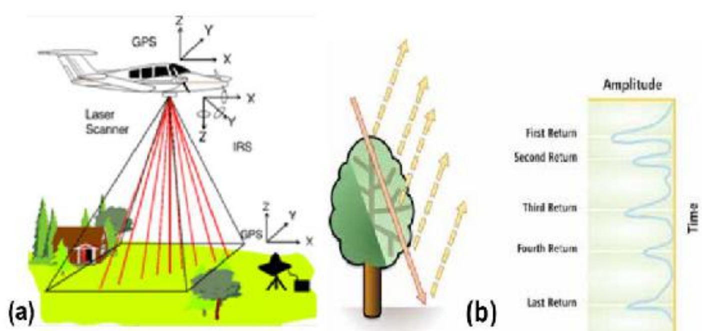
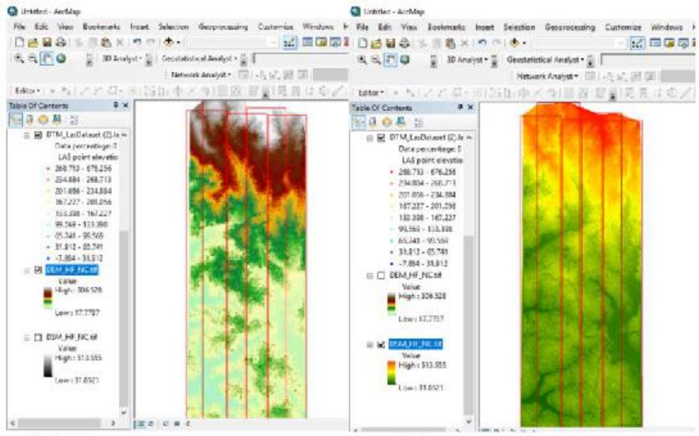


Figure 14: LiDAR Technique and Tools [(a) LiDAR Acquisition Geometry; (b) LiDAR Pulse Returns]

Applications of LiDAR products

LiDAR data products can be used to address a number of topographic issues such as topographic mapping and DTMs, ground and structural subsidence studies, erosion survey and management, establishing beach setback lines, coastal and shoreline inundation and beach volume changes, flood hazard risk analysis, water-flow analysis, habitat assessment and settlement mapping, civil and construction engineering, vegetation and forestry management, emergency response, transportation mapping and urban development, and telecommunication planning, etc**.**



(a) (b)

Figure 15: LiDAR Products [(a) Digital Elevation Model; (a) Digital Surface Model created from LiDAR data]

Data conversion tools

There are instruments and tools in surveying and geoinformatics that are meant for conversion of data from one format and structure to another. Few of such tools and techniques are explained below.

Geospatial Information System (GIS) and map digitization tools

Geospatial data digitization is the process of modifying any paper document into a digital file. This process saves space and time. Digitization systems are mainly used for converting maps, sketches, schematic diagrams and circuit diagrams into digital formats. Digitization systems are also used in zonal maps, contour maps, cadastral maps, topographical maps and utility maps. This can be in the form of:

i. 2D and 3D Digitization,
ii. Paper to CAD Conversion and
iii. Raster to Vector Conversion.

(a) (b) (c)

Figure 16: Geospatial Information System and Map Digitization Tools [(a) 3D Printer; (b) HP Colortrac SmartLF Ci40 A0 Scanner; (c) HP Design Jet T1120 A0 Plotter]

There are four types of GIS data digitization. These are manual, heads-up, interactive tracing and automatic methods of digitization.

Manual digitization

In this approach, the hardcopy map is pasted on a digitizing tablet for physical tracing of the line, points and polygons. Thereafter, the surveyor or cartographer manually uses a special magnetic pen, puck or stylus that feeds information into a computer to trace the points, lines and polygons of a hard-copy map and create an identical, digital map from the digitizing tablet. The features are then registered digitally and stored for further analysis and representation using the computer. The puck *(*a mouse-like tool*)* has a small window with cross-hairs which allows for greater precision and pin-pointing map features and tracing as shown in figures 17a and b.

Figure 17a, b and c): Digitizing Tools and Process [(a) A Calcomp Tablet Digitizer [1]; (b) Sitting position for tracing map features; (c) Heads-up digitizing of building outlines performed in ArcMap10 http://wiki.gis.com/wiki/index.php/File:Digitize.png

Heads-up digitization
This approach is described as shown in figure 17c. This is so called because the focus of the of the surveyor, cartographer or analyst is up on the computer screen, rather than down on a digitizing tablet. It uses a digitally scanned map, digital orthophoto from aerial photography or drone surveys, satellite images from which the lines, polygons and features are drawn directly on the computer screen. The relevant digitizing software platform such as ArcGIS Pro, ER-Mapper, Erdas Imagine, PCI-Geomatica, e-Cognition, Global Mapper, QGIS amongst others are used. Accuracy of traced features increases and the time spent in the operation decreases with this approach.

Interactive tracing method of digitization
The speed and accuracy increase in this method, although it's just an upgraded version of Heads-up digitizing in which features are interactively recognized as attempts are made by the user or operator to click and digitize the features.

Automatic digitization
This is an automatic raster to vector conversion using image processing and pattern recognition techniques. Machine learning and artificial intelligence are now deployed to achieve automated feature extraction and digitization.

Summary

This chapter presents a general description and development of instrumentation and tools used in surveying and geoinformatics. Attempts were also made to explain the features and the various platforms where specific instruments and tools are deployed or applied for practical solutions. Some examples of products from various instrumentation and tools used in surveying and geoinformatics were provided. Considering the rapid developments and innovations in the technologies of instrumentation and tools used in surveying and geoinformatics, adequate and up-to-date knowledge in instrumentation, optimization and tooling by professionals have become imperative for effective and enhanced usage, maintenance, development and management of all relevant instruments and tools.

Exercise

1. Mention any three features of linear tapes and infra-red distance meter used for surveying and geoinformatics measurements.
2. Differentiate between the features of space-based and terrestrial-based instrumentation and tools in surveying and geoinformatics.
3. Make a table of ten known surveying instrumentation and tools and their respective products.

References

https://www.gtcocalcomp.com

http://wiki.gis.com/wiki/index.php/File:Digitize.png

Lemmens, M. (2016). Total Stations: The Surveyor's Workhorse. *GIM Int.*, *30*, 20–25.

Lienhart, W., Ehrhart, M. and Grick, M. (2017). High frequent total station measurements for the monitoring of bridge vibrations. Journal of Applied Geodesy. Published by De Gruyter. February, 13, https://doi.org/10.1515/jag-2016-0028

Ojigi, M. L. (2023). Exploring Emerging Space and Terrestrial Sensing Techniques for Improving Civil Engineering Infrastructure Resilience to Earth Dynamics and Climate Change. Academic visit research seminar paper presented at the department of Civil and Environmental Engineering, Imperial College, Skempton Building, South Kensington Campus London. 17th February.

Ojigi, M. L. (2022). Strategies for Enhanced Geodetic Reference Network and Financial Returns on Investments from GNSS Network Real Time Kinematic Services in Nigeria. In 'Chapter 4: Satellite Positioning, Navigation and Space Transport; *Space Science and Technology for Sustainable Development in Nigeria'.* Igbokwe, J. I, *et al.,* (eds). Pub. *By GEOSON.* Pp. 201-220.

Ojigi, M. L. and Dodo, J. D. (2022). GNSS Ground-Based Augmentation System Architecture for Real Time Kinematics and Mobile GIS Realization in Nigeria. In 'Chapter 4: Satellite Positioning, Navigation and Space Transport; *Space Science and Technology for Sustainable Development in Nigeria'* Igbokwe, J. I, Kufoniyi, O., and Ojigi, M. L (eds). Pub. *By GEOSON.* Pp. 168-183.

Ojigi, M. L. and Folaranmi, J. A., (2022). Satellite Altimetry-based Sea Level Anomalies Over Selected Tide Gauge Stations in Nigeria. A scientific paper presented at the *3rd NASGL AGM/Conference. Theme: Innovations in Surveying and mapping Technologies for Earth Systems and Resource Monitoring & Management at Prof. Ajayi Boroffice Conference Centre, NASRDA Abuja. 28-31 March, 2022.*

Ojigi, M. L. and Ogba, C. (2015). Integrating Modern Surveying Tools with the Project Team in Nigeria (7795). FIG Working Week 2015 From the Wisdom of the Ages to the Challenges of the Modern World Sofia, Bulgaria, 17-21 May. 16pp.

Ojigi, M. L. (2012). Modelling Flood Water Kinematics Using Numeric Terrain Descriptors in Minna and Environs, Nigeria. In: *Geospatial Technologies and Digital Cartography for National security, Tourism and Disaster Management*. Ayeni, B and Fabiyi, O. (eds). Proceedings of joint Conference of *GEOSON & Nigerian Cartographic Association (NCA) held at Regional Centre for Training in Aerospace Surveys (RECTAS) OAU, Ile-Ife, Nigeria, 19–22 Nov. Pp. 221-238.*

Paar, R., Roic, M., Marendić, A. and Miletić, S. (2021). Technological Development and Application of Photo and Video Theodolites. *Appl. Sci.*, *11*(9), 3893; https://doi.org/10.3390/app11093893

Staiger, R. (2023). The Surveyor 4.0: Which Technical Skills are needed today? March, 30th. https://www.gim-international.com/content/article/the-surveyor-4-0?utm_source=newsletter&utm_medium=email&utm_campaign=Newsletter+%7C+GIM+%7C+30-03-2023+++&sid=26844 (Accessed on 01/04/2023)

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CHAPTER 17

Introduction to Basic Computations in Surveying and Geoinformatics

By

IDOWU Timothy Oluwadare

Overview

Surveying can be defined as the art and science of taking land based, sea borne and airborne measurements as well as analyzing the measured quantities to depict the natural and artificial features on the surface of the earth. It aims at producing plan/map to show the features on the earth's surface which can be used for planning and development as well as laying out marks on the earth's surface in such a way that constructions can be carried out correctly, sufficiently and economically using the information on the plan/map. Generally, the work involved in surveying can be categorized into field and office works. The field works involve collection of data which includes carrying out measurements/observations of distances and angles amongst others while office works include computations to prepare the field data for graphical representation, plan/map drawing, keeping office records and so on. The chapter attempts to emphasize on introductory aspect of basic surveying and geoinformatics computations. Though, this aspect is classified as part of office works, it is conventionally referred to as surveying computation instead of office computation. This is because it involves computations carried out for surveying and geoinformatics operation and not all computations are carried out in the office as other minor computations like reduction of angles and distances are randomly carried out in the field to detect the presence of errors, immediately after observations, for on the spot correction.

Objectives

At the end of this chapter, students should be able to:

1. explain the importance of basic computations in surveying and geoinformatics;
2. state applicable rules for effective surveying computations;
3. demonstrate understanding of approximation, significant figure, rounding-off, accurate and inaccurate figures;
4. explain methods of computation and care of computation hardware;
5. identify and explain classes of measurements and the errors associated with measurements;
6. carry out computations based on rectangular coordinate system; and
7. carry out elementary traverse and leveling computations.

Surveying computation

Surveying computation is generally referred to as the numerical calculation required to put the results of field acquired data (measurements) into the form in which they can be used for whatever purpose the surveying and geoinformatics is required (Idowu, 2015). Generally, in order to prevent propagation of errors as computations progresses, simple and effective geometric checks are available and possibly used. Where these are not applicable, the only appropriate check is a complete re-computation of the network. When this happens, the re-computer/checker must be independent of the original computer. In order to reduce computation errors to the barest minimum and for effective

surveying computations, the following rules apply:
(a) Surveying computations should be neatly and uniformly done in ink;
(b) Computations should be well arranged to minimize copying of figures from one sheet to another;
(c) Prepared standard sheets should be used for the computations;
(d) Re-computation must be independent of original computation; and
(e) Different computation sheets used for the surveying network must be properly and serially numbered, indexed and titled.

Approximation
In surveying computation, it may be sufficient, for certain purposes, to use some figures considered to be more important while we ignore the considered less important figures. The more important figures are referred to as approximate values which mean values that are considered closest to true value or most probable values. Therefore, the process of determining the approximate values from the results obtained during surveying computation is called Approximation. This process is employed in surveying and geoinformatics computations with strict precision and under certain rule which states that the number of important figures which can be depended or relied upon in the final result will generally be less than or equal to the least number of important numbers among the numbers employed in the computations.
For instance, 52.234 + 122.1012 = 6377.8

Rounding-off figure
This is the process of ignoring less important or non-significant figures of a given number. In order to do this satisfactorily, it is important to keep to the following rules so that the laws of chance and not personal or computer biases operate (Idowu, 2015):

1. If the computation is to "n" significant figures, the figures from the n^{th} term to the left should be kept as they are if the $(n+1)^{th}$term is less than 5 and the other figures from $(n+1)^{th}$ term to the right should be ignored. That is, **25.6411** to 3 significant figures ⇨**25.6;**
2. If the $(n+1)^{th}$term is greater than 5, the n^{th} term should be increased by one unit and others from
$(n+1)^{th}$ term to the right should be ignored. That is, **25.6811** to 3 significant figures ⇨**25.7;**
3. If the n^{th} term is an even number followed by $(n+1)^{th}$ term which is 5, keep the figures from the n^{th}
term to the left and ignore the figures from $(n+1)^{th}$ term to the right. That is, **25.6511** to 3 significant figures ⇨**25.6;**
4. If the n^{th} term is an odd number followed by $(n+1)^{th}$ term which is 5, increase the n^{th} term by one
unit and ignore others from $(n+1)^{th}$ term to the right. That is, **25.7511** to 3 significant figures ⇨**25.8;**
5. In multiplication and division, the number of significant figures of the product or quotient is equal to
the number of significant figures in the factor or divisor which has the least number of significant figures among the factors or divisors. That is, **4.11** X 2.1123 = **8.68** and **7.23**/3.892 = **1.86; and**
6. In addition or subtraction of figures, the number of significant figures in the sum or difference is equal to the number of significant figures in the numbers entering the sum or difference with

the least number of decimal numbers. That is, **141.11** + 2.1123 = **143.22** and **141.11** – 2.123 = **138.99.**

Significant figure

This is a phase used to indicate the degree of accuracy which takes note of the figures in order of their importance irrespective of whether they are decimal figures or integers. The following rules clearly state how figures of a given number are significant:

a. All non-zero figures are significant. That is, all the figures in **2177.834** are significant.
b. Zero figure which lies between significant figures is significant. That is, the zero in 7**0**77 is significant.
c. Zero figure that lie to the right of the decimal point and at the same time lie to the left of a non-zero figure is significant. That is, the zeros in 412.**0**12 is significant.
d. The significant figure written in scientific notation T x 10^p consists of all the figures expressed solely in T. That is, **22.16 x 10^4** to 3 significant figures ⇨ 22.2 x 10^4.
e. Significant figures are counted from left to right, starting with the left-most non-zero figure. That is, **0414** to 3 significant figures ⇨ 414.
f. The position of a decimal point is not counted when determining the number of significant figures. That is, **413.674** to 4 significant figures ⇨**413.7**.
g. In the case of a decimal fraction which does not follow an integer, the first non-zero number, after the decimal point. is the first significant figure. That is, **0.0433** to 2 significant figures ⇨**0.043**

Accurate and inaccurate figures

An accurate figure is the observed or computed quantity which cannot be changed by the refinement of the observation or computation while any figure that is subject to change is called inaccurate figure. That is, in order to approximate **6677.8341** to 5 significant figures, **6377** can never be changed by any refinement, hence, they are accurate figures. On the other hand, **8** may or may not be changed, hence, **8** is regarded, during approximation, as an inaccurate figure. Therefore, it can be inferred that all accurate figures are significant but not all significant figures are accurate.

Methods of computations

Methods to be adopted in survey computations depend on the expected accuracy of work, number of required significant figures, availability of computation hard ware and electronic power, cost of project, availability of trained personnel, complexity of computation, size of the project and time restriction. The older methods of computations require the use of slide rule, four- figure table and graphical method while the modern methods depend on the use of manually operated calculator, electrically operated calculator, scientific calculator, programmable calculator and computers which is the most recent, faster, more accurate and economical.

Care of computation hardware

1) It is composed of precision electronic components and should never be dissembled;
2) It should not be dropped or otherwise subjected to sudden impact or temperature changes;
3) It should not be stored or left in the areas exposed to high temperature and humidity or dust;
4) Its batteries, where applicable, should not be left in it more than the period specified by the manufacturer;
5) It should be cleaned with a soft, dry cloth or a cloth that has been dipped in a neutral detergent solution; and
6) If malfunction occurs, it should be taken to the nearest dealer or manufacturer.

Measurement

Measurement can be defined as the process of determining the values of unknown physical quantity using appropriate instrument. This involves some elementary operations such as setting, centering, pointing and reading on the appropriate instrumental scales to obtain desired quantities like distances, coordinates, angles, gravities, etc. An observation is a single reading from an instrument to determine the value of a quantity. Therefore, while an observation defines an instant of action, measurement comprises of series of observations that make up the number of sets required to determine the value of a physical quantity. Measurement is subject to variations due to atmospheric (temperature, pressure, etc) effect, natural effect on observer's imperfection in setting, centering, pointing and reading of the instruments and mechanical imperfection of the instrument's limitations which leads to error in unit graduation of the instrument's circle.

Measurements are grouped into three major classes according to:

a. **Type of measured quantity**: These include linear measurement, angular measurement, etc.
b. **The instrument used:** These include chain measurement, theodolite measurement, Global Positioning System (GPS) measurement, etc.
c. **The procedure used:** This leads to direct and indirect measurements. Direct measurements are made by reading off the desired values of the measured quantity on calibrated scales of instrument such as direct reading of distances from linen/steel tapes and direct reading of magnetic bearings of lines from magnetic compass. Indirect measurements are the measurements made on another quantity which is used to obtain the values of the desired quantity. In this case, the value of the desired quantity is obtained from the mathematical relationship between the desired quantity and the measured quantity. Example includes obtaining measured angle between two lines by measuring the angular directions of the two lines using theodolite.

In order to ease representation and ensure uniform calibration standard, measured quantities are represented in specified globally acceptable units. These are generally referred to as Standard International (S I) units. The S I units of samples of different measured quantities in surveying and geoinformatics are presented in Table 1.

Table 1: S I units of samples of measurements

S/N	Measured Quantity	Units
1	Distance (Linear Measurements)	Meters (m)
2	Angles (Angular measurements)	Degrees, Minutes and Seconds
3	Elevations (Heights)	Meters (m)
4	Gravity	Meter per Second per Second (ms^2)
5	Time	Seconds (s)
6	Mass	Kilogram (Kg)
7	Force	Newton (N)

Errors associated with measurements

Error (e) is the difference between the measured value (y) and the true value (t) of the same quantity. It can be functionally represented using equation 1.

$$e = y - t \qquad 1$$

There are three basic types of error associated with measurements. These are gross, systematic and random errors.

Gross error: Also known as blunder or mistake, is caused by inexperience or carelessness of surveying and geoinformatics field party during observations. This may happen as a result of non-centering the instrument on the appropriate station before observation, wrong reading of values from the instrument, wrong booking of read-out instrument values, placing the target on the wrong station, etc. The presence of this error constitutes outlier within the sets of observations and degrade the accuracy of the entire survey process. Therefore, they must be eliminated, when detected, from the set of observations by repeating the entire measurements.

Systematic error: This is the type of error which follow some physical laws, hence, they can be predicted and eliminated from measurements by following appropriate mathematical procedures. That is, it can be mathematically modelled and its effect can be computed and removed from the measurements. Temperature error is an example of systematic error in distance measurement. This happens when the field temperature is different from the temperature recommended by the manufacturer for the use of the instrument (steel tape) to measure distance. The systematic error (e_S) introduced in the measured distance (y_1), due to the temperature change (T), can be computed and removed from the measured distance using equations 2a and 2b.

$$e_S = y_1CT \quad \text{2a}$$

$$y = y_1 \pm e_S \quad \text{2b}$$

Where: C = coefficient of linear expansion, y_1 = Measured distance at field temperature and y = Actual distance at standard temperature.

Example

The distances of a survey line, measured two times with a chain at field temperatures 25^0 and 29^0 were found to be 38.786m and 38.784 respectively. What will be the actual distance of this line at standard temperature 27^0 given the coefficient of linear expansion as 0.0000112per^{0}c?

Solution

Distance (y) at standard temperature 27^0 (T_1) is required.

At temperature 25^0 (T_2), Temperature change (T) = $T_2 - T_1 = 25^0 - 27^0 = -2^0$

e = 38.786 x 2 x 0.0000112 = - 0.001m

Therefore, actual distance (y) at 27^0 = 38.786 - 0.001 = 38.785m

At temperature 29^0 (T_2), Temperature change (T) = $T_2 - T_1 = 29^0 - 27^0 = 2^0$

e = 38.784 x 2 x 0.0000112 = 0.001m

Therefore, distance at 27^0 = 38.784 + 0.001 = 38.785m

As a general rule for the application of equation 2b, if T_1 is greater than T_2 then, e_S should be subtracted from y_1 to obtain y. On the other hand, if T_1 is less than T_2 then, e_S should be added to y_1 to obtain y.

Random error: This is the remaining part of error in the observation after the gross and systematic errors have been eliminated. In general, they are considered to be the result of natural and unavoidable instrumental and human imperfections. It is usually small in magnitude with unpredictable direction. That is, it has equal probability of being negative and positive. Therefore, they cannot be mathematically modelled and eliminated but can only be reduced to the barest minimum according to the laws of probability. Example of this error includes non-centeredness of the instrument bubble at an instant of observation even though the bubble might have been well centered, slight deviations in the centering of an instrument from the station mark and small approximation errors in reading graduated scale of the instrument during observation.

True Value, Most Probable Value, Residual, Precision and Accuracy

True value: It is the theoretically correct or exact value of a physical quantity as defined in equation 1. **Most Probable Value (MPV):** It is the value that has the highest probability of representing the true value of a measured quantity. It is usually derived from some samples considered to be of good representation of but not the entire population.

Residual (v): It is the difference between measured quantity (y) and the MPV for that quantity (y_{MPV}). It can be functionally expressed as shown in equation (3).

$$v = y - y_{MPV} \quad (3)$$

Precision: It is the degree of closeness of repeated measurements of the same quantity to one another. **Accuracy:** It is the degree of closeness of the measured quantity to the true value of the same quantity.

Rectangular coordinates system

Surveying and geoinformatics is concerned with the determination and representation of relative positions of points on, above or below the earth's surface. Therefore, the coordinate system used to define these positions is of great importance and must be chosen to provide an adequate resemblance to the physical reality. In general, the simpler the system, the more limited is its application. One of these coordinate systems, which happen to be the simplest is rectangular coordinate system. It defines the position of a point with respect to reference lines known as the axes of coordinates and the point of intersection of these lines is referred to as the origin of coordinates system as shown in figure 1. Therefore, X_p and Y_p are the X and Y rectangular coordinates of P respectively.

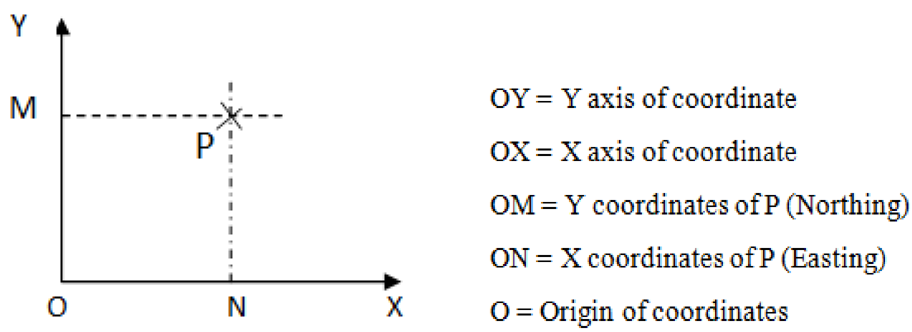

Figure 1: Axes of rectangular coordinates

<u>P lies in</u>	<u>Signs of coordinates</u> X	Y	<u>Limit of bearing</u>
1st quadrant	+ve	+ve	$00^0 - 90^0$
2nd quadrant	+ve	-ve	$90^0 - 180^0$
3rd quadrant	-ve	-ve	$180^0 - 270^0$
4th quadrant	-ve	+ve	$270^0 - 360^0$

Bearing

This is the angle between the survey line and the reference line (direction). True bearing (azimuth) is the angle between the survey line and the geographical meridian while magnetic bearing is the angular difference between the survey line and the magnetic meridian. Also, if the reference direction is tangent to the geographical meridian, that is, pointing to the grid north, the bearing obtained is called grid bearing. Therefore, it can be inferred that:

True bearing (Azimuth) = Grid bearing ± Convergence

True bearing = Magnetic bearing ± declination

Bearing can be classified into **whole circle bearing** which is defined as the bearing obtained directly on a continuously graduated circle as fitted into the angular instrument and **reduced bearing** is the angle between the main vertical line marking the direction to which bearings are referred and the survey line. It is usually measured from 0^0 - 90^0, east or west and north or south of the point to the survey line. As an illustration, if the whole circle bearing:

1) is between 0^0 - 90^0, the reduced bearing is the same as the whole circle bearing.

2) lies in the 2nd quadrant between 90^0 and 180^0, the reduced bearing is 180^0 minus whole circle bearing.

3) is in the 3rd quadrant, between 180^0 and 270^0, the reduced bearing is whole circle bearing minus 180^0.

4) lies in the 4th quadrant, between 270^0 and 360^0, the reduced bearing is 360^0 minus whole circle bearing.

Two types of bearing (forward and backward bearings**)** are usually referred to during surveying network computations. That is, given line AB as shown in figure 2, the bearing of AB is called forward bearing while that of BA is called backward bearing. The relationship between the two bearings can be functionally stated as shown in equation 4.

Bearing BA = Bearing AB ± 180^0. 4

If Bearing AB > 180^0, then Bearing BA = Bearing AB - 180^0

If Bearing AB <180^0, then Bearing BA = Bearing AB +180^0.

Figure 2: Surveying line connecting points A and B.

Latitude and Departure

Latitude is the difference in northing coordinates while departure is the difference in easting coordinates between two surveying stations. There are two methods of computing latitude and departure of a survey line depending on the available data.

a. Given that the bearing and distance of line AB are α and L respectively, Latitude (AB) = L cos α while Departure (AB) = L sin α.
b. Given that the coordinates of stations A and B are (X_A, Y_A) and (X_B, Y_B) respectively, Latitude (AB) = Y_B - Y_A while Departure (AB) = X_B - X_A.

Computation of coordinates of survey station (forward computation).

Given the coordinates of station A as (X_A, Y_A), measured distance and bearing of line AB as L and α respectively, the coordinates of station B can be computed as:

$X_B = X_A + L \sin \alpha$

5a

$Y_B = Y_A + L \cos \alpha$

5b

Example: Given the following data: coordinates of A = (432.40, 611.50)

Distance AB (L) = 217.20m and Bearing AB (α) = 311^0 36' 00"

Calculate the latitude and departure of AB and hence the coordinate of B.

Solution:

Latitude AB = L cos α = 217.20 cos 311^0 36' 00" = 144.205

Departure AB = L sin α = 217.20 sin 311^0 36' 00" = -162.422
Coordinates of B = $X_B = X_A + L \sin \alpha$ = 269.978
$Y_B = Y_A + L \cos \alpha$ = 755.705

Computation of departure, latitude, bearing and distance given coordinates of two stations (back computation.
Given the coordinates of two stations A and B as (X_A, Y_A) and (X_B, Y_B) respectively, the latitude, departure, distance and bearing of line AB can be computed as follows:

Latitude (AB) $= Y_B - Y_A$ 6a

Departure (AB) $= X_B - X_A$ 6b

Distance (AB) $= [(X_B - X_A)^2 + (Y_B - Y_A)^2]^{1/2}$ 6c

Bearing (AB) $= \tan^{-1}\left(\dfrac{X_B - X_A}{Y_B - Y_A}\right)$ 6d

Example:
Given the coordinates of A and B as: A = (691.70, 312.30) and B = (332.20, 591.10) respectively, compute the latitude, departure, distance and reduced/whole circle bearing of line AB.

Solution:
Latitude (AB) = 591.10 – 312.30 = 278.80
Departure (AB) = 332.20 – 691.70 = -359.50
Distance (AB) = $[(-359.50)^2 + (278.80)^2]^{1/2}$ = 454.939m
Bearing (AB) = $\tan^{-1}\left(\dfrac{-359.50}{278.80}\right)$ = - 52^0 12' 24". This is the **Reduced Bearing**
The bearing obtained is in the 4^{th} quadrant, therefore, the **Whole Circle** bearing = 360^0 - 52^0 12' 24" = 307^0 47' 36".

Traversing
This is the process that leads to the series of connected straight lines whose bearings and distances are known. The figure formed by these connected straight lines, as shown in figures 3a, 3b and 3c, is referred to as traverse or traverse network. The three types of traverse are close loop, close non-loop and open traverses. Close loop traverse is a traverse that starts from a known (coordinated/control) point and ends on the same point, close non-loop traverse starts from a known point and ends on another known point while open traverse starts on a known point but ends on unknown (uncoordinated/non-control) point as shown in figures 3a, 3b and 3c respectively. In the figures below, the triangular symbol representing points "**A** and **E"** in figure 3b and points **"A"** in figures 3a and 3c indicates known points while the circular symbol representing point **"E"** in figure 3c indicates unknown point.

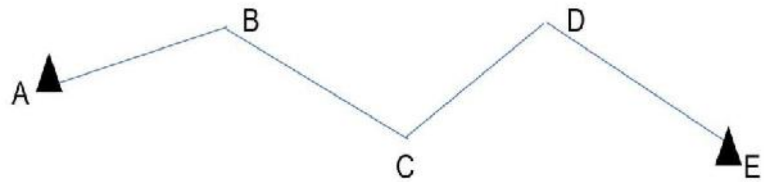

Figure 3b: Close non-loop traverse

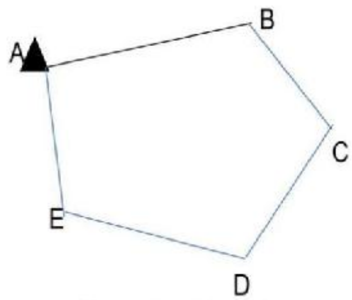

Figure 3a: Close loop traverse

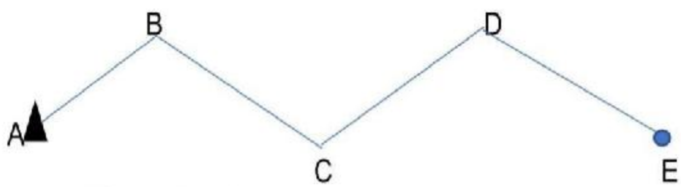

Figure 3c: Open traverse

Traverse computation

From figures 3a, 3b and 3c, station A is the known/control/coordinated point with X_A, Y_B as coordinates. Bearings of AB, BC, CD and DE are: α_1, α_2, α_3 and α_4 respectively. Also, the corresponding distances are L_1, L_2, L_3, and L_4. The coordinates of other traverse points are computed as follows:

$X_B = X_A + L_1 \sin \alpha_1$
$Y_B = Y_A + L_1 \cos \alpha_1$
$X_C = X_A + L_1 \sin \alpha_1 + L_2 \sin \alpha_2$
$Y_C = Y_A + L_1 \cos \alpha_1 + L_2 \cos \alpha_2$
$X_D = X_A + L_1 \sin \alpha_1 + L_2 \sin \alpha_2 + L_3 \sin \alpha_3$
$Y_D = Y_A + L_1 \cos \alpha_1 + L_2 \cos \alpha_2 + L_3 \cos \alpha_3$
$X_E = X_A + L_1 \sin \alpha_1 + L_2 \sin \alpha_2 + L_3 \sin \alpha_P + L_4 \sin \alpha_4$
$Y_E = Y_A + L_1 \cos \alpha_1 + L_2 \cos \alpha_2 + L_3 \cos \alpha_P + L_4 \sin \alpha_4$

Therefore, the general formula for an arbitrary point P can be given as:

$X_P = X_A + L_1 \sin \alpha_1 + L_2 \sin \alpha_2 + L_3 \sin \alpha_P + L_4 \sin \alpha_4 + \ldots\ldots\ldots + L_P \sin \alpha_P$ 7a

$Y_P = Y_A + L_1 \cos \alpha_1 + L_2 \cos \alpha_2 + L_3 \cos \alpha_P + L_4 \cos \alpha_4 + \ldots + L_P \cos \alpha_P$ 7b

Area computation of a close loop traverse

During close loop traverse computation, the coordinates of the traverse points (junctions of the connected sides of a straight-sided figure) are computed. These coordinates can be used to compute the area enclosed by the traverse lines. This procedure is referred to as cross-coordinate method (Olugbemi, 2014).

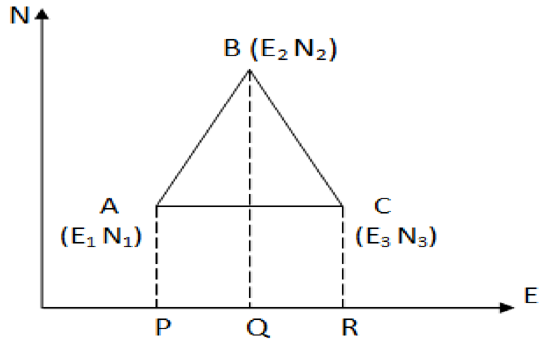

Figure 4: Showing close loop traverse defined by triangle ABC

Figure 4 shows a three-sided clockwise traverse ABC whose area is required. That is, from the figure 4, it can be inferred that: Area ABC = Area ABQP + BCRQ – Area ACRP.

ABQP, BCRQ and ACRP are trapezia, hence their areas can be computed using the formula for computing the area of a trapezium. That is: Area of trapezium = (mean of the parallel heights x perpendicular width).

Therefore, Area ABC = $\frac{1}{2}(N_1 + N_2)(E_2 - E_1) + \frac{1}{2}(N_2 + N_3)(E_2 - E_3) - \frac{1}{2}(N_1 + N_3)(E_3 - E_1)$

Area ABC = $[N_1E_2 - N_1E_1 + N_2E_2 - N_2E_1 + N_2E_3 - N_2E_2 + N_3E_3 - N_3E_2 - N_1E_3 + N_1E_1 - N_3E_3 + N_3E_1]/2$

$= [N_1E_2 + N_2E_3 + N_3E_1) - (E_1N_2 + E_2N_3 + E_2N_1]/2$

This can be used for a figure containing "n" sides and the general formula for that can be given as stated in equation 8.

Area = $[N_1E_2 + N_2E_3 + N_3E_4 + \ldots.. + N_{n-1}E_n + N_nE_1) - (E_1N_2 + E_2N_3 + E_3N_4 + \ldots + E_{n-1}N_n + E_nN_1]/2$

8

Example:

Compute the area of a close loop traverse with figure PQRST using the following coordinates:

P	136.200E(m)	109.900N(m)
Q	210.400	283.500
R	232.100	208.600
S	198.700	155.400
T	215.400	122.100

Solution:

P	136.200E(m)	109.900N(m)	Station 1
Q	210.400	283.500	2
R	232.100	208.600	3
S	198.700	155.400	4
T	215.400	122.100	5
P	136.200	109.900	1

Area = [(109.900 x 210.400) + (283.500 x 232.100) + (208.600 x 198.700) + (155.400 x 215.400) + (122.100 x 136.200)]/2-[(136.200 x 283.500) + (210.400 x 208.600) + (232.100 x 155.400) + (198.700 x 122.100) + (215.400 x 109.900)]/2

= [(23,122.96 + 65,800.35 + 41,448.82 + 33,473.16 + 16,630.02) – (38,612.70 + 43,889.44 + 36,068.34 + 24,261.27 + 23,672.46)]/2
= [180,475.31 – 166,504.21]/2
= 6,985.55 m^2

Computation of omitted dimension(s) in a close traverse

A close traverse, that is, traverse that closes back to its starting point or another known point, will have two (initial and final) sets of coordinates for the closing point. These coordinates can be represented as ($E_{INITIAL}$, $N_{INITIAL}$) and (E_{FINAL}, N_{FINAL}). During traverse observations, if a maximum of two dimensions of the traverse legs are omitted (not observed/measured), they can be computed based on the assumption that other measured dimensions are free from gross and systematic errors. This can be achieved by solving the following two equations simultaneously to determine the values of maximum of two unknown/omitted dimensions.

$L_1 \sin \alpha_1 + L_2 \sin \alpha_2 + L_3 \sin \alpha_3 + \ldots\ldots\ldots\ldots + L_{LAST} \sin \alpha_{LAST} + = E_{INITIAL} – E_{FINAL}$ 9a

$L_1 \cos \alpha_1 + L_2 \cos \alpha_2 + L_3 \cos \alpha_2 + \ldots\ldots\ldots + L_{LAST} \cos \alpha_{LAST} + = N_{INITIAL} - N_{FINAL}$ 9b

Example:

Using the data of a close loop traverse given below, compute the missing distances of lines BC and CD given that the first and last coordinates of A are the same.

Line	Lengths	Bearings
AB	344	$14^0\ 31^/$
BC	-	$319^0\ 42^/$
CD	-	$347^0\ 15^/$
DE	300	$5^0\ 16^/$
EA	1958	$168^0\ 12^/$

Solution:

From equations 9a and 9b, it can be shown that:

$344 \sin 14^0\ 31^/ + L_2 \sin 319^0\ 42^/ + L_3 \sin 347^0\ 15^/ + 300 \sin 5^0\ 16^/ + 1958 \sin 168^0\ 12^/ = 0$

$344 \cos 14^0\ 31^/ + L_2 \cos 319^0\ 42^/ + L_3 \cos 347^0\ 15^/ + 300 \cos 5^0\ 16^/ + 1958 \cos 168^0\ 12^/ = 0$

$86.228 - 0.647L_2 - 0.221L_3 + 27.537 + 400.403 = 0$

$333.018 + 0.763L_2 + 0.975L_3 + 298.733 - 1,916.622 = 0$

$0.647L_2 + 0.221L_3 = 514.168 \quad \Rightarrow L_2 = 794.695 - 0.342L_3$

$0.763L_2 + 0.975L_3 = 1,284.871 \quad \Rightarrow L_2 = 1,683.972 – 1.278L_3$

$794.695 - 0.342L_3 = 1,683.972 – 1.278L_3 \Rightarrow 1.278L_3 - 0.342L_3 = 889.277$

$L_3 = 950.029$

Since, $L_2 = 794.695 - 0.342L_3 \quad \Rightarrow L_2 = 794.695 - 0.342(950.029) \Rightarrow L_2 = 469.785$

Leveling

This is the procedure for the determination of elevation/height difference between two survey points. That is, if the height of a survey point A is known, through leveling from A, the height of another point B can be determined. It is particularly useful in the determination of topography of the earth's surface.

Definition of leveling computation terms:

RL_A = Reduced level or Height of point A
RL_B = Reduced level or Height of point B

BS = Back site is the observation taken to the target at the back of instrument
FS = Fore site is the observation taken to the target (change point) in front of the instrument
IS = Intermediate site is the observation taken to a target between the position of instrument and change
point.

During leveling, point A is the starting point with known RL_A, Instrument is set on point (R), the first observation (BS) is taken to target set on A, the next observation (IS) is taken to target set on (Q) and the final observation (FS) is taken to target set on point (B). This process leads to the determination of RL_B. In order to determine RL_C, the instrument is moved to point (H) and the observation (BS) is taken to point B, the next observation (IS) is taken to point (K) while the final observation (FS) is taken to point C for the determination of RL_C. Points B and C, where fore sites are observed are called change points. This is because after carrying out these observations, the instrument must change position.

Figure 5: Leveling lines

Leveling computation:

Two methods are generally used for this computation. These are Height of Instrument and Rise and Fall methods. However, this chapter considers the treatment of only the Height of Instrument method. This involves the following three steps:

$R.L_A + B.S = H.I$
$H.I - I.S = RL_Q$
$H.I - F.S = RL_B$

Also, $R.L_B + B.S = H.I$
$H.I - I.S = RL_K$
$H.I - F.S = RL_C$

The process continues with the determination of reduced levels of Q, B, K and C as shown in table 1.

Table 1: Sample leveling computation.

B.S	I.S	F.S	H.I	R.L	Station
2.390			33.907	31.517	A
	1.985			31.922	Q
0.988		1.612	33.283	32.295	B
	1.502			31.781	K
2.420		0.316	35.387	32.967	C

Summary

This chapter has provided the definition and importance of surveying computations in surveying and geoinformatics. It has highlighted the necessary rules for effective and reliable surveying computations. Description and applications of important terms such as approximation, significant figure, rounding-off, accurate and inaccurate figures have been provided. Also, the methods of computations and care of computation hardware were fully explained. Identification and explanation of classes of measurements and the errors associated with measurement have been achieved. Furthermore, all the computations carried out were based on rectangular coordinate system. The chapter concluded with the detailed explanation of the procedure involved in latitude, departure, distance, bearing, leveling and traverse computations using series of sample questions and solutions.

Exercise

1. State the importance and basic rules for effective surveying computations
2. Briefly explain the factors that determine the chosen method of computation and care of computation devices.
3. Write short notes on the following: (a) Measurement and its associated errors, (b) Precision, accuracy and significant figure.
4. Correct the following figures to 3 significant figures: (a) 88.455×10^3, (b) 4231. 642 and (c) 52.234 x 122.1012.
5. Convert the following whole circle bearings to reduced bearings:
   (a) $89^0\ 55^{/}\ 40^{//}$ (b) $91^0\ 37^{/}\ 40^{//}$ (c) $270^0\ 00^{/}\ 00^{//}$ (d) $90^0 00^{/} 00^{//}$
6. The distance of a survey line, measured with a chain of standard temperature 27^0, was found to be 50.000m. What will be the distance of this line at field temperature 30^0, given the coefficient of linear expansion as 0.0000112per^{0}c?
7. Given the coordinates of points A, B and C as shown below. Compute the distances and bearings of lines BA, BC and AC.

A	26141.60E	10862.10N
B	19329.80	13995.50
C	21943.60	12061.70

8. Using the data of a close loop traverse given below, compute the missing distance and bearing of lines BC given that the initial and final coordinates of A are the same.

Line	Lengths	Bearings
AB	344	$14^0\ 31^{/}$
BC	-	-
CD	900	$347^0\ 15^{/}$
DE	300	$5^0\ 16^{/}$
EA	1958	$168^0\ 12^{/}$

9. The following is a series of leveling observations taken in sequence starting and finishing on the same bench mark with reduced level of 25.000.
   4.907 <u>4.632</u> 0.517 2.671 <u>1.745</u> 1.956 3.998 4.098 <u>1.0000</u>. The instrument position was changed immediately after the underlined readings. Compute the reduced levels of the change points using Height of Instrument method.

References

Anderson, J. M. and Mikhail, E. M. (2018). Surveying: Theory and practice. McGraw-Hill Education.

Ezeigbo, C. U. (2022). Fundamentals of surveying and geoinformatics (with applications to special surveys). Published by El 'Demak.

Idowu, T. O. (2015). Lecture notes on surveying computations.

Idowu, T. O. (2012). Lecture notes on introduction to surveying and geoinformatics.

Kanetkar, T. P. (2008). Surveying and levelling. Everest Publishing House.

Kavanagh, B. F. (2012). Surveying: principles and applications. Prentice Hall.
Kavanagh, B. F. and Mastin, T. (2010). Surveying: Principles and applications. Prentice Hall.
Olugbemi, J. O. (2014). Numerical problems and solutions in land surveying. Published by MINDSECT communication ventures, Ikeja, Lagos, Nigeria.
Uren, J. and Price, B. (2010). Surveying for Engineers, 5th edition. Published by Palgrave Macmillan, UK.
US Army (2001): Field manual on topographic surveying. Published by Headquarter of Department of Army, Washington DC.

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CHAPTER 18

Definition, Historical Development, Principles and Branches of Surveying and Geoinformatics

By

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Overview

Surveying and Geoinformatics are synonymous in meaning. As a profession, surveying and geoinformatics have contributed immensely to the development of humanity and it is needed in every aspect of life and human development. It is the art, science and technology of measurements, observations, processing analysis and management of geodata. The art, science and technology of surveying and geoinformatics deal with obtaining information about objects and environments directly by physical contact or indirectly without being in physical contact or both, depending on the methods being adopted, the extent of work, location, purpose and expected outcome of the job. Historically, Surveying is as old as civilization and religiously, surveying has been recognized in the scriptures. Legally, surveying is one of the foremost professions to be regulated. Socially, surveying is synonymous with development and civilization. When civilization was only on land, various land surveying methods existed. When the ship was invented and moved to the sea, hydrographic surveying methods were developed to capture data. When civilization moved to air with the invention of aeroplane, photogrammetry methods were developed using aerial cameras. In contrast, before civilization moved to space, sun and stars had been used to control surveying works. When the satellite was invented and launched into space, remote sensing satellites were also manned to capture data. Also, Global Navigation Satellite System was in space for positioning and timing Information. The advent of computers and information technology has also brought various other methods like Geospatial and other Information systems. The innovation of the fourth industrial revolution of Artificial Intelligence, robotics, the Internet of Things, and virtual and augmented reality. Researchers and other professionals in surveying geoinformatics and other geospatial disciplines have applied these technologies in solving real-life problems. Surveying and geoinformatics methods, using physical methods are found in some branches, depending on the project. Non-physical contact could be done using low-altitude aeroplanes (Photogrammetry) – mainly by aerial photography and high-altitude satellite (remote sensing). Photogrammetry and remote sensing provide professional with imagery for metric measurements and interpretive analysis. That is the regular measurement of spatial and spectral information. The branches of surveying and geoinformatics involve physical and non-physical contacts in geodesy, hydrographic and cartography.

Objectives

At the end of this chapter, students should be able to:

1. define surveying and other related terms;
2. enumerate the historical development of surveying and geoinformatics;
3. discuss the principles of surveying and geoinformatics;
4. explain the branches of surveying and geoinformatics;
5. identify the qualities of surveyors;

6. justify the relationships between surveying and geoinformatics disciplines; and
7. identify employment opportunities in surveying and geoinformatics.

Definitions

Surveying is the art or science of measuring, determining, depicting or representing the dimensions, extent, features or relative positions of the earth's surface and representing it on a map, plan or chat. (Ogbebor, 2023). Surveyors are the only professionals legally and statutorily empowered to carry out surveying exercises on any or all parcels of land in Nigeria, with a view to determining its identity, location, size, shape, boundaries, area and description as well as producing the plan thereof and collect fees. A surveyor is a person with the academic qualification and technical expertise to determine, measure and represent three-dimensional objects, point fields and trajectories above or below the surface of the land, the sea and any structure therein. Geoinformatics is coined from two words, 'geo' meaning earth and 'informatics', defined as the study of the structure, behaviour and interactions of natural and engineered computational systems. Informatics studies the representation, processing and communication of information in natural and engineered systems. Geoinformatics is the science and the technology which develops and uses information science infrastructure to acquire, store, retrieve, manipulate, integrate display and address geospatial problems.

Historical Development

Historically, the science of surveying dates back to 2700BC in Egypt (the cradle of civilization) with the construction of the great pyramid at Khufu in Giza. It was so accurately square and perfectly oriented to the cardinal points of the compass. The earliest agricultural settlements along the Nile River used Cadastre for taxation purposes. Also, the Greeks and Romans used land records to support land taxation since 320 AD.

Summarian culture, which lasted till 1720 BC, showed the advancement of surveying. The origin of modern cadastre was traced to Italy in 1720BC with the Milanese cadastral mapping program in Milan, Italy which involved using a map on the scale of 1:2000. The Astro-Hungarian monarchy ordered a cadastral surveying of the territory in 1786. Also, Napoleon in France initiated a cadastral surveying for taxation and land assessment purposes as far back as 1807. The first documentation about the earth's figure is ascribed to Thales of Miletus (625-574 BC), who regarded the earth as a disc-like body floating on an infinite ocean. Thales is commonly recognized as the founder of trigonometry. Anaximander felt the earth was cylindrical with an axis oriented in the east-west direction. In 580-500 BC, the school of Pythagoras believed that the earth was like a globe. Eratosthenes, known as the founding father of geodesy, postulated spherical earth and therefore determined the size of the earth and gave 5,950km as the radius of the earth. In 1670, the French clergyman Picard made the first modern measurement of the size of the earth. His result was 6275km as the radius of the earth. Others like Newton, Cassin, Gauss and Legendre have worked extensively to get better shape and size of the earth as well as other relevant theories of geodesy being applied nowadays.

Religiously, evidence of Surveying has been found in the scripture. From the Biblical point of view, Deuteronomy 19:14, King James Version, says “Thou shalt not remove thy neighbour's landmark, which they of old time have set in thine inheritance, which thou shalt inherit in the land that the LORD thy God giveth thee to possess” and Proverb 22:28 says “Do not remove the ancient landmark which your fathers have set”. Also, from an Islamic point of view, great punishment awaits whoever changes boundaries or forcefully acquires the landed property. “It is He, who made the earth subservient to you. So, traverse in its tracks and partake of the sustenance He has provided. To Him will you be resurrected? (Quran 67:15). Abdullah ibn Omar (RA) narrated from the Prophet Muhammad (PBUH) saying, "Whoever unlawfully acquires a piece of land Allah will cause the earth to sink him down to the seventh earth on the Day of Judgement. (Hadith recorded by Bukhari.

Legally, in Nigeria, surveying was one of the professions that were regulated with Colonial Ordinance No. 10 of 1897, establishing the Surveyors Licensing Board (SLB). Surveying then was exploratory in nature for opening up the country, acquisition of private and government properties and systematic colonization by the colonialists. SLB of 1897 has metamorphosized into the present Surveyors Council of Nigeria (SURCON). Also, the Nigerian Institution of Surveyors (NIS), a Non-Governmental Organization and professional social club was founded in 1934 as Licensed Surveyors Association. No other professional association in Nigeria has such a long history.
Educationally, in Nigeria, the Federal School of Surveying, Oyo, was founded in 1908, perhaps the oldest institution of higher learning in Nigeria. The Regional Centre for Training in Aerospace Surveys (RECTAS), now African Regional Institute for Geospatial Information Science and Technology (AFRIGIST), was created in 1972 under the auspices of the United Nations Economic Commission for Africa (UNECA) with a mandate for training, research, consultancy and advisory services in geoinformatics with sixteen participating countries cited on the campus of Obafemi Awolowo University, Ile Ife, Osun State, Nigeria. Several other institutions have been founded with surveying and geoinformatics as one of the departments.

Methods of surveying and geoinformatics and civilization

When the civilization was only on land, various land surveying methods existed such as taping, traversing, triangulation, trilateration, field astronomy and geodesy. When the ship was invented and moved to the sea, hydrographic surveying methods such as bathymetry, dredging, coastal management and others were developed to capture data. When civilization moved to air with the invention of aeroplane, photogrammetry methods were developed using aerial cameras. In contrast, before civilization moved to space, sun and stars had been used to control surveying works. When the satellite was invented and launched into space, remote sensing satellites were also manned to capture data. Also, Global Navigation Satellite Systems (GNSS) were in space for positioning, navigation and timing information. Also, the advent of computers and information technology has brought various other methods like geospatial and other information systems. The innovation of the fourth industrial revolution of artificial intelligence, robotics, the Internet of Things and virtual and augmented reality. Researchers and other professionals in surveying and geoinformatics and other geospatial disciplines have applied these technologies to solve real-life problems. Machine learning and artificial intelligence have been used to solve erosion, coordinate transformation, geoid and quantify geographical variations of solid earth tidal effects in hydrographic surveying.

Surveying, geoinformatics and digital technology

Digital technology came as a result of the exploitation of computer and Information Technology (IT). Though, the origin of IT could be traced to the invention of electromagnetism by Maxwell, the invention of the electronic thermionic diode valve in 1948 gave us the hope of telecommunication and computer application in surveying and geoinformatics improved. In the 1950s, British Botanists produced 2,000 maps of an atlas of flora and faunal using the computer. By the late 1950s, geologists, geophysicists and other professionals used computer for mapping. The introduction of modular programming language in the 1960s gave another outlook to mapping as programmers moved away from monolithic programs to modular programs. These programs can perform data analysis and manipulations to produce choropleth and isoline maps. Also, they have the ability to overlay data sets and eliminate the need for transparency. In this period, Computer Assisted Mapping (CAM) was developed, increasing the map production rate, but map data were still being kept in analogue format. In the late 1960s, the

Canadians developed a continent-wide Geographic Information System (GIS) called the Canadian GIS. They developed thematic maps based on agriculture, forestry, wildlife, recreation capabilities, census attributes and land use. Along the same direction, the United States Census Bureau developed the Dual Independent Map Encoding System (DIMES) which links attribute data collected during census exercises to geographical or spatial data. By 1974, computer mapping had been shifted from displaying maps alone and the term GIS was widely accepted as the generic name for the new application. In the 1980s, Data Base Management System (DBMS) put the finishing touches to digital mapping through its application in the spatial domain and its linkage to Computer Assisted Drafting (CAD) and CAM. In 1985, the 5th General Assembly of the Commonwealth Association of Surveying and Land Economy (CASLE) held in Kuala agreed that a text should be prepared on Land Information System (LIS) for the need of policy makers and land administration specialists and introduction of LIS in developing countries. This led to the publication of a book titled "Land Information Management by P. F. Dale and J. D Mclaughlin in 1988. The University of Calgary, in 1992, brought the idea of combining GIS, Global Positioning System (GPS), digital mapping, remote sensing and other modern technologies and techniques into a course. That led to the adoption of the name “Geomatics”. The United Nations Regional Cartographic Conference held in Addis Ababa in 1996 encouraged member countries to establish GIS in their countries. As methods are being developed, so also improvements in equipment.

Nomenclature

After several years of professional development, training and practice, the surveyors started looking for another name because the services continue to widen in scope to include all the developments taking place with civilization. Also, the younger generation of surveyors wants a new name because of the image, some personalities have been created for the profession due to bad practices. The name does not attract new intakes into the profession for too much work with very little income. The profession has suffered so much at the hands of policy makers and some view the change as typical of the trends in other countries. To proffer a solution to these pertinent challenges, several names were proposed before adopting surveying and geoinformatics to keep the name the same for fear of difficulties in changing the constitution as surveying has been legalized (Aleem, 2002).

Basic principles of surveying

The basic principles of surveying are as follows: Working from whole to parts, consistency of work, independent check, accuracy, location of a point and economy.

The principle of working from ‘whole to parts: The first basic principle of surveying is ‘working from whole to parts: This is to ensure proper planning with adequate provision of controls so that the area to be surveyed is adequately covered. It should be done in such a way that the framework of the survey area should be covered with the establishment of controls. The primary controls should be first established with sophisticated, refined and advanced equipment and method to attain the high precision and accuracy expected of primary controls. The primary control will serve as a skeleton or framework to which all other controls will hang. The primary controls are densified to have secondary controls which are less accurate than primary controls. The secondary controls are further densified to tertiary controls with less accuracy than secondary controls. All surveying jobs must be connected to the existing controls, which must either be higher or in the same order as the new job. For example, a second-order work should be tied to a first-order or second-order control, never to a third-order control. This principle will prevent undue accumulation of errors and limit minor errors in lower-order controls.

Reconnaissance

Reconnaissance can be divided into two. These are field and office reconnaissance. It involves a site visit and cursory examination of the area in order to:
1. know the best way to meet the given specification;
2. know the nature of terrain;
3. carry out the job with refined equipment and method; and
4. assess the likely problem(s) to be encountered during the execution of the job;
5. identify features (both natural and artificial) in the area;
6. identify the points to be used for station marks, considering the physical stability on the ground, intervisibility and accessibility, depending on the type of surveying and method to be used; and
7. draw the recce diagram;
8. monument every change in the direction of the survey area and should be demarcated using precast concrete beacons constructed using sharp sand, gravel and cement in the ratio of 3:2:1 respectively. The dimension of the pillar varies according to the order of the work as detailed in the specifications;
9. determine the instruments to be used; and
10. move the equipment and personnel to the site.

Office reconnaissance

This includes preparation of field sheets or collection of field books, collection of coordinates of control, designing of Triangulation network on the topographical map, selection of equipment, charging of battery for electronics instruments and any other work regarding the planning for field exercises.

Field reconnaissance

Site visitation, boundary demarcation, search for the controls, station marking and monumentation, initialization of electronic instruments, recce diagram, in-situ check Instruments test (depending on the type of survey and method to be used), and other activities relating to planning done on-site.

Principle of the location of a point

The principle requires the location of the desired point to be surveyed should be fixed by taking measurements or observations from a minimum of two points of reference, such that the position of control or reference point has already been fixed.

Principle of consistency

The principle expects consistency in the method, equipment, reading and noting observations, observers (personnel) etc. It must be noted that consistency aids in gaining the desired level of accuracy.

Principle of independent check

The principle requires that all measurements and observations must be checked to confirm that the measurements taken are correct and devoid of errors and/or mistakes. Re-check may be done by adopting a suitable method of the independent field test so that mistakes can be noticed before leaving the station.

Principle of accuracy

In any survey job, specifications should be used to attain a required degree of accuracy. The specifications may include but are not limited to methods, instruments, and records. These must be followed to attain the required accuracy for a specific order and type of work. In Nigeria, the specifications are regulated, produced and reviewed from time to time by the Surveyors Council of Nigeria (SURCON)

Principle of economy
The survey business is capital and manpower intensive. Hence, there is a need to keep the economic minimum. In executing the project, proper planning will reduce the cost of execution and increase the profit. The specification for all survey products is achieved by working from 'the part to the whole' The specification for the control may be derived from estimation based upon experience using knowledge of survey methods to be applied, the instruments to be used and the capabilities of the personnel involved. Such a specification defines the expected quality of the output by defining the quality of the work that goes into the survey.

Branches surveying and geoinformatics
The branches of surveying and geoinformatics include, but are not limited to, cadastral surveying, geodesy, hydrographic surveying, geophysical surveying, photogrammetry, remote sensing, cartography, geospatial/ geographic information system.

Cadastral surveying
This involves the establishment and re-establishment of real property boundaries. That is the physical delineation of property boundaries and determination of dimensions, areas and specific rights associated with properties. Cadastral surveying deals with the measurement of a parcel of land to determine the ownership, location, size, shape, boundaries, description and features; analysis of acquired data and production of a plan.
There are two types of cadastral surveying. These are:

1. **The title-based cadastral surveying**: It is for determination of right and ownership of the property.
2. **Forensic cadastral surveying**: This is carried out during dispute for the production of dispute or counter or composite plan/map.

The cadastral plan should contain details such as plan number, pillar numbers, date, name of the surveyor that prepared the plan and the coordinates of the first pillar. This is used, among others, as a registrable instrument in a court of law. "quic quid plantator solo solocedit" means, he who owns the land owns whatever is attached to it.

Cadastre
Closely and often taken to mean the same as cadastral surveying is the word 'cadastre'. It is a parcel-based, complete and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It is the core or basis of a land administration system. Cadastre is a land information system, usually managed by one or more government agencies. Since many different users often need information about land parcels, a unified cadastre helps avoid duplication and facilitates the efficient exchange of information.

GIS is geospatial information study
It is a system designed to capture, input, store, manipulate, analyze, manage, and present all types of geographically referenced or spatial data. In the simplest terms, GIS is the merging of cartography, statistical analysis and database technology
GIS can:

1. collect, store and retrieve information based on its spatial location;

2. arrange and link the spatial data to attribute data sources;
3. identify locations within a targeted environment which meet specific criteria;
4. explore relationships among data sets within that environment;
5. analyze related data spatially as an aid in making decisions; and
6. display the result of the analysis graphically and numerically.

Land Information System (LIS)

It is a software framework for high-performance land surface modelling and data assimilation. LIS is a geographic information system for cadastral and land-use mapping, typically used by local governments. It is a flexible land surface modeling and data assimilation framework developed to integrate satellite- and ground-based observational data products and advanced land surface modelling techniques to produce optimal fields of land surface states and fluxes. The LIS infrastructure provides the modelling tools to integrate these observations with the model forecasts to generate improved estimates of land surface conditions, such as soil moisture, evaporation, snowpack, and runoff, at 1km and finer spatial resolutions and one-hour and finer temporal resolutions. It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and ownership or control of those interests, and often the value of the parcel and its improvements (FIG, 1995). The International Federation of Surveyors statement on the cadastre highlights the importance of the cadastre as a LIS for social and economic development from an international perspective. It recognizes surveyors' central role in the establishment and maintenance of cadastre. The statement does not recommend a uniform cadastre for every country or jurisdiction but gives various options for establishing and managing a cadastre. The basic building block in any land administration system is the cadastral parcel. Cadastre consists of two parts – the registers and the maps. The three types of cadastre are:

1. Fiscal cadastre – supports land taxation
2. Legal Cadastre – supports land markets.
3. Multi-purpose Cadastre – integrated land information system – supports many uses.

Other information systems

Spatial Information Management (SIM)

The International Federation of Surveyors has renamed LIS to Spatial Information Management (SIM). This has widened the scope and concept to include service incorporation data, information management, information technology, organisational issues and spatial data infrastructure. (Aleem, 2003).

Utility Management Information System (UMIS)

GIS, used to manage the utility, is tagged UMIS. It is the technology and techniques for gathering, storing, retrieving, manipulating, integrating and displaying spatial reference data on utility-supplied to support decision-making in a wide range of utility management problems (Ezeigbo, 1998).

Geodesy

Geodesy may be defined as that branch of applied mathematics and planetary physics that deals with the determination of the size, shape and external gravity of the field of the earth as well as the coordinates of points on the earth's surface in a three-dimensional, time-varying space, using relevant observations.

The aim of Geodesy has two major objectives:

(a) Scientific objectives are the determination of the size and shape of the earth and, in cooperation with other sciences, the study of its gravity field and, to some extent, the internal structure of the earth.
(b) The practical objective is to carry out the measurements and computations needed for making accurate and reliable maps of the earth's surface.

In order to realize the practical objectives of geodesy, one needs to utilize the results of scientific objectives. On the other hand, the result of the practical objective is a necessary input in the scientific objective, thereby requiring an iterative solution between them. The iterative process ensures, at each stage, an improvement in observations, instrumentation and techniques as well as further improving the theory and technology (Idowu, 2022).

Fields of geodesy: Barriers between various fields are mainly artificial and should not restrict one's attention or focus, but, historically, geodesy has been categorized as:

Geometric geodesy: This is concerned with the three-dimensional geometrical elements of the mathematical model of the earth.

Physical geodesy: This relates the geophysical internal constitution of the earth to the corresponding gravity field and its observable effects.

Satellite/Space geodesy deals with satellite orbits, tracks existing satellites, and predicts the trajectory of a given missile, satellite, or spacecraft.

Geodetic astronomy chronicles the changing position of stars and other celestial objects. Although listed separately, it overlaps other areas of geodesy.

Cartography

Cartography is the art, science and technology of making good maps for providing information, instructions and directions to the users, with understanding and use of principles, based on creativity and insight coupled with skills. Cartography deals with map design, types, symbology, generalization and naming convention

The field of cartography can be divided into general cartography, thematic cartography and Orienteering.

1. **General cartography** involves those maps that are constructed for a general audience and thus contain a variety of features. General maps exhibit many reference and location systems and often are produced in series.
2. **Thematic cartography** involves maps of specific geographic themes or purposes oriented towards specific audiences. Thematic cartography has become increasingly useful and necessary to interpret spatial, cultural and social data. e.g. Dot map, choropleth etc.
3. **Orienteering map** combines general and thematic cartography designed for a specific user community. The most prominent thematic element is shading, which indicates degrees of difficulty of travel due to vegetation.

The cartographic profession has taken advantage of the revolutionary impact of computer and information technology with the use of Computer-assisted methods, which have several advantages over manual cartography, such as speed, ease of production, the capacity for keeping maps up to date, and rapid use of cartographic options.

Computer-Assisted Drafting (CAD): The electronic drafting system for input, construction storage, manipulation, retrieval, editing, and analysis of the object and its pictorial representation of the map features. Graphic elements such as points, lines and polygons are used.

Computer-Assisted Cartography (**CAC**)The use of computer hardware and software for the production of digital mapping in combination with a Geographic Information System. Graphics are produced from digital mapping using proper symbolization, map generalization, a map displaying and printing to provide a clear, concise and attractive visual representation of the map features.

Computer-Assisted Mapping (CAM): This involves the digital compilation and production of maps, mainly from hybrid and analytical stereo plotters. The main objective of CAM is for the computer to take over most of the tasks usually performed by human beings in the conventional mapping process.

Hydrography

Hydrography is the branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the earth's surface [seas] and adjoining coastal areas, with particular reference to their use for navigation and other purposes on water and underwater. Hydrographic surveying can generally be described as the process of gathering information about waters both off-shore and in-shore waters, navigable and non-navigable – for the core and fundamental purposes of providing social and physical infrastructural development, with products ranging from the traditional nautical charting to contemporary delimitation, delineation and data. Hydrographic activities involve mainly position fixing, depth determination, density and current measurements, discharge measurements, bed and suspended load sampling, spillage measurements etc. These data of hydrography are usually mapped and charted. The data of hydrographic series are now digitally acquired, stored, retrieved, updated, analyzed and integrated with other surveys or data for better decision-making efforts. The data of hydrographic surveying will then enable off-shore mineral exploration and exploitation, pipeline routing, Oil rig siting, wharf and harbour development, construction of wharves, Jetties, quays, Hydro Electric Power development, and underground cable operations. Dams, current measurement and discharge determinations, safe navigation routing, dredging activities, bed load quantities determination and interpretations etc.

Photogrammetry

Photogrammetry is generally used for the processing of raw imagery through the creation of geospatial data products such as Digital Terrain Models, 3D features, and digital orthophotos. There are several approaches for photogrammetric applications. Imagery may come from remote sensing satellites, airborne cameras (film or digital), or ground-based cameras.

Digital Photogrammetry System (DPS): the use of hardware and software which has the capability of deriving photogrammetry products from digital products using automatic techniques. DPS uses a photogrammetry workstation, which can perform such photogrammetric tasks as Real-time photogrammetric mathematics, Image manipulation functions, photogrammetric orientation and feature collection. (Aleem,2000). An example of such a workstation is Leica Photogrammetry Suite

Leica Photogrammetry Suite (LPS) is a Leica Geosystems GIS and Mapping product. This seamlessly integrated suite of digital photogrammetry products empowers users to transform raw imagery into reliable data layers required for all digital mapping, GIS analysis and 3D visualization.

Analytical Photogrammetry borders on the use of optical and mechanical instruments to solve Photogrammetric problems using a comparator to measure coordinates and heights on the photographs taking the advantages of speed of the computer

Remote Sensing

Remote sensing is the science and art of collecting and extracting information about ground features using sensors without being in physical contact**.**

Remote sensing of the environment is the method of obtaining reliable information about the object and the earth's environment through the use of satellite imagery and other related data from the ground, air or spacecraft without physical contact with the object and the processing of such data into valuable information for the understanding of the environment. (Aleem, 1996). There are so many satellite sensors. A satellite does not record all the imaged areas simultaneously but instead collects the data piece by piece. When the radiation reaches the satellite, the sensor records the data using a sensitive material (detector) (CCD – Charged Coupled Device).

Geomatics

International Standard Organization defined geomatics as a modern scientific term referring to the integrated approach of measurements, analysis, management and display of spatial data (Aleem, 2001). Geomatics is a growing engineering and information technology field that comprises the collection, analysis, modelling, mapping, interpretation, distribution, management, and use of geospatial data; data identified according to its location relative to the earth's surface; data collected using land, marine, airborne and satellite-based sensors through surveys for mapping the earth surface (GET, 2011). Geomatics is a multidisciplinary field and an integrated academic discipline covering various activities in surveying and other geo-information-based disciplines. The activities of geomatics include but are not limited to cadastral, engineering and mining surveying, cartography, geodesy, hydrography, digital mapping, GIS, geospatial information studies, LIS, digital photogrammetry, remote sensing. The activities of geomatics cover all disciplines which depend upon spatial data and spatial information, including resources, environmental studies, planning, agriculture, geology and geophysics and land development and tourism (Adeoye et al., 1999 in Aleem, 2000).

Geospatial analytics

Geospatial analysis is the gathering, display, and manipulation of imagery, GPS, satellite photography and historical data, described explicitly in terms of geographic coordinates or implicitly, in terms of a street address, postal code, or forest stand identifier as they are applied to geographic models. Geospatial Analytics can support Monitoring, Evaluation, Accountability and Learning (MEAL) operations by providing a way to analyze and visualize geographic data in a spatial context. MEAL operations involve tracking and assessing the progress and impact of development programs, and geospatial analytics can help in several ways. (Osibote, 2023). Geospatial analytics can be used to monitor the implementation of development programs by tracking progress against program targets in specific geographic locations. Secondly, geospatial analytics can support the evaluation of development programs by analyzing program data in a spatial context. Analysts can identify program outcomes and impacts in specific geographic locations by overlaying program data on geographic maps. This can help identify program strengths and weaknesses and provide recommendations for program improvement (Osibote, 2023). Geospatial analytics can assist with accountability and reporting by providing visual evidence of program progress and impact. This can build trust and credibility with stakeholders and donors and ensure that programs meet their objectives. Finally, geospatial analytics can support learning by analysing program data over time and identifying trends and patterns. This can inform future program design and implementation by providing insights into what works and what does not in specific geographic contexts. Overall, geospatial analytics can provide MEAL professionals with a powerful tool to monitor, evaluate, and learn from development programs, ultimately leading to more effective and impactful programs (Osibote, 2023).

Types of surveying, according to purposes and methods, include the following:

1. **Engineering surveying:** Most engineering work, especially in civil, agriculture and bioresource engineering, requires the topographical nature of the terrain for planning, setting out and executing the engineering construction projects, such as roads, pipelines, tunnellings, high tension lines, dams, irrigation, airport and other construction projects. Surveying for roads, pipelines, tunnellings and high- tension lines, are often referred to as route survey**.** Generally, engineering surveys are also called **Construction surveying.** This can be broadly grouped as topographical surveying. All these projects allow graduates of surveying and geoinformatics to be gainfully employed in construction, telecommunication companies and oil and gas industries.
2. **Topographic surveying:** A survey of the natural features of the land, as well as improved areas, that determines the horizontal and vertical relationships, and shown with grades or contours, and all improvements and utilities
3. **Geodetic surveying**: The practical aim of geodesy is achieved through geodetic surveying methods. The use of detailed surveys for providing national controls, deformation studies etc, covering large area curvature of the earth is taken into consideration. Geodetic surveying allows graduates of surveying and geoinformatics to be gainfully employed in ministries, offices of Surveyor-Generals and other geospatial organizations.
4. **As-built surveying:** Literarily means survey as it was built**.** It is post-construction. This is a survey performed to obtain dimensional data so that constructed improvements in the form of alterations in the original design may be located and delineated.
5. "**Location surveying:** A location survey shows the location of the improvements on the property in relation to the clear boundary lines of the property. It generally involves a physical inspection of the property and is accurate to plus or minus a few feet.https://www.federaltitle.com/understanding-4-types-of-property-surveys/
6. **Boundary surveying:** Boundary surveying involves creating, delineating, and retracement of land boundaries. A survey which documents the perimeter of a tract or parcel of land by establishing or re-establishing corners, monuments and boundary lines to describe the parcel, location of fixed improvements on the parcel, divide the parcel or for planning.
7. **Plat of condominium surveying:** A survey of new construction or conversion of an existing building delineating the limits of ownership, both horizontal and vertical, for each unit and those areas of shared ownership within the condominium association. Condominium surveys are a specialized class of boundary surveys governed by the Condominium Property Act.
8. The Plat of the Condominium is the result of actual field measurements. Data is sometimes transcribed from plans, but it must be verified with field measurements and amended on the Plat after completion of the construction work. Notes on the Condominium Plats must indicate whether the interior measurements refer to finished or unfinished surfaces and the vertical data used for any elevations depicted on the Plat. Units, Limited Common Elements, Common Elements/ Shared Areas, and Parking Spaces must be clearly labelled. (Wersja, 2023).
9. **Layout surveying**: A survey of subdivision of perimeter surveyed property designed by a qualified town planner into plots and transferring the designed plan onto the ground
10. **Setting out:** This is surveying in which measurements are made before and during construction to control elevation, configuration, position and dimensions of structures and any other improvements.

11. **Land dispute surveying:** A Survey that may be carried out to settle the case of the misunderstanding of the relationship between survey plats, final subdivision plats, and original monuments. The dispute may occur as a result of encroachment when a neighbour builds a structure (building, shed, garage, landscaping, fence or an addition/improvement to an existing building) beyond the boundary line.
12. **Control surveying:** Control is established to follow the principle of working from whole to part.' Here Primary, Secondary and Tertiary controls are established. Also, a new job must be tied to an existing control, which must be searched within specifications. In the past, when getting such controls within the specification is difficult, a local origin used to be established. However, the advent of Satellite and Information technology has eroded the establishment of "Local Origin. All-weather satellites are available day and night to establish Global Navigation Satellite System (GNSS) control anywhere globally. A survey which provides horizontal or vertical position data for the reference, support or control of subordinate or lower-order surveys or mapping.
13. **Mortgage surveying:** A basic survey, generally used for residential real estate closings and refinancing purposes, which shows the relationship of buildings, fences and other major structures to the property line. This is always used in land transactions. Like as-built surveying, mortgage surveying shows property boundaries for an entire property that will be mortgaged.
14. **Property surveying:** This is done to determine or confirm land boundaries, such as the plot of land a home sits on and any sub-surface improvements, like a septic tank or well. They also identify other types of restrictions and conditions that apply to the legal description of a property, including easement and encroachment.
15. **Plot of easement of plot of vacation** This survey visually depicts areas dedicated for a particular use, such as ingress and egress (travel/access) purposes, public utilities, drainage and other special needs. Plats of Vacation reverse the use of publicly dedicated roadways, alleys, or easements. These Plats are usually the visual exhibit attached to the legal documentation that verbally describes the intended purposes.
16. **Plot of subdivision or plot of redivision:** This survey divides a large parcel of land into smaller parcels of land known as "lots". This usually must conform to the review process, guidelines and jurisdiction of a local agency (often the village, town or county board within whose limits the property is located). The surveyor begins with a boundary survey and may also be called to provide a topographic survey or survey. Often a civil engineer will be contracted to create grading plans, storm drainage, utility and street plans.
    Sometimes a plat of easement for utilities and rights of way must be created. After the design and approval of the subdivision plat, the surveyor may also be involved in the construction layout.
17. **Quantity surveying:** A survey to obtain measurements of quantity, such as earthwork. The survey carried out to quantify the materials. It may be described as surveying for economic purposes.
18. **Right of way surveying:** This is part of engineering surveying. A detailed survey of a strip or area of land used or proposed for constructing and maintaining a public way for travel (roadway), railroads, drainage or irrigation canals, and any other public or private right-of-way. It is usually 25m on both sides of the center line.
19. **Special purpose surveying:** A survey performed for a purpose other than the purposes detailed in the other types of surveys listed here, such as for obtaining special permits for ad signs, cell towers, etc.

20. **Coastal zone surveying** can be defined as the area on both sides of the actual land-water interface, where territorial and marine environments influence each other.
21. **Unmanned Aerial Vehicle** (**UAV**): An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a pilot. UAVs can be remote-controlled aircraft (e.g. flown by a ground control station pilot) or fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. UAVs are components of an Unmanned Aircraft System (UAS), which include a UAV ground-based controller and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy, either under remote control by a human operator or autonomously by onboard computers. UAV will capture data which can be processed using appropriate software to get orthophoto as the product of the survey. Some processing software may include Pix4D, Agisoft, Drone Deploy, Propeller Network, Precision Hawk and soon.
22. **Geophysical surveying:** It is the systematic collection and processing of geophysical data relating to magnetic and gravitational fields emanating from the earth's interior for spatial studies. Detection and analysis of the geophysical signals form the core of Geophysical signal processing. The magnetic and gravitational fields from the earth’s interior hold essential information concerning seismic activities and the internal structure. Hence, detection and analysis of the electric and Magnetic fields are crucial. As Electromagnetic and gravitational waves are multi-dimensional signals
23. **Trigonometrical surveying**: It is surveying of a portion of a country by measuring a single base, and connecting it with various points in the tract surveyed by a series of triangles, the angles of which are carefully measured, the relative positions and distances of all parts being computed from these data.

Summary

In this chapter, surveying and geoinformatics have been defined. Its development has been traced historically, religiously, legally, socially and educationally. Historical development resulting from civilization and digital improvement in surveying. The branches of surveying and geoinformatics were identified to include: cadastral surveying, geodesy, photogrammetry, remote sensing, hydrographic surveying, land information system, geography/geospatial information system, cartography and other types of surveying resulting from location, purposes and methods of execution were discussed with explanation and examples.

Graduate of surveying and geoinformatics will find employment in any of the areas where the above activities of the profession are being carried out.

Exercise

1. Define Surveying and Geoinformatics.
2. What is the first principle of surveying?
3. Explain five major branches of surveying and geoinformatics.
4. Enumerate historical development of surveying and geoinformatics.
5. What are the branches of surveying and geoinformatics?
6. What are the basic principles of surveying?
7. What are the qualities of surveyors?

8. Justify the relationship between surveying and geoinformatics and other disciplines.
9. Identify employment opportunities in surveying and geoinformatics.

References

Adeoye, A. A., Komalafe, E. O. and M. O. Idowu (1999). Capacity Building and Institutional Development of Surveying Industry in the Next Millenium. Proceeding of the 34th Annual General Meeting and Conference of the Nigerian Institution of Surveyors, Nnamdi Azikiwe University, Awka, Anambra state. 28 – 39th April. 34(1)5-11

Aleem, K. F. A**.** (1999). "Applications of Management Processes in Surveying" Technical Education Today-Journal of National Board for Technical Education. 9 (1) 1-7

Aleem, K. F. A. (1998). "Surveying for National Development". *Journal of Science and Technology*. 2.(.1) 98-103

Aleem, K. F. A. (1999). "Applications of Management Processes in Surveying" Technical Education Today-Journal of National Board for Technical Education. 9.(1) 1-7

Aleem, K. F. A. (2002). "Naming Surveying According to Technological Development". Proceeding of 4th National Conference on Application of Science for National Development. 4 (1) 8-11

Aleem, K. F. A. (2000). "Automated Mapping and Nigerian Child". Nigerian Journal of Childhood Education. Journal of Childhood Association of Nigeria. 1(2) 101-114

Aleem, K. F. A. (2003). "Digital Mapping: Impact of Information Technology on Surveying Profession to Enhance the Economic Growth of the Country". Sabondale Journal of Technical Education

Aleem, K. F. (2021). Introduction to Surveying and Geoinformatics (SG111) *Lecture Note* Department of Surveying and Geoinformatics, Abubakar Tafawa Belewa University, Bauchi Unpublished

Aleem, K. F. (2023). Geometric Geodesy *Lecture Note* Department of Surveying and Geoinformatics, Abubakar Tafawa Belewa University, Bauchi Unpublished

Aleem, K. F. (2023). Physical Geodesy *Lecture Note* Department of Surveying and Geoinformatics, Abubakar Tafawa Belewa University, Bauchi Unpublished.

Aleem, K. F. and Abubakar, A. F. (2022) The Review and Development of the Nigerian Geodetic Control Network. Journal of Geospatial Surveying 2 (2)22-29 https://jgs.sljol.info/articles/abstract/10.4038/jgs.v2i2.40/

Dale, P.F. and J. D. McLaughlin (1989). Land Information Management. Clerendon Press, Oxford. 1-266

Ezeigbo, C. U. (1998). Application of Geographic Information System GIS in Utility Management. Principle and Application of Geographic Information System. Panaf Press, Lagos 1(1)124-131

Geomatics Engineering Technology (GET) (2011). YIC Academic Catalog 2011. Yambu Industrial College Yambu Industrial City, Saudi Arabia http://cms.yic.edu.sa/get/getb

Land Information System | LIS Framework - NASA. https://lis.gsfc.nasa.gov/software/lis

Cartography - Wikipedia. https://en.wikipedia.org/wiki/Cartography Cartography - Wikipedia. https://en.wikipedia.org/wiki/Cartography

https://www.bankrate.com/real-estate/where-do-i-get-my-property-survey/

https://www.federaltitle.com/understanding-4-types-of-property-surveys/

What is Surveying?: 5 Principles of Surveying, Objectives & Uses https://dreamcivil.com/principles-of- surveying/

Idowu, T. O. (2022). Geometric Geodesy Lecture note, Department of Surveying and Geoinformatics, Federal University of Technology, Akure.

Kufoniyi, O. (1998). Basic Concept in Geographic Information System GIS. Principle and Application of

Geographic Information System. Panaf Press, Lagos 1(1)1-14.
Nwilo, P. C. and A. O. Adebisi (2001). Map and Map Data as a Tool for Monitoring Nigerian Boarders Proceeding of the 36th Annual General Meeting and Conference of the Nigerian Institution of Surveyors, U.K. Bello Art Theatre, Minna, Niger State
Osibote O. A. (2023). Geospatial Analytics. https://www.linkedin.com/posts/olusolaaosibote_arcmap-activity-6895714562939961344-cs0bThe Commonwealth Association of Surveying and Land Economy. http://www.casle.org/publications.htm
Jiya, S. and Alaci, D. (2014). The Use of Computer and Manual Analysis In Detection of Land Use Changes In Jos, Plateau State, Nigeria. Indian Journal of Life Sciences, 3(2), 115.
Wersja, P. (2023). Condominium Survey. Spiewak Consulting Andrew Spiewak Land Surveyor, inc.https://landsurveyors.pro/home/condominium-survey/#Content

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CHAPTER 19

Fundamentals of Cadastral Surveying

By

IBITOYE Matthew Olomolatan

Overview

Land in its "raw" nature is regarded as "dead capital" if it has not been properly demarcated, coordinated and legally documented by the way of registering the title. Cadastral surveying plays a significant and fundamental role in the demarcation of land parcel separately both geographically and physically on ground with means of concrete marks technically referred to as survey beacons. It answers questions such as: what is the extent of the land surveyed (area of land in square meters), location, dimension of the land etc. Because of the significant role played in land administration, Cadastral surveying is always linked to ownership of land and in addition serves as an important ingredient in land titling registration in many parts of the world. As a result of close connection of cadastral surveying to land, it is directly control by laws and regulations ie Surveyors Council of Nigeria (SURCON) Act (CAP. S18, Law of Federation of Nigeria) and several regulations. Cadastral survey data in form of plans, graphs, coordinates, is one of the fundamental datasets of national spatial data infrastructure (SDI) for appropriate land administration in achieving sustainable development goal. It has been acknowledged that countries with a proper cadastre system of land registration thrive in business compared with countries with a less efficient registration system. It was on this premise that government of Nigeria in 2009 introduced Systematic Land Titling Registration (SLTR) where systematic land registration was advocated for as against sporadic method. In the two approaches, product of cadastral surveying is an indispensable document in effective land registration process. This overview is designed to convince students of this course, the importance of cadastral surveying for self-reliance, as cadastral surveyors and economic development, through property market.

Objectives

By the end of the course, students should be able to:

1. define cadastral surveying;
2. explain what cadastre is all about;
3. differentiate between cadastral surveying and cadaster;
4. illustrate other aspects of cadastral surveying; and
5. explain methods/procedures used in carrying out different aspects of cadastral surveying.

What is cadastral surveying?

There is no static definition for cadastral surveying, however, few of the general definitions are given as:

Cadastral surveying is the discipline of land surveying that relates to the laws of land ownership and the definition of property boundaries.

Cadastral surveying is the sub-field of cadastre and surveying that specializes in the establishment and re-establishment of real property boundaries.

Cadastral surveying is that aspect of land surveying that is generally performed to subdivide land into parcels for ownership under a land title and to re-establish boundaries of previously surveyed properties to determine the physical extent of ownership or to facilitate the transfer of the property title.

Cadastral surveying principally involves physical delineation on ground, the boundaries of a parcel of land with either permanent (concrete) or temporary materials. It involves both linear and angular measurements along the boundary lines, determination of areas enclosed by the boundary as well as fixing features proportionally within and without the property. A person who is registered as a surveyor under the Surveyors registration Council of Nigeria, according to CAP. S18, Law of the of Federation Nigeria, 2004, is the only person authorized to perform cadastral surveys in Nigeria.
Cadastre System is a parcel-based system of property (land) administration. It comprises of physically delineated boundaries, being the extents of parcels or interests and datasets containing the public record of the interests (i e. rights, restrictions and responsibilities) in those parcels.

Methods of cadastral surveying
When a parcel of land is acquired by an individual ether from government, cooperate organization or family, service of registered cadastral surveyor will be required to carry out measurement with the aim of producing a legal document often referred to as cadastral surveying plan.

Procedures in cadastral surveying
Reconnaissance
A reconnaissance survey is a rapid but thorough examination of an area or property earmarked for survey. It is the first stage of site investigation. In this stage, visual inspection of the site is done and information relating to the natural features on the site are collected, recorded and sketched in a field book as reconnaissance diagram.

Boundary demarcation
The turning points or change in direction of the parcel of land to be surveyed are marked with concrete pillars, which preferably pre-casted pillars whose specification are given by law (Cadastral Survey Regulations, 2014) to be 75cm long by 18cm squired in section (75cm X18cm X18cm), buried in the ground with upper part projecting 8cm above ground surface. Another alternative to pre-casted concrete mark is in-situ pillar built which is by pouring concrete into an undercut hole not less than 60cm deep in soil or 25cm deep in rock. The upper face of the pillar is marked with identification number, that is, SURCON number and prefix of Surveyor that executed the survey i.e. SC/OD 234 B where, SC represents surveyors Council of Nigeria (SURCON), OD represents Ondo State and B represents Surveyors prefix. On the other hand, PBs are used for property belonging to Government. It is worth to mention that the concreate used as pillars are in accordance with specification. The concrete is mixed in the proportion of five part of sand and gravel to one part of cement. Apart from boundary corners, pillars are placed on a long straight line at intervals of 250m and 400m for layout and farmland, respectively. Where a river/stream formed boundary of a property, pillar would be placed only at the point near the stream above flood level. Under no condition can the demarcation of boundary and bury of pillar be entrusted to a chainman, no matter how experienced he may be. The surveyor must personally supervise the exercise.

Instruments: The boundaries of property are always surveyed in a closed traverse method using any of the following measuring instrument: Theodolite (Electronic or Analogue), Total Station, Differential GNSS (GPS receivers) in a rapid static mode.

Connection of survey: Survey shall be connected to government traverse network commonly referred to as government control pillars. Before the survey is connected to framework control pillar, the accuracy of the pillars shall be checked by angular and linear measurements and confirm that the control pillars are in situ.

Angular Observation: The instrument use for cadastral survey should not be less than 10'' graduation interval and horizontal observations shall be in rounds; a round shall comprise one face left (FL) and one face right (FR) reading to each sight to complete a set of observation at one instrument station. Accuracy of the observation shall not be more than 10 seconds.

Linear measurement

The instrument used for linear observation are steel tape, Electromagnetic Distance Measurement (EDM) and digital measuring devices i.e. Total Station. Before use, steel tape must be standardized while other equipment such as EDM or Total Station be calibrated. When the survey is to be carried out on a fairly leveled surface, ground taping may be employed. If it is on rough terrain, catenary taping or stepping methods can be used. Linear measurement shall be recorded to the third decimal place of a meter in a traverse field book. However, digital and EDM devices are more preferable as they provide more accurate data as well as chance of mis-book, mis-read are eliminated the reading are stored in the internal memories of the instruments.

Where part of the boundary of the property is irregular such as stream, the traverse line is taken as close as possible to the stream and offset would be taken from the traverse line to fix the stream.

Traversing

A traverse is a continuous framework of lines connecting a number of points, lengths of the lines and their angular relationship to each other line being measured. Traversing consists of selecting, marking and referencing stations, pickup details and booking in the field note. The lines are known as traverse legs and points as traverse stations. Traverse is of two types. These are closed traverse and opened traverses.

Closed traverse

A traverse is said to be closed if it returns to the starting point. That is, end at the starting point, thus, forming a loop or closed polygon. A traverse which start from known (coordinated) point and end at another known (coordinated) point is also referred to as closed traverse. Close traverse allows for adequate checking and corrections for errors.

Open traverse

An open traverse occurred when a traverse start from known point but did not return to starting point or start from coordinated point and end on uncoordinated point. This type of traverse is often referred to as hanging traverse. As a matter of fact, an open traverse cannot be checked and adjusted accurately. Despite that fact of the weakness of open traverse, the method is used for surveying along narrow strips such as highways, railways, canals, pipelines, transmission lines etc.

Computations

The computation can either be manual or electronic and will involve the following steps:

Computations of bearings from observed angles

This is method, where observed angles recorded from the fieldwork are used to compute bearings between consecutive lines. Corrections such as angular misclosure are applied during the process.

Corrections to linear measurement:

Measured distances are corrected for various errors such as:

1. Slope: Lengths measured on sloping terrain or in catenary will be longer than those measured on flat terrain. Therefore, measurements made under this condition must be reduced to true horizontal distance. Hence, the application of slope correction is given by equation 1.

$D = L - L\,[1-\cos\alpha]$ 1

Where, D = corrected distance
L = measured length
α = slope angle

2. Standardization: This is by comparing a steel band with a standardized base or a reference steel band. The computed value of field steel tape or band minus baseline is referred to as standardization correction as given by equation 2.

Standardization = $L\,(L_B - L_T)/\,L_B$ 2

Where: L = Measured length
L_B = Length of baseline
L_T = Length of tape along the baseline.

3. Sag: If a tape is used in suspension during catenary chaining, where the tape is supported throughout its entire length, sag correction must be applied as functionally given by equation 3.

Sag correction = $(nw^2L^2)/\,24T^2$ 3

Where: n = number of unsupported lengths
w = weight per meter of tape (mg)
L = unsupported length in meters
T = Tension applied in kilogramme

4. Temperature correction: Steel tape expands or contracts with temperature variation. If the temperature during measurement is different from that at which the tape was standardized, the resulting error will be accumulated, indirect proportion to the number of tape length measured. Unless the field temperature considerably differs from when the tape was standardized, this error is always negligible and thus, ignore in cadastral survey. The temperature correction is given by equation 4.

Temperature correction = $\alpha\,L\,(t_f - t_s)$ 4

Where: α = co-efficient of linear expansion
L = length of the tape used
t_f = Temperature during measurement
t_s = Tape standard temperature

5. Tension correction: Variations in tension are bound to occur even when using a spring balance, but resulting errors are small and tend to compensate each other. This error is very negligible and often ignore in cadastral surveying. It is given by equation 5,

Tension correction = $[L\,(T_f - T_s)]/AE$ 5

Where: L = measured length
T_f = Tension applied to the tape (*N*)
T_s = Standard tension
A = Cross sectional area of the tape (mm^2)
E = Modules of elasticity for the tape material (N/mm^2)

Traverse computations

The corrected bearings, corrected linear measurements are use as variables to produce unadjusted coordinates for all the survey points. The following steps are used for the survey computations:

Latitudes and Departure

Latitude of a line is the distance which the line extends in the north or south direction. When a line runs in a southerly direction shows a negative latitude while its northerly direction indicates positive latitude.

Departure of a line is the distance which the line extends in the east (+ve) or west (-ve) direction.

The calculations for both latitude and departure are shown in equations 6a and 6b.:

$$\text{Latitude} = L \cos \alpha \quad (6a)$$

$$\text{Departure} = L \sin \alpha \quad (6b)$$

Where: L = corrected length of the traverse line
α = corrected bearing of the traverse line

Traverse adjustment

1. Determine the latitudes and departures of each line using corrected distances to nearest 0.05m and adjusted bearings to the nearest 10' of arc.
2. Determine the algebraic sums of the latitudes and departures and compare them with the fixed latitudes and departures of a straight line from the origin to the closing point.
3. Determine the arithmetic sum of the latitude and latitude for each line
4. Calculate the correction to each coordinate using equations 7a and 7b.

$$C_n = (Y\sum dn)/\sum dN \quad (7a)$$

$$C_n = (X\sum de)/ \sum dE \quad (7b)$$

Where: C_n = correction to northing coordinate
Y = misclosure in northing
$\sum dn$ = arithmetic sum of latitude at the point
$\sum dN$ = total arithmetic sum of latitude
C_e = correction to easting coordinate
C_n = correction to northing coordinate
X = misclosure in easting
$\sum de$ = arithmetic sum of departure at the point
$\sum dE$ = total arithmetic sum of departure

The corrections applied to the coordinates can be negative or positive depending on the values of misclosure in the northing and easting. The final coordinates shall be rounded off to the nearest second decimal place of a meter (nearest centimeter). In line with the cadastral surveying regulations, all computations are connected to Universal Traverse Mercator (UTM) projection system.

Area computation

The area of a piece of land bounded by straight lines may be computed from the final adjusted coordinates of the corners manually or through programmable calculator or computer with specialized software. The steps for the manual calculation are as follows:

1. List the X and Y coordinates of each of the points in columns;
2. Repeat the starting point after all the coordinates of points are completed;
3. Multiply the value of first row x by the value of second row y;
4. Multiply the value of first row y by the value of second row x;
5. Subtract the sum of second product from the sum of first product; and
6. Make the result positive if negative and divide by 2.

Let us assume that a polygon with four sides A, B, C and D has the following coordinates:

A = (N_I, E_1), B = (N_2, E_2), C = (N_3, E_3) and D = (N_4, E_4).

The area of the polygon shall be determined by:

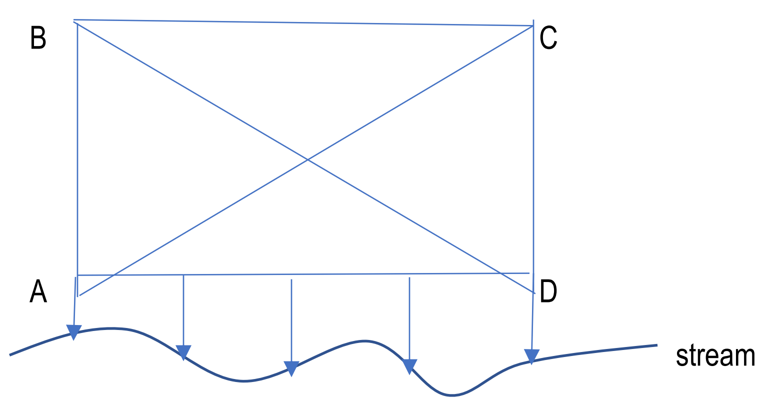
$$2A = (N_1 E_2 + N_2 E_3 + N_3 E_4 + N_4 E_1) - (E_1 N_2 + E_2 N_3 + E_3 N_4 + E_4 N_1).$$

The equation can be represented in a tabular form as shown below;

N1 E1
N2 E2
N3 E3
N4 E4
N1 E1 = 2A

Irregular area computation

The area enclosed between an irregular boundary and adjacent traverse lines shall be computed as series of trapezia. Two methods are commonly used in calculating area from offset measurements. These are Trapezoidal and Simpson rules.



Example

Point	A				D
Distance (m)	0	10	20	30	40
Offset length	3	2.5	3.2	4.0	3.6

Trapezoidal Rule

Using the above figure:

Area of first trapezoid $= \frac{(O_1+O_2)}{2} \times d$

Area of second trapezoid $= \frac{(O_2+O_3)}{2} \times d$

Area of third trapezoid $= \frac{(O_3+O_4)}{2} \times d$

Area can be summed up as;

$A = d\left[\frac{O_1+O_n}{2}+O_2+O_3\ldots.O_{n-1}\right]$

Where: O_1 = the 1st offset distance
O_n = the last offset distance
d = distance between offset

Working example using Trapezoidal Rule

$A = \underline{10}\left[\frac{3+3.6}{2}+2.5+3.2+4.0\right]$

A = 10 [3.3+2.5+3.2+4.0]

A = 130m^2

Simpson Rule

$\mathbf{A} = \frac{d}{3}\left[(O_1+O_n)+4\,(O_2+O_4+\ldots\ldots\ldots O_{n-l})+2\,(O_3+O_5+\ldots.O_{n-2})\right]$

Working example using Simpson Rule

$A = \frac{10}{3}\left[(3+3.6)+4\ (\text{Even Nos.})+2\ (\text{Odd Nos.})\right]$

$A = \frac{10}{3}\left[(3+3.6)+4\,(2.5+4)+2\,(3.2)\right]$

$A = \frac{10}{3}\left[6.6+4(6.5)+2(3.2)\right]$

$A = \frac{10}{3}\left[6.6+26+6.4\right]$

$A = \frac{10}{3}[39]$

$A = \frac{390}{3}$

A = 130 m^2

Where a property is bounded by stream, both areas computed from the regular shape and that of irregular shapes are added together as the total area covered by the property in square meters or hectares.

GNSS observation in cadastral surveying

GNSS, using GPS receiver, is a new technology that facilitate the network of control points that are available for use in cadastral surveying. Satellite positioning is a recent development technique, though, was originally planned for military only but now available for civilian use. Signals transmitted from satellites make almost immediate positioning possible. When all the planned satellites are in orbit, it will be relatively easy to observe a minimum of four satellites at a time. If four satellites are observed, the three-dimensional coordinates and the bias between the clocks can be calculated. Greater relative accuracy can be obtained by making simultaneous observations from two or more stations and then comparing the relative positions of the satellites. Unlike traditional method, GNSS observation is capable of determining direct coordinates of positions with a few centimeters or less accuracy, and are playing very important role especially in the densification of existing control point network. With the introduction of Continuously Operating Reference Stations (CORS), the cadastral surveying has becoming easier to carry out. CORS system is a network of stations in a region that continually record GPS signal, and then provide the data to GPS users over the internet. The GPS receiver connects to established CORS within a region to provide real-time direct coordinates of pillars (points) in cadastral surveying. The equipment is very efficient as well as sufficiently accurate for the determination of coordinates of points than conventional devices of measuring angles and distances that will lead to rigorous computation before coordinates of point can be obtained. What the surveyor does after obtaining the coordinates is to use back computation method to compute bearings and distances of boundary lines. These few advantages have made the technology frequently used and more acceptable in the fast delivery of cadastral survey plans to the users.

Cadastral plan

All cadastral plan must be drawn in waterproof ink on mounted paper or any stable material of not less than A4 size paper. The original plan of a survey shall show the following information: title i.e names of the person or body for whom the survey was made, location of the survey, North Arrow, scale of the survey plan, origin of the survey, beacon numbers, coordinate of one of the points, area of the survey, bearings and distances of the boundaries, certification, live signature of the surveyor in green, seal and designation/address of the surveyor, the date the survey is prepared.

Cadastral sub-division

Sub-division of a parcel of land into smaller parts is an occasional task a cadastral surveyor undertakes. The client often give instruction to cadastral surveyor to the proportion to which a parcel of land will be divided. The tasks involved are as follows:

1. The area of the entire parcel of land will be determined and computed from the coordinates of corner points.
2. The extent of the property plotted accurately on a plan at a suitable scale
3. From the area of the original plan, area of portion to be calved out can be estimated
4. Using the best possible judgement, a line can be drawn either parallel or perpendicular from any part of the boundary in line with the client instruction to have two points along the boundaries that may give approximately the area required.
5. Coordinates of the two points are computed using the bearing and distance and coordinates of

the
nearest corner points.

6. Area of the excised portion can be computed from the coordinates of the new points and the existing
two corner points.

7. The area obtain can be compared with the required portion of the property. If the area calved out is
greater or less than expected area, adjustment can be made to the new points along the boundary until
a near perfect area of excised portion is achieved.

Cadastral layouts

Cadastral Layout is an aspect of cadastral survey that involves several building plots arranged systematically with other facilities such as roads, recreational and other utilities. Ideally, the design should be based on an accurately surveyed and drawn plan of the area being proposed to be planned, which must have been approved by the appropriate authority e. g Urban and Regional Planning Authority. The layout plan or design is not in any means a survey plan because it contains some considerable inadequacies. The actual operation of marking out these designs on the ground and making the necessary measurements to obtain coordinates of beacons by the surveyor is called layout survey. The surveyor translates the paper designs to the ground, though with some degree of latitude to some amendment where what designed was not in agreement with reality on the ground. It may be necessary for surveyor to make adjustment to the design if he discovers that the design will not fix in to the existing terrain configuration and natural boundaries. Where major alteration on the design is required, the surveyor may revert back to the relevant authority for amendment. In a layout survey, general principle of "working from whole to part" is always followed. That is, from the coordinated boundary points to blocks and thereafter to individual plots. Layout survey can be approached in two ways; using bearings, distance and external angles between two adjacent lines or by converting the design to raster format and the coordinates of all the points are extracted.

Approach number one

Using bearing, distance and external angle of two adjacent lines, the surveyor starts the layout survey by adopting the following steps:

1. With the aid of circular protractor, all external angles of the lines to be turned on the layout plan are
determined while distances of the blocks and plots are estimated using scale rule.
The boundary pillars upon which the design was based are confirmed on ground to be in situ and where
some pillars are missing, the surveyor establishes them.

2. A straight line between two inter-visible beacons is ranged with either theodolite or total station and pegs
are driven on ground along the line at proper horizontal distance as measured on the layout design to
mark out the edges of the blocks

3. Instrument (theodolite) is set at one of the edges of the block, and the telescope of the instrument will
be pointed to the target at the second edge of the block and the value of external angles will be added

to the reading obtained from the instrument. The instrument telescope will be turned clock wisely until the new reading appeared in the vanier of the theodolite, thus provide the direction as shown in the layout design. The step is repeated until the block is perfectly set out,

4. In the same manner, the plots within the block are set out by marking out with pegs the widths of each plot along the straight lines within a block.
5. Pegs will be later replaced with concrete pillars under a thoroughly supervision of the surveyor. After this, a closed traverse will be carried out to coordinate the points following the principles of cadastral survey methods earlier described.

Approach number two

This approach is only applicable in the case of Total station or GPS receivers

1. The boundary pillars upon which the design was based are confirmed on ground to be in situ and where some pillars are missing, the surveyor establishes them.
2. The layout plan is scanned and georeferenced with coordinates of the boundary pillars. With this, coordinates of each point on the layout plan can be determined.
3. The points which may be marked with pegs will later be replaced with concrete pillars under the supervision of a surveyor.
4. In a coordinate mode of Total station or GPS receivers, all the points will be identified on the ground with the values of their coordinates.
5. A close traverse will be carried out on all the points to obtain corrected coordinates for the points
6. The area of each plot will be computed from the final coordinates of the corner points manually, or through programmable calculator or computer with specialized software.

Summary

This chapter has discussed the methodology required in the production of cadastral survey plan. Also, it has shown that it is one of the aspects of land surveying that is seriously controlled by laws and regulations.

Exercise

1. What is cadastral surveying?
2. Describe the procedure for cadastral surveying from field work to plan production.
3. State the difference between sub-division and layout plan.
4. Explain in details the use of GNSS technology in cadastral surveying.
5. State the importance of cadastral survey plan in land management in Nigeria

References

Dashe, J.D.J (1987). Cadastral Surveying Practice in Nigeria, Department of Printing Technology, Kaduna Polytechnic, Kaduna.

Gerhard Larsson (1991). Land registration and Cadastral systems: tools for land information and management, Longman Group UK Limited.

SURCON (2014a). Cadastral Survey Regulations

SURCON (2004b). Surveyors Council of Nigeria, CAPS, 18 Law of the Federation of Nigeria, 2004.

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CHAPTER 20

Basic Concepts of Surveying and Geoinformatics in Natural Environment

By

IDOWU Timothy Oluwadare and NZELIBE Ifechukwu Ugochukwu

Overview

Surveying and geoinformatics is the art and science of mapping the earth's surface which involves acquisition, processing, analysis and presentation of geospatial data using digital tools. It plays a critical role in understanding and managing the natural environment. Natural environment is that which encompasses all living and non-living things which are not artificial and most often applied to the whole and/or parts of the earth. This chapter provides a basic introduction to surveying and geoinformatics in natural environment. It covers definition, types and domain of natural environment and definition, brief history, scope, fundamental principles and concepts, uses, hardware/software and techniques of surveying and geoinformatics. Also, it provides basic understanding on the applications of surveying and geoinformatics in natural resource management and conservation which includes land cover mapping and monitoring, marine studies and coastal management, inventory and monitoring of forest resources, monitoring wetlands, mineral exploration, water resource management, waste management, seismic studies and drainage systems.

Objectives

At the end of this chapter, students will be able to:

1. define and identify types as well as domain of natural environment;
2. explain the uses and classes of surveying and geoinformatics;
3. explain the fundamental principles and practice of surveying and geoinformatics
4. demonstrate understanding of surveying and geoinformatics techniques;
5. explain the role of Surveying and Geoinformatics in natural resource management and conservation;
6. identify basic hardware and software used to collect, process and analyze geospatial data; and
7. identify areas of employment opportunities that exist for surveying and geoinformatics experts.

Natural environment

Natural environment, which is often referred to as an ecosystem, is a unit which consists of all plants, animals and micro-organism in an area functioning together with all the non-living physical factors of the environment. There are five types of natural environments. These are land, air, water, plants and animals existing within different domain of natural environment such as lithosphere, hydrosphere, atmosphere and biosphere. It is a type of environment where human impact or interaction has been extremely limited as it encompasses all living and non-living things occurring naturally as applied to the whole earth or some parts of the earth.

Definition and scope of surveying and geoinformatics

Surveying is traditionally concerned with the art and science of obtaining reliable information about the relative positions of spatial objects on, above and below the earth surface and representing these positions in a usable format such as charts, plans and maps (Kavanagh, 2012). Its scope encompasses various activities that are aimed at determining the relative positions and elevations of points on the earth's surface. This includes measuring and mapping land features such as boundaries, topography and infrastructure as well as mapping underwater features and celestial bodies such as moon, stars and satellites. Recently, with the advent of modern technologies using highly sophisticated computing hardware and software, the scope of surveying has greatly expanded. This has led to the advent of new technologies such as laser scanning, Unmanned Aerial Vehicles (UAV), Geographic Information System (GIS) and other digital tools have resulted into more accurate and efficient data collection and processing as well as analysis, visualization and presentation of the outputs obtained. This revolution that led to the great expansion of surveying has given birth to a new nomenclature for surveying called Geoinformatics. Geoinformatics, often referred to, in some areas, as Geomatics or Geospatial Information Science, is a science that makes use of modern technologies to acquire, store, process, analyze, visualize and manage geospatial data. It is a multidisciplinary field that incorporates principles of computer science, geography, mathematics, physics, statistics and engineering to provide insights into complex problems related to the spatial and temporal relationships between natural and man-made features on earth's surface. It is a science that encompasses a wide range of applications which includes natural resource management, environmental monitoring, disaster management, urban planning, transportation planning and many others.

Abridged history of surveying and geoinformatics

The summarized history of surveying and geoinformatics, as presented by Idowu (2012), stated that the need to survey land first arose when land suitable for cultivation was required to be divided and registered for allocation to interested individual in Egypt. Early land surveying, inform of field measurement can be traced to Babylonia and Egypt where the great pyramids of Egypt was built through the knowledge and application of surveying principles. Also, the Egyptians made use of surveying techniques in the explorations of the river Nile. This was made possible because the Egyptians knew how to range out a straight line to set out angles which forms an important aspect of surveying nowadays. Masterpieces of the Greek Architecture (The Parthenon and the Theatre of Dionysus) demonstrated surveying skills. The Romans, considered to be the greatest of the world's engineers not only understood and used the principle of surveying but further developed the act of surveying. The greatest tribute of these early skills is the fact that the structures built, where surveying skills were employed, are still with us today. In Britain, surveyors and architects used their knowledge of surveying for the development of British empire. Leonard and Thomas Digges (father and Son), Jonathan Soissons and Jesse Ramsden helped to develop surveying angular measuring instrument (theodolite), while Aaron Rathbone wrote in praise of surveying besides developing a surveying instrument called surveyor's chain. It is from Egypt, Greeks, Romans, Britain that men such as Galileo, Leonardo da Vin, Marco polo, Columbus, Digges, Ramsden etc. were able to pave way for the development of many techniques and instrumentations now available for surveying and geoinformatics. In Nigeria, surveying crept in when some Royal Army Engineers from Britain came to the country around 1893 to carry out route surveying for the Nigerian Railway Corporation (NRC). Due to harsh climate (weather) condition, they could not stay long but succeeded in training some Africans in various states to continue surveying in Nigeria. Late Herbert Macaulay and C. T. Olumide were the early indigenous surveyors so trained to fully take off surveying in Nigeria. To date, surveying and geoinformatics profession has fully developed, creating openings for employments and economic opportunities for Nigerians.

Uses of surveying and geoinformatics

Surveying and geoinformatics can be used, amongst others, to:

1. study the configuration of the earth's surface;
2. give distances and directions of boundaries lines;
3. measure the area and volume of earth works during engineering construction;
4. establish control points which serve as references for other surveying operations;
5. determine configuration of the water beds for navigation purpose and to provide demarcation for the coastlines;
6. fix appropriate direction and height for aircraft's route; and
7. provide information about the location, quantity and type of subsurface mineral resources.

Classes of surveying and geoinformatics

Generally, surveying and geoinformatics can be grouped into primary and secondary classes (McCormac and Wilhelm, 2016).

Primary class is sub-classified into:

1. **Plane surveying and geoinformatics:** This is a class in which the shape of the earth is considered flat or plane (usually covering small parts of the earth) without giving consideration to the possible curvature of the earth's shape. Typical types of this class are:
   - (i) **Topographical surveying and geoinformatics** which is carried out to depict the undulation of the earth surface.
   - (ii) **Cadastral surveying and geoinformatics** which is carried out for the purpose of determining the registration of man's title or ownership to land.
   - (iii) **Engineering surveying and geoinformatics** which is carried out for setting out the position, level and alignment of structures such as buildings, bridges and roads during construction.
2. **Geodetic surveying and geoinformatics:** It is another type of primary class of surveying and geoinformatics in which the curvature of the earth is taken into consideration. The work involved in this class includes those of larger magnitude which requires high degree of precision and accuracy. This includes determination of the shape and size of the earth's surface or part thereof and establishment of control points that sever as references for other surveying tasks.

Secondary class is sub-classified into:

1. **Classification based on natural environment where the exercise takes place**. This includes:

a. **Land surveying and geoinformatics**: This is where the measurements and all other operations required in the task are land-based.

b. **Hydrographic and marine surveying and geoinformatics**: This deals with the task to be carried out on water for the purpose of navigation, water supply etc. That is, the operations involved are water or sea-borne.

c. **Astronomical surveying and geoinformatics:** This is where observations are taken to natural celestial bodies such as sun and stars. In this type, the operations involved are air-borne.

d. **Photogrammetry:** It involves mapping the earth's surface using terrestrial and/or aerial photographs taken from aircraft or drones.

e. **Remote Sensing:** This is the process of acquiring information about the earth's surface from the space without having physical contact with the earth's surface. This is usually achieved using sensors mounted on aircraft or artificial satellites.

2. **Classification based on specific object.** This includes:

a. **Geological surveying and geoinformatics:** This process involves observations of an area to determine the character, relations, distribution, origin and mode of formation of its rock masses.

b. **Mine surveying and geoinformatics:** It is the process of determining the relative positions of points on or below the earth's surface by direct or indirect measurements of distances, bearings and heights.

c. **Geophysical surveying and geoinformatics:** This process involves using ground-based physical sensing techniques to produce detailed information of underground mineral resources. It provides spatial location of the center of mass, type and approximate quantity of underground mineral resources.

d. **Archaeological surveying and geoinformatics:** This is the process of searching to collect information about the location, distribution and organization of past human history and cultures within a large study area.

e. **Military surveying and geoinformatics**: It is a type of surveying process, carried out by specially-trained military officers, to provide information for locating military targets and troop movements.

3. **Classification based on instruments used for the operations includes amongst others**:

a. Chain surveying and geoinformatics;
b. Compass surveying and geoinformatics;
c. Plane table surveying and geoinformatics;
d. Theodolite surveying and geoinformatics;
e. Tachometric surveying and geoinformatics;
f. Photographic surveying and geoinformatics; and
g. Global Positioning System (GPS) surveying and geoinformatics.

4. **Classifications based on methods used:**

a. **Triangulation:** This is the process of surveying and geoinformatics that involves the use of series of connected triangles where all the interior angles of the triangles and at least the distance (L) of only one line, called Baseline (AB) is measured as shown in figure 1.

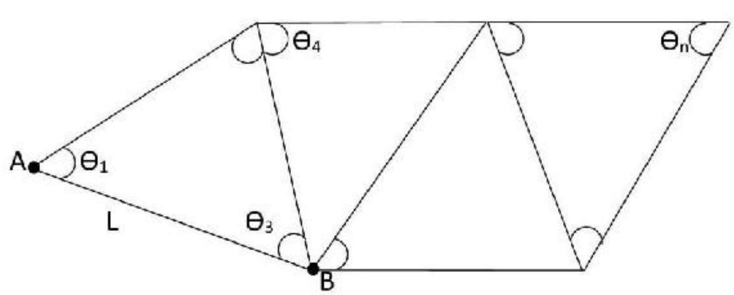

Figure 1: Triangulation network

b. **Trilateration:** It is the process of surveying and geoinformatics that involves the use of series of connected triangles where all the distances of the lines of triangles and at least one interior angle is measured as shown in figure 2.

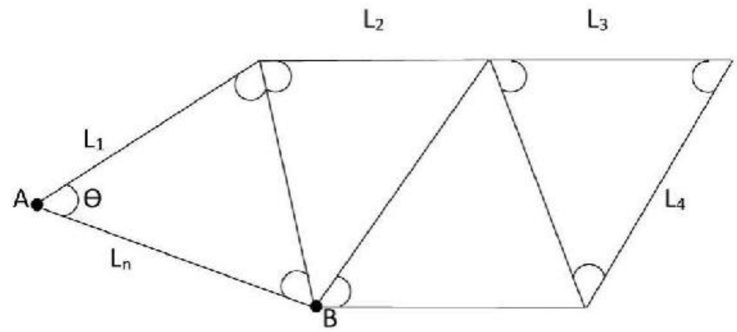

Figure 2: Trilateration network

c. **Traversing:** This is the process that leads to the series of connected straight lines whose bearings (α) and distances (L) are known. The figure formed by these connected straight lines is called a traverse or traverse network as shown in figure 3.

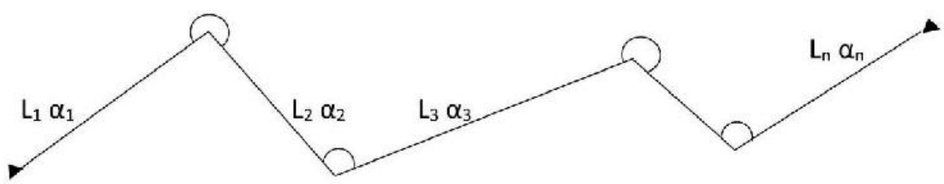

Figure 3: Traverse network

d. **Leveling:** This is the procedure for the determination of elevation/height difference between two survey points. That is, if the height of a survey point A is known, through leveling from A, the height of another survey point B can be determined.
e. **Intersection:** This involves dealing with fixing the position of unknown/uncoordinated inaccessible survey (intersected) point by taking observations from two known/coordinated accessible surveying points (AB).

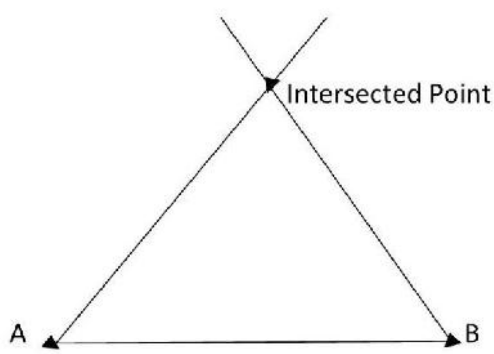

Figure 4: Showing intersected point

f. **Resection:** This is the process of fixing the position of an unknown/uncoordinated but accessible survey (resected) point by taking observations from the unknown resected point to three known/coordinated but inaccessible surveying points (A, B and C).

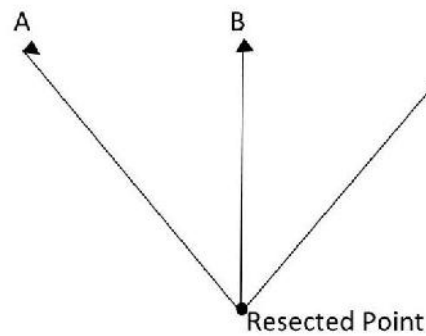

Figure 5: Showing resected point

g. **Offsetting:** It is the procedure that deals with measuring perpendicular line to a straight surveying line as shown in figure 6.

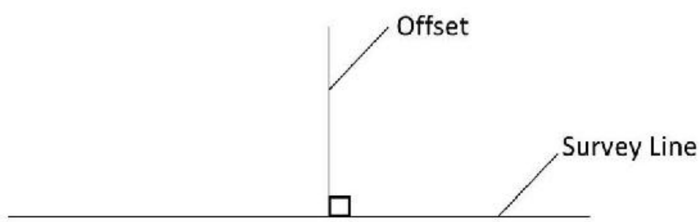

Figure 6: Showing offset on survey line

h. **Radiation:** This method involves using a fixed reference point and measuring angular directions of lines from this point.
i. **Tachymetry:** This is one of the methods used to determine distance between two points. It involves the of an instrument called tachymeter to simultaneously measure angles and vertical height difference between instrument station (A) and target station (B) to determine distance (AB).

Practice of surveying and geoinformatics

The progress being made in the growth of the surveying and geoinformatics profession is a function of the rules and regulations which have been formulated and applied to control the practice of surveying. In Nigeria, for instance, there are such rules and regulations that attempt to answer the following questions amongst others:

1. Who should practice surveying and geoinformatics?
2. What type of surveying and geoinformatics should be carried out by an individual or group of persons?

3. What are the specifications governing the surveying and geoinformatics operations to be carried out?
4. What are the expectations of the surveyors after surveying and geoinformatics exercises?
5. What should be taken into consideration when preparing the bill or quotation for a survey contract?

All the rules were made and are still being made, locally, regionally and globally, in form of decrees by the military governments or chapters of constitution, by-laws, edicts and other government resolutions by democratic governments. In Nigeria, Surveyors Licensing Board (SLB) was set up to regulate the practice of surveying. Later and till today, Surveyors Council of Nigeria (SURCON) has replaced SLB for the same purpose. Therefore, a person shall be called a Registered Surveyor if he/she has met all the conditions laid down by SURCON and is duly recognized and registered by SURCON to practice the profession of surveying and geoinformatics in Nigeria. The work of SURCON is being complemented by other government approved surveying organizations. Some of these surveying organizations are:

a. Nigerian institution of Surveying and Geoinformatics Students (NISGS);
b. Nigerian Institutions of Surveyors (NIS)
c. Federation of International Surveyors (FIS)
d. American Congress on Surveying and Mapping (ACSM)
e. Royal Institute of Chartered Surveyors (RICS)
f. Institution of Civil Engineering Surveyors (Inst CES)
g. The Society of Surveying Technicians (SST)

Fundamental principles of surveying and geoinformatics

The principles of surveying and geoinformatics are essential ingredients for producing precise and accurate measurements and maps/plans. They ensure that surveying and geoinformatics results are consistent, repeatable and useful for a wide range of applications. By following these principles, as stated below, surveyors will be able to provide valuable information for a variety of applications such as engineering, architecture, land management, environmental assessment etc.

1. **Working from whole to part**s: This involves starting with a large-scale (Whole) view of the survey area after which the small-scale views (Parts) are carried out within the frame work of the large-scale view. This is important to manage the possible build-up of errors within the survey area.
2. **Fit for purpose:** This involves making use of appropriate staff, techniques, instruments and methodology that fit the purpose for which surveying and geoinformatics is required.
3. **Integrity:** Surveyors must transparently maintain a high level of professional and ethical standard as well as avoid conflicts of interest in order to ensure the high integrity of the surveying and geoinformatics work.
4. **Safety:** The process involved in surveying and geoinformatics can be hazardous, especially, when working in remote or difficult terrain area. Therefore, appropriate safety precautions, to protect lives and surveying equipment must be well prepared for emergencies before work commences.
5. **Independent Check:** This involves possible use of more than one surveying methods and/or instruments for a particular task to verify measurements in order to ensure that the results obtained meet specifications.
6. **Accuracy and precision:** These are two key words in surveying and geoinformatics. They are related but different in principle. Accuracy refers to how close a measured value of a quantity is to the true value of the same quantity. Precision, on the other hand, refers to how

close many measured values of a quantity are to one another. Therefore, it can be inferred that a measured value of a quantity can be precise but not accurate.

Hardware

These are the components used to acquire, store, process and display geospatial data in surveying and geoinformatics. Detailed information about them are provided in Kavanagh (2012) and Idowu (2018). However, for easy reference, some of the common ones are presented below:

1. **Total Station (TS):** It is an electronic instrument used to measure angles, distances and coordinates. A typical total station is represented in Figure 7a.
2. **Global Navigation Satellite System (GNSS):** This is a satellite-based navigation system that provides accurate information about position of points. The GNSS comprises of the space-based satellites, control and user segments. The user segments is made up of receivers with antennas for capturing the satellite signals. The typical GNSS receivers are depicted in Figure 7b.
3. **Theodolite:** It is an instrument used for measuring angles in the horizontal and vertical planes. Figure 7c represents a digital theodolite
4. **Level:** This is an instrument used in surveying and geoinformatics to measure height differences between points. These levelling instruments are commonly categorised into: dumpy, tilting and automatic levels. Figure 7d represents a sample of the dumpy levelling
5. **Laser scanner:** This is a device that uses laser light to create a detailed three-dimensional (3-D) map of part of earth's surface. Figure 7e is a typical laser scanner
6. **Unmanned Aerial Vehicle (UAV)**: This instrument, also known as a Drone, is a small aircraft that can be fly remotely and autonomously (unmanly) for mapping. A sample of the UAV is depicted in Figure 7f
7. **Electronic Distance Measurement (EDM):** It is an electronic instrument used for measuring distances of surveying and geoinformatics lines. The EDM is commonly embedded in a total station instrument.
8. **Digitizer:** This is device for converting data from analogue to digital formats.
9. **Computer:** This is used for storing, manipulating and displaying geospatial data and results obtained.
10. **Output devices:** These are screen displayers, plotters and printers used for screen displaying, plotting and printing of geospatial data and results.
11. **Ground Penetrating Radar (GPR)**: This is used to generate radar waves to penetrate the ground for the purpose of creating an image of the subsurface. It is normally used to locate underground features such as pipes, cables and archaeological artifacts.
12. **Echo sounder:** This is a Sound Navigation and Ranging (SONAR) instrument used in hydrographic surveying and geoinformatics for measuring the depth of a water body. Figure 7g depicts a typical echo sounder.
13. **Other traditional instruments:** They include steel/linen tape, odometer, chain, compass, plane table, substance bar, hand level, clinometer etc.

Figure 7: Some modern surveying instruments (a) Total Station (b) GNSS Receivers (c) Digital Theodolite (d) Dumpy Level (e) Laser Scanner (f) UAV (Drone) (g) Echo Sounder

Software

These refer to computer programs, with different programming languages, designed to support the acquisition, processing, analysis and management of geospatial data. Some of the most commonly types of software being used in surveying and geoinformatics software are:

1. **Geographic Information Systems (GIS) software**: This is used for creating, managing, analyzing and visualizing geospatial data. It provides a wide range of functionalities such as

capturing, storing, processing, analyzing and presentation of geospatial data. Few of the popular GIS software are ArcGIS, QGIS, and GRASS GIS.

2. **Remote sensing software:** This is used for processing, analyzing, and visualizing data obtained from satellites or airborne sensors. It includes functionalities for image processing, classification and analysis. Some of popular remote sensing software include ENVI, ERDAS IMAGINE, and PCI Geomatics.
3. **Global Navigation Satellite Systems (GNSS) software:** It is used for processing and analyzing data obtained from satellite-based navigation systems such as GPS. It provides applications for data processing, analysis and visualization. Some of these are Trimble GPS Pathfinder Office, RTK-LIB, GAMIT/GLOBK, GIPSY-JPL, Bernese, GAPS, GPS Trackmaker and Garmin Base Camp.
4. **Web mapping software:** It is used for creating, publishing and sharing interactive maps over the internet. This includes functionalities for data visualization, analysis and collaboration. Examples of web mapping software include Google Maps, Map-box, and Leaflet.
5. **Geospatial database management software**: This is a management software used for storing, managing and querying geospatial data. It includes functionalities for data storage, indexing and querying. Examples of this software are Post-GIS, Oracle Spatial and Microsoft SQL Server.

Applications of surveying and geoinformatics in natural resource management and conservation.

Surveying and geoinformatics, in recent times, is being applied in several aspects of natural resource managements and conservation such as forest inventory, wildlife tracking, water supply scheme, waste management, watershed management, land use change, mining impacts, urbanization, site suitability assessment and soil erosion. Some of the applications of the concepts of surveying and geoinformatics in natural resource management and conservations are discussed below.

1. **Land cover mapping and monitoring**

   Land cover mapping and monitoring involves identification and analysis of changes in the natural and human-made features of the earth's surface. It is an essential component of environmental management, land-use planning and natural resource conservation. Surveying and geoinformatics plays a crucial role in land cover mapping and monitoring by providing accurate and reliable data on the spatial distribution and changes in land cover (Tata, Nzelibe and Ajayi, 2018).

2. **Marine studies and coastal management**

   This involves identification and analysis of the physical and biological features of the marine environment and their interaction with the coastal zone. Surveying and geoinformatics plays significant roles in marine studies and coastal management by providing accurate and reliable data on the spatial distribution and changes in the marine environment and the coastal zone. This includes the use of various surveying instruments and techniques to collect data on the location, depth, and attributes of features in the marine environment and the coastal zone (Nwilo, 2011).

3. **Inventory and monitoring of forest resources**

   Forests are very important in the world's ecosystems and economy, providing essential goods and services such as timber, clean air and water. The inventory and monitoring of forest resources are essential for sustainable forest management. Inventory and monitoring of forest resources involve the identification and analysis of the physical and biological features of forest ecosystems and their interaction with the environment. Surveying and geoinformatics plays a vital role in forest inventory and monitoring by providing accurate and reliable data on the spatial distribution and changes in forest ecosystems. This involves the use of various surveying instruments and techniques to collect data on the location, height, diameter, and attributes of trees and other features in forest ecosystems as well as analyze and manage these spatial data.

4. **Monitoring of wetlands**
   Wetlands are unique and diverse ecosystems that provide a range of ecological, social, and economic benefits. Wetlands monitoring is essential to ensure their long-term health and sustainability. Surveying and geoinformatics, in this case, provides accurate and reliable data on the spatial distribution and changes in wetland ecosystems. This involves the use of various surveying instruments and techniques to collect data on the location, elevation and attributes of wetland features.
5. **Mineral exploration**
   Surveying and geoinformatics play a critical role in mineral exploration as they provide essential data and information required for effective exploration and mining activities. This involves the measurement, mapping and analysis of the natural and man-made features of a given area. Its applications in mineral exploration include creating detailed maps of the terrain, geological structures and mineral deposits. It provides useful information to plan exploration activities and identify areas with high mineral potential, collect and analyze geospatial data in order to estimate the location, quantity and type of mineral deposit (Idowu and Abubakar, 2014).
6. **Water resource management**
   Surveying and geoinformatics plays an important role in water resource management as it accurately determines the locations of water sources such as rivers, lakes and groundwater aquifers for developing and managing water resources sustainably. Through the use of surveying and geoinformatics, water resource managers can create detailed maps and models of water resources needed for planning and implementing water management strategies, monitoring and managing the environmental impact of water resource development and management as well as water quality monitoring by locating pollution sources and detecting changes in water quality over time.
7. **Waste management**
   The process of managing waste which includes collection, transportation, disposal and treatment involves surveying and geoinformatics where spatial data must be accurately measured and analyzed to ensure efficient and effective management of waste (Tata, and Nzelibe, 2019).
   Waste collection is the first step in waste management where surveying and geoinformatics can be used to plan the routes of waste collection trucks to optimize the collection process and minimize the time and resources required for waste collection and to monitor the progress of waste collection trucks in real-time by allowing for better tracking of the collection process.
   Waste disposal involves removal of waste from its origin to its prepared final destination. In the process, surveying and geoinformatics can be used to identify a suitable final location of waste disposal sites.
   Waste treatment is the process of converting waste into useful product for the benefit of the environment. During this process, surveying and geoinformatics can be used to plan the location and design of waste treatment facilities needed for processing waste and converting it into useful products.
   Environmental impact assessment is the process of evaluating the consequences of certain

activities
in a particular environment. Surveying and geoinformatics can be used, in this process, to evaluate the
effect of waste management activities in a typical locality. This assessment can help to identify potential
environmental risks for immediate mitigation.

8. **Seismic studies and monitoring**
This is important in understanding the behavior of the earth's crust and detecting seismic activity. Seismic studies involve the use of seismic waves to study the properties of the subsurface to detect and record seismic activity. Surveying and geoinformatics play important roles in seismic studies and monitoring to locate seismic stations, measure the magnitude and analyze the data collected from seismic sensors.
Locating seismic stations is the first step in seismic studies and monitoring to locate seismic stations.
Surveying and geoinformatics is used to determine the coordinates of the stations, limiting depth and total
depth of the mineral's center of mass.
Measuring seismic events: Surveying and Geoinformatics are used to measure the magnitude and
location of seismic events. Seismic waves travel through the earth's crust and can be detected by seismic
sensors. The sensors record the seismic waves and the data recorded will be analyzed to determine the
location and magnitude of the event.

9. **Drainage systems**
Drainage systems are infrastructures which are designed to remove excess water from urban and rural areas to prevent flooding and ensure proper sanitation. Surveying and geoinformatics play an important role in the design, construction and maintenance of drainage systems using techniques such as topographic and hydrographic surveys to map the natural and man-made features of the terrain and water bodies. The information collected will be analyzed to determine the flow of water, slope, elevation of the terrain and the location of existing drainage systems as well as designing effective drainage systems that can withstand flooding and reduce the risk of property damage and loss of life (Idowu, Edan and Damuya, 2013):

Employment opportunities in surveying and geoinformatics

Many opportunities exist for surveying and geoinformatics science specialists in private firms, government ministries and parastatals, non-governmental organizations etc. These include:
Ministries of work, Housing, Land and Survey
Federal and States Housing Development Corporation or Authorities
Federal Environmental Protection Agencies
Banks and other Finance Institutions
Electric power co-operations
Telecommunication Agencies
Ports Authorities
Oil exploration and marketing companies
Oil services and offshore engineering private companies
Universities, Polytechnics and other Research Centers and Institutions

Private surveying and geoinformatics companies
Agricultural development agencies
Dredging and marine resource agencies
Engineering construction companies
Armed forces (Army, Airforce and Navy)

Summary

This chapter has presented basic concepts of surveying and geoinformatics in natural environment. Brief definition and types of natural environment have been provided. Definition, scope, abridged history, uses and classes of surveying and geoinformatics have been highlighted. Also, the fundamental principles and practice of surveying and geoinformatics were explained. Brief explanation of the hardware and software used in surveying and geoinformatics have been provided. The chapter went further to briefly discuss the applications of surveying and geoinformatics in natural resource management and conservation. It concluded by identifying many employment opportunities for experts and specialists in the profession of surveying and geoinformatics in natural environment.

Exercise

1. Briefly explain the meaning and type of natural environment
2. List the uses and classes of surveying and geoinformatics
3. Write short notes on fundamental principles and practice of surveying and geoinformatics
4. Outline the hardware and software used in surveying and geoinformatics
5. Briefly discuss the applications surveying and geoinformatics in natural environment
6. List ten areas of employment opportunities for surveying and geoinformatics experts.

References

Anderson, J. M. and Mikhail, E. M. (2018). Surveying: Theory and practice. McGraw-Hill Education.

Badejo O. T. (2011) Contemporary Issues in Surveying and Geoinformatics: Modern trends in hydrography. Edited by F.A Fajemirokun

Brinker, R. C. and Minnick, R. (1995). The surveying handbook. Van Nostrand Reinhold.

Idowu, T. O. (2012). Unpublished lecture notes on introduction to surveying and geoinformatics.

Idowu, T. O., Edan, J. D. and Damuya, S. T. (2013). Estimation of the quantity of surface runoff to determine appropriate location and size of drainage structures in Jimeta Metropolis, Adamawa State, Nigeria. *Journal of Geography and Earth Science, 1(1), pp 19-29.*

Idowu, T. O. and Abubakar, T. (2014). Determination of type of underground mineral deposit in Gongola basin, Nigeria using gravimetric technique. *International Journal of Science and Technology (IJST), Vol. 4, No. 1, pp 17-25.*

Jensen, J. R. (2016). Remote sensing of the environment: an earth resource perspective. Pearson.

Kanetkar, T. P. (2008). Surveying and levelling. Everest Publishing House.

Kavanagh, B. F. (2012). Surveying: principles and applications. Prentice Hall.

Kavanagh, B. F. and Mastin, T. (2010). Surveying: Principles and applications. Prentice Hall.

Kavanagh, B. and Slattery, D. K. (2011). Surveying with construction applications. Prentice Hall.

McCormac, J. C. and Wilhelm, W. E. (2016). Surveying. John Wiley & Sons.
Nwilo P. C. (2011) Contemporary Issues in Surveying and Geoinformatics: Sea level variations along coast of Nigeria. Edited by F.A Fajemirokun
Tata, Herbert, Nzelibe, Ifechukwu Ugochukwu and Ajayi, Gabriel Esan. (2018) Spatio-Temporal Analysis of Urban Land Cover Growth Dynamics in Akure South Metropolis, Ondo State Nigeria. *Earth and Atmospheric Sciences;* USA. Vol. 1, No. 1, pp. 1-9.
Tata, H., Nzelibe, I. U. and Faneye, A. J. (2019). Bathymetric Mapping for Safe Navigation: A Case Study of Part of Lagos Lagoon. *African Scholar Journal of Environmental Design and Construction Management*. Center for Urban and Regional Planning University of Ibadan, Ibadan Oyo State, Nigeria. Vol. 14 No. 3 ISSN: 1896-6782.
Tata, Herbert and Nzelibe, Ifechukwu Ugochukwu (2019). "Mapping and Analysis of Site Suitability for Waste Disposal in the Federal University of Technology, Akure Ondo State, Nigeria." *Journal of Environmental Technology (SETJET)* FUTA, Akure 1(2): 101–11.
Wolf, P. R. and Ghilani, C. D. (2012). Elementary surveying. Prentice Hall.

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CHAPTER 21
Introduction to Technical French Language
By
OYINLOYE Raphael Olaniyi

This chapter has been designed to expose students of surveying and geoinformatics to the rudiments of technical French language, commonly used in measurement, weighing, volume and communicate figures in French as well as being able to read scientific publications. French language was first used in an official document in 842 AD and has since become one of the leading languages of the world. Its origin is France, which formally adopted it as her official language in 1539. The French language became the official language of France after the French revolution which took place in 1789. It was from France that French entered other parts of the world through colonization of Africa and the Far - East, emigration (Canada, and USA) and through culture and civilization (many other countries in which French enjoyed acceptability and popularity). Since early 1970s, the Standard International (SI) unit of measurement which is actually the French system of measurement has been adopted in the technical, scientific and construction industry globally. Even the countries that retained the imperial unit of measurement still keep the SI unit side by side with the imperial unit. It is necessary to highlight here that most international scientific technical conferences are held in English and French languages under simultaneous interpretation or with parallel sessions in English and French languages. It is thus imperative to have the knowledge of written and/or spoken French. French language is one of the modern European languages and the official language of many countries in Africa. Specifically, French is the official language of many West African countries and all the countries surrounding Nigeria (Benin, Cameroun, Niger and Chad) are Francophone with French as their official language. Furthermore, Nigeria is a member of the Economic Commission of West African States (ECOWAS) which is bilingual in English and French as official languages. Thus, in locating, determining or defining the international boundaries or even resolving boundary disputes with these countries, the students of surveying and geoinformatics need the minimum knowledge of technical French language. Furthermore, Nigeria shares borders with these countries which provide economic, social and commercial activities between them as well as cultural activities between the towns and villages along the boundaries.

Objectives

At the end of this chapter, students should be able to:

1. read alphabets, numbers and communicate in French language;
2. read scientific publications written in French language and participate at conferences organized for French speaking audience;
3. engage in surveying and geoinformatics computations in the SI unit and be able to convert from the imperial unit to the SI unit;
4. evaluate mathematical expressions written in French and construct simple and short sentences in French to express the results and analysis of the results;
5. conjugate the three groups of French verbs in the simple present and past forms;
6. participate in a project team comprised of both Anglophone and Francophone in surveying and geoinformatics professionals;
7. state the French names of common surveying and geoinformatics instruments and make reliable recording of field observations and measurements using the instruments; and
8. identify the essential features of the computer hardware and use French software package for data processing, interpret and communicate the outputs in French language.

Introduction

Surveying and geoinformatics, as one of the professions in the construction industry, is indispensable in the location of construction sites, setting-out of development projects and demarcation of boundaries between land parcels, international boundaries on land and in the continental shelf territorial waters, assisting the military in their operations, monitoring, mapping and management of natural resources etc. It could be recalled that Nigeria is surrounded by francophone countries and being a member of the Economic Commission of West African States (ECOWAS) will be at a serious disadvantage if her technical experts in the surveying and geoinformatics are devoid of working knowledge of, at least, rudimentary technical French language. Therefore, the necessary outlines of the required technical French language which are sufficient to put the experts of surveying and geoinformatics in a good position for the tasks are:

1. Learning of the Arabic numbers in French and Introduction to French verbs;
2. French Verbs, The Art of Conjugating French verbs and Simple Past;
3. Article, what is it? Main Features of Articles, Definite and Indefinite Articles;
4. What is a Noun? Functions of a Noun in a Sentence, Special Features of Nouns. Pronouns;
5. Adjectives, Types of Adjective, Special features of Descriptive Adjectives;
6. Adverbs and Prepositions;
7. Specific Terminologies in Surveying and Geoinformatics including Photogrammetry, Remote Sensing, Instruments and Devices;
8. Reading of some small historical or fiction booklets;
9. French Dictations: Numerical figures, words Terminologies Surveying and Geoinformatics including Photogrammetry, Remote Sensing, Instruments and Devices; and
10. Revision.

Learning of the arabic numerals in French and introduction to French verbs

The learning of numbers and alphabets in French is basic. The numbers in figures and words from **0** to **1000** and the alphabets from **a** to **z** as well as the vowels are required. It is emphasized here that the numbers with decimals are of the form (**n,m), e.g. 11,12** while **one hundred and fifty thousand is written as 150.000**.

French is a rich language because it has accents that control the pronunciation of words. The basic vowels of the alphabet are a,e,i,o,u. The vowels could have different accents depending on the word. The accents are, for example, as observed in **é**, **è**, **ô**, **ï**, e.g., guérrier, fiancé, congé, étude, réunir, après, promène, règle, caractère, frontière, rivière, diplôme, forêt, théâtre, bientôt, chaîne, traîner, côtiser, coûter, être, français, haïr, trahïr, ouïr, etc.

French verbs, The art of conjugating French verbs and simple past of French verbs

French verbs

The verb is an action word and thus it is the ***central word*** or ***power unit*** in a clause or sentence. There are three groups of French verbs, first, second and third groups:

The first group of verbs: This ends in **er** in they infinitive form, e.g., aimer, tomber, aller, jeter, mesurer, peser, placer, lever, céder, apeler, créer, donner, accepter, parler, assayer, regarder, compter, écouter, payer, donner, diviser, multiplier, additioner, agréer, marquer, manger, apprécier, modeler, envoyer, employer, amener, etc. This first group constitutes the majority of French verbs.

The second group of verbs: It ends in **ir** in the infinitive form. Examples are finir, venir, tenir, grandir, blanchir, sentir, agrandir, salir, remplir, élargir, acquérir, aboutir, affaiblir, agir, bénir, courir, établir, accomplir, guérir, faillir, fleurir, franchir, fuir, intervenir, mourir, offrir, nourir, etc.

The third group of verbs: This is a little bit complicated. They are often referred to as irregular verbs. In general, they constitute the other verbs that are neither in the first group nor in the second group. They consist of a mixture of verbs that end in **oir or** in **re**. Examples are concevoir, voir, pourvoir, choir, croir, pourvoir, recevoir, pleuvoir, falloir, vouloir, choir, comprendre, connaitre, être, prendre, rendre, battre, mettre, joindre, vaincre, faire, plaire, connaitre, naitre, croitre, croire, boire, conclure, coudre, suivre, vivre, lire, dire, rire, écrire, cuire, construire, confondre, débattre, conduire, savoir, devoir, mouvoir, falloir, valoir, vouloir, craindre, boire, etc.

Mention should be made of the auxiliary verbs. These are verbs used to conjugate other verbs. They are the verbs aller, **être** and **avoir**. When they are conjugated (in the present tense), any other verb that immediately follows must be in the infinitive. The pronominal verb should also be briefly touched. They pronominal verbs follow **se.** Example are **se faire**, **se tenir**, **se metre**, **se jeter**, **se tomber**, etc.

The art of conjugating French verbs
The conjugation of French verbs is easily understood according to the group.
The first group is conjugated as follows:

Verb aimer
J'aime, Tu aimes, Il/Elle aime, Nous aimons, Vous aimez, Ils/Elles aiment

Verb manger
Je mange, Tu manges, Il/Elle mange, Nous mangeons, vous mangez, Ils/Elles Mangent

Verb parler
Je parle, Tu parles, Il/Elle parle, Nous parlons, Vous parlez, Ils/Elles Parlent

Verb payer
Je paie, Tu paies, Il/Elle paie, Nous payons, Vous payez, Ils/Elles paient

Verb regarder
Je regarde, Tu regardes, Il regarde, Nous regardons, Vous regardez, Ils/Elles regardent
The second group is conjugated as follows:

Verb finir
Je finis, Tu finis, Il/Elle finit,, Nous finissons, Vous finissez, Ils/Elles finissent

Verb sentir
Je sens, Tu sens, Il/Elle sent, Nous sentons, vous sentez, Ils/Elles sentent

Verb tenir
Je tiens, Tu tiens, Il/Elle tient, Nous tenons, Vous tenez, Ils/Elles tiennent

Verb courir
Je cours, Tu cours, Il/Elle court, Nous courons, Vous courez, Ils/Elles Courent

Verb fuir

Je fuis, Tu fuis, Il/Elle fuit, Nous fuyons, Vous fuyez, Ils/Elles fuient
The third group is conjugated as follows:

Verb Avoir
J'ai, Tu as, Il/Elle a, Vous avez, Nous avons, Ils/Elles ont

Verb voir
Je vois, Tu vois, Il/Elle voit, Nous voyons, Vous voyez, Ils/Elles voient

Verb pourvoir
Je pourvois, Tu pourvois, Il/Elle pourvoit, Nous pouvoyons, Vous pourvoyez, Ils/Elles pourvoient

Verb devoir
Je dois, Tu dois, Il/Elle doit, Nous devons, Vous devez, Ils/Elles doivent

Verb savoir
Je sais, Tu sais, Il/Elle sait, Nous savons, Vous savez, Ils/Elle savent

Verb pouvoir
Je peux, Tu peux, Il/Elle peut, Nous pouvons, Vous pouvez, Ils/Elles poivent

Verb être
Je suis, Tu es, Il/Elle est, Vous êtes, Nous sommes, Ils/Elles sont

Simple past of French verbs
Using the conjugated verbs, the simple past tense of the verbs in that order are as follows:

Verb aimer
J'ai aimé, Tu as aimé, Il/Elle a aimé, Nous avons aimés, Vous avez aimé, Ils/Elles ont aimé

Verb manger
J'ai mangé, Tu as mangé, Il/Elle a mangé, Vous avez mangé, Nous avons mangé, Ils/Elles ont mangé

Verb parler
J'ai parlé, Tu as parlé, Il/Elle a parlé, Vous avez parlé, Nous avons Parlé, Ils/Elles ont parlé

Verb payer
J'ai payé, Tu as payé, I/Elle a payé, Vous avez parlé, Nous avons parlé, Ils/Elles ont parlé

Verb aller
Je suis allé, Tu es allé, Il/Elle est allé, Vous êtes allés, Nous sommes allés, Ils/Elles sont allés

Verb regarder
J'ai regardé, Tu as regardé, Il/Elle a regardé, Vous avez regardé, Nous avons regardé, Ils/Elles ont regardé

Verb finir
J'ai fini, Tu as fini, Il/Elle a fini, Vous avez fini, Nous avons fini, Ils/Elles ont fini

Verb sentir
J'ai senti, Tu as senti, Il/Elle a senti, Vous avez senti, Nous avons senti, Ils/Elles ont senti

Verb tenir
J'ai tenu, Tu as tenu, Il/Elle a tenu, Vous avez tenu, Nous avons tenu, Ils/Elles ont tenu

Verb courir
J'ai courou, Tu as couru, Il/Elle a couru, Vous avez couru, Nous avons couru, Ils/Elles ont couru

Verb fuir
J'ai fui, Tu as fui, Il/Elle a fui, Vous avez fui, Nous avons fui, Ils/Elles ont fui

Verb avoir
J'ai eu, Tu as eu, Il/Elle a eu, Vous avez eu, Nous avons eu, Ils/Elles ont eu

Verb voir
J'ai vu, Tu as vu, Il/Elle a vu, Vous avez vu, Nous avons vu, Ils/Elles ont vu

Verb pourvoir
J'ai pourvu, Tu as pourvu, Il/Elle a pourvu, Vous avez pourvu, Nous avons pourvu, Ils/Elles ont pourvu

Verb devoir
J'ai dû, Tu as dû, Il/Elle a dû, Vous avez dû, Nous avons dû, Ils/Elles ont dû

Verb savoir
J'ai su, Tu as su, Il/Elle a su, Vous avez su, Nous avons su, Ils/Elles ont su

Verb être
J'ai été, Tu as été, Il/Elle a été, Vous avez été, Nous avez été, Ils/Elles ont été

Verb battre
J'ai battu, Tu as battu, Il/Elle a battu, Vous avez battu, Nous avons battu, Ils/Elles ont battu

Verb mettre
J'ai mis, Tu as mis, Il/Elle a mis, Vous avez mis, Nous avons mis, Ils/Elles ont mis

Verb faire
J'ai fait, Tu as fait, Il/Elle a fait, Vous avez fait, Nous avons fait, Ils/Elles ont fait
Verb boire
J'ai bu, Tu as bu, Il/Elle a bu, Vous avez bu, Nous avons bu, Ils/Elles ont bu

Verb é**crire**
J'ai écrit, Tu as écrit, Il/Elle a écrit, Vous avez écrit, Nous avons écrit, Ils/Elles ont écrit

Verb vivre
J'ai vécu, Tu a vécu, Il/Elle a vécu, vacuous avez vécu, Nous avons vécu, Ils/Elles ont vécu

Verb lire
J'ai lu, Tu as lu, Il/Elle a lu, Vous avez lu, Nous avons lu, Ils/Elles ont lu

Verb dire
J'ai dit, Tu a dit, Il/Elle a dit, Vous avez dit, Nous avons dit, Ils/Elles ont dit

Verb rendre
J'ai rendu, Tu as rendu, Il a rendu, Il/Elle a rendu, Vous avez rendu, Nous avons rendu, Ills/Elles ont rendu

Verb prendre
J'ai pris, Tu as pris, Il/Elle a pris, Vous avez pris, Nous avons pris, Ils/Elles ont pris

Verb Rire
J'ai ri, Tu a ri, Il/Ell a ri, Vous avez ri, Nous avons ri, Ils/Elles ont ri

Definition of article, main features of articles, definite and indefinite articles
Definition and main features of articles
Articles are the words for presenting or identifying nouns, which they immediately precede, except when there is an intervening adjective before the noun and so the article is placed before such an adjective. In French, articles are grouped into three subdivisions. Apart from this special feature, French articles follow the French language law of agreement by agreeing in number and gender with the noun or pronoun that any of the articles introduces. Therefore, articles are either singular or plural and they are either masculine or feminine as shown in table 1).

Table 1: Features of articles

Gender	**Definite**	**Indefinite**	**Partitive**
Masculine Singular	le/l'	Un	du/de l'
Feminine Singular	la/l'	Une	de la/de l'
Masculine and Feminine Plural	Les	Les	Des

L' is the form of the definite article used before nouns beginning with any of the vowels (a, e, i, o, u) and also before a mute (silent) h, whether the noun is masculine or feminine. E.g.: l'Afrique, l'eau, l'éléctricité, l'angle, l'ordinateur, l'avion, l'idée, l'image, l'air, l'analyse, and l'hiver, l'homme, l'horloge, l'hôpital, l'arrivée, l'histoire, l'hélicoptère, l'harmonie, l'héritage, l'exemple, etc.

On definite articles
However, changes occur when the definite article is used with the preposition **de** or **à**
For example:
de + **le** changes to **du**: Je parle **du** ballon

de + **les** changes to **des**: Je parle **des** images avec mon camarade
à + **le** changes to **au**: Je vais **au** terrain, Je vais au village demain
à + **les** changes to **aux**: Il voayage **aux** Etas-Unis

Note that there is no contradiction when any of the prepositions is used with **la** or **l'**. Examples are:

Il a donné dix naira **à** lhomme
Je vais **à** l'école
Le bout **de la** banane est sale
Il prend le stylo **de la** poche

The definite article + aspirated h has a peculiar nature

The definite article is used in its full form (**la**, **le**) before an aspirated **h**: (the form of '**h**' which, because of its aspirated nature, does not allow any liaison or elision with the word preceding it)
le hall, le héros, le huit, le handball, le hameau, le heurt, le harcèlement, le haricot, le huis clos, le hockey, le Honduras, la Havanne, la Hongrie, la halle, la halte, la houille, la basse, la hiérarchie, la Hollande, la honte, ét cétéra.

On indefinite articles

The indefinite article is generally used in French language whenever the noun is being introduced in an indefinite manner such as un garçon, une jeune fille, des garçons, le père, la mère, etc.
Examples:

Un chien est devant la porte	-	**Des chiens sont devant la porte**
Un stylo sert à écrire	-	**Des stylos sont envoyés par mon ami**
Il reste une chambre à coucher au premier étage	-	**Il y a des chambres qui ne sont encore occupées**
Il garde une chemise dans l'armoire	-	**Il garde des chemises dans l'armoire**
C'est un Nigerian	-	**Ce sont des Nigérians**
C'est un avocat	-	**Ce sont des avocats**
C'est un é**tudiant**	-	**Ce sont des** é**tudiants**
Il est Nigérian	-	**Ils sont des Nigérians**
Il est avocat	-	**Ils sont des avocats**
Elle est chrétienne	-	**Elles sont chrétiennes**

On partitive articles

The partitive, compressed form of de + indefinite article (du, de l', de la, des) meaning *some*, *part of* and *from* article is used before nouns that are uncountable or of undetermined quantity: du sel, du café, du sucre, du beurre, de leau, de l'huile, de l'argent, de la monnaie, des gateaux, des arbres, des maisons, etc.

a. It is to be noted that the partitive article is used whenever the notion of *some* or *any* is implied with reference to a singular or plural noun: **Je veux du thé et tu veux du café; Avez-vous des questions à me poser?; Ya-t-il des étudiants dans la sale de cours?; Il fait du bruit; Il a de la fièvre; Pour être en forme, mangez des épinards et des gâteaux; etc.**

b. In a similar way, it is to be noted that the partitive article is used whenever there is a need to determine a noun that is trying to convey a partitive or indefinite meaning: **J'ai de l'argent; Tu veux du vin ou du café ou du jus d'orange?; Le pasteur conseille au condamné à mort de faire prevue du courage; J'aime le vin; Je déteste la limonade; Je préfère le paradis à l'enfer**

c. The full partitive is used when reference is made to such products as wine, cheese and tobacco. It is to be noted that the product begins with a small letter: **du champagne**, **du bordeaux**, **du tabac**, **du ballon**, **du virginie**, **du maryland**, etc.

Noun, functions of a noun in a sentence, special features of nouns and pronouns

What is a noun?
A noun is the name of a place, person, thing, quality, action, objects, etc. It serves to identify living things including human beings. We can have (i) proper noun such as names of persons or countries (God, Raphaël, Michel, Oloukoi, Didier, Jean, Paris, Toulouse, Nigéria, France, Lagos, Abuja, etc.); (ii) common noun such as table, chaise, maison, cuisine, etc or (iii) collective noun such as ensemble, forêt, foule, people, troupeau, etc.

Functions of a noun in a sentence
While a noun can be used alone, as a single word, in response to a question or in enumerations, it is generally used in a sentence to play the following roles:
(i) subject of a verb: <u>L'**homme**</u> **regarde la femme**
(ii) complement of a subject: **Monsieur David est professeur et auteur en même temps**
(iii) direct object of transitive verb: **J'aime la mademoiselle**
(iv) complement of the second object: **Le médecin a donné une piqûre au malade**
(v) complement of a noun: **Un verre <u>de bière.</u> Une paire de bottes**
(vi) to form an adverbial phrase of:
place: **Vous me verrez à l'église**
time: **Il lave ses slips tous les trois jours**
cause: **Il pleure de joie**

Special features of nouns
French language nouns have specific features, which impose on each learner or user of the language the need to pay very special attention to every noun learnt or used. It has a gender being either **masculine** (m) or **feminine** (f). There is no neural gender, unlike in English language:
(a) The gender is not necessarily semantic, that is, signified by the meaning of the word. **Un siège** and **une chaise,** for example, refer to object belonging to an identical concept – objects for sitting. **Un rat** and **une souris** refer to an identical animal. **Professeur** (m), **amateur** (m), **médecin** (m), **docteur** (m), **chauffeur** (m), **secrétaire** (m), **auteur** (m), **maire** (m), **député** (m), **avocat** (m), **ingénieur** (m), **ministre** (m), **chef** (m), **poète** (m), **écrivain** (m), **juge** (m), **peintre** (m), **témoin** (m), **soldat** (m), **diplomate** (m) refer to both males and females but they are masculine nouns.
The female of the above may be determined by the use of **femme: une femme médecin**, **une femme écrivain**, **une femme soldat**, **une femme diplomate**, etc. The following are also commonly said: **Madame le minister**, **la Ministre Fatima**, **la député-maire de Lyon**, etc. On the other hand, the following words are feminine: **relation**, **équipe**, **victime**, **famille**, **faculté**, **armée**, **nourrice**, **amazone**, **personne**, **table**, **fenêtre**, **dent**. Other words are both feminine and masculine: **touriste**, **élève**, **libraire**, **camarade**, **artiste**.

Pronouns
A pronoun is a word used in place of noun, an element, a clause, a sentence or an idea. It can be used as the subject, the direct object or the indirect object of a verb or after a preposition. There are different types of pronoun serving different purposes. Some pronouns, for example, help to reduce sentences

or phrases, by helping the speaker to avoid repeating a noun, a statement or an idea that has already been given or used.

For example: **J'ai vu le garçon qui est venu** nous vendre le tissu

C'est vrai, je l'ai vu devant l'église. Oui, je l'y ai vu

J'ai pris une partie **de la sauce**. J'**en** ai pris une partie

We can have the following different types of pronoun: personal pronoun, possessive pronoun, demonstrative pronoun, relative pronoun, interrogative pronoun, indefinite pronoun and exclamatory pronoun. Of much relevance to us in technical French language is the personal pronoun, which can be either singular or plural; and can be one of the three persons:

1st person singular – I, me **Je**, **moi**
1st person plural – We, us **nous**
2nd person ingular – You **tu**, **te**, **toi**
2nd person plural – You **vous**
3rd person singular – He/she, it, him/her **Il**, e**lle**, **le**/**la**, **se**, **lui**, **elle**, **soi**
3rd person plural – They, them **Ils**, **elles**, **les**, **leur**, **eux**, **elles**, **soi**

Adjectives, types of adjective, special features of descriptive adjectives

Adjectives

An adjective is a word used in qualifying, defining, modifying, specifying, supporting or accompanying a noun or pronoun. As a rule, the adjective, being variable, agrees in gender and number, with the noun or pronoun to which it is associated. It is used with both of the two parts of speech (nouns and pronouns) as either a direct modifier (**une épithète**) or a predicate (**un attribu**t) or in apposition.

Examples:

(a) Predicate or attribute adjective, linked to the noun through a **verb - to be** (**être**, **paraîte**, **sembler**, **devenir**, etc.)

Le garçon (Il) est beau
La fille (Elle) paraît belle
Les garcons (Ils) semblent tous beaux
Les filles (Elles) sont sans aucun doute belles

(b) Direct modifier or epithet, placed immediately after or before the noun:
J'ai une belle robe, un beau boubou, de jolis stylos, des chemises neuves, des pantaloons rouges et des costumes vert foncé

(c) In apposition to nouns, placed before the noun: **Gourmand, le garcon ne fait que manger** (Fond of eating, the is always eating something)

Types of adjective

There are different types of adjective with each one performing the duty of qualifying a noun or pronoun:

(a) The first category is made up of specific words, each of which agrees in number and gender with the noun to which it refers. They are:

Possessive adjectives: e.g. **mon**, **ma**, **mes**; **ton**, **ta**, **tes**, **son**, **sa**, **ses**, etc.
Demonstrative adjectives: e.g. ce, cet, cette, ces, etc
Relative adjectives: e.g. **lequel**, **auquel**, **duquel**, **laquelle**, etc.
Interrogative adjectives: e.g. **quel**, **quelle**, **quelles**
Indefinite adjectives: **certain**, **chacun**, **nul**, etc.
Numeral adjectives: **un**, **deux**, **trois**, **quatre**, **premier**, **deuxième**, etc.

(b) The second category is the descriptive adjective which, as the name implies, performs the function of describing (of giving helpful information on) the noun or the pronoun to which it refers:

Une voîture blanche
Un chien noir
Une maison verte

Special features of descriptive adjectives

The three special aspects of descriptive adjectives to which attention should be paid are:
(a) the position of such adjectives when used directly with nouns;
(b) the implications of its variable nature as touching feminization and pluralisation; and
(c) its degrees: comparative and superlative forms

In French, descriptive adjective follows, in general, the noun which it qualifies. However, there are many exceptions to this general rule; the effect of which makes certain adjectives to precede the nouns, while a few adjectives are placed with relation to the nouns at the discetion of the user or the speaker. Examples are:

Un livre utile, un homme génèreux, un livre noir, un home blanc, une chemise bleue;

Le dipolmate nigérian s'habille bien; Ce problème gênant n'a pas été résolu; Le participe passé s'emploie beaucoup en français; C'est une femme extrèmement élégante, C'est un concept fondamentalement conçu; C'est une idée formidablement conçue; C'est une si belle dame!; C'est une assez chère merchandise; C'est une histore trop dure à dénouer; C'est une photocopieuse trop vielle pour faire la photocopie; C'est un professeur trop difficile à comprendre; Voici un home extraordinaire; Il s'agit d'une situation dangereuse et déplorable (It is about a situation that is dangerous and disgraceful); Le jeune home est beau; La vielle femme est vraiement grosse; Le meilleur candidat a toujours gagné; C'est un grave incident qui a forcé le roi à parler devant le public ce soir.

Un musée **ancien** – an old/ancient museum
Un **ancien** musée –a former museum
Un **brave** home –a good/fine man
Un home **brave** – a brave/courageous man
Un cher ami – a dear/beloved friend
Une chemise chère – a costly shirt
Le dernier jour de la semaine est samedi – the last day of the week is saturday
Le jour dernier – the last day (previous to the last one)
Le même endroit – the same place
La sagesse même – wisdom itself
Un seul garçon – a single boy/only
Un garçon seul – a boy alone/a lonely boy
Une vraie histoire – a real story
Une histoire vraie – a true story

Adverbs and prepositions

Adverbs

An adverb is a word or word that does not change, which describes or add to the meaning of a verb, a qualifying adjective, other verbs or even a sentence. It is the only part of speech that helps to change or modify the sense of verbs. It supplies answers to such questions as **Comment? Quand?**, **Où**? The identity of every adverb is identified by its function. Thus, we have:

Adverbs of manner – used to modify verbs, adjectives, other adverbs and nouns. Most of the adverbs of manner end in **–ment** by adding **–ment** to the feminine singular form of most of the adjectives: **frais** – **fraîchement**; **heureux** – **heureusement**; **calme** – **calmement**; **fou** – **follement**; **doux** – **doucement**; **direct** – **directement**; **complet** – **complètement**; **pur** – **purement**; **net** – **nettement**; **excessif** – **excessivement**; etc.
It should be realised that there are many other types of adverb such as adverbs of quantity, adverbs of time, adverbs of place, adverbs of cause and consequence, etc., which are not described since we are not students of French language. We may come across some of such adverbs in the course of discussion.

Prepositions
A preposition is a word used (positioned) before (pre) a noun, pronoun, verb or phrase to establish the word's connection with another word or phrase. It is indispensable, as for its meaning, from the word that it introduces. In other words, except it is attached to the word that it introduces, the preposition does not reflect its full and distinct meaning. We should note that prepositions are invariable.
As illustrations, prepositions are written in bold and underlined in the following sentences:
Il a filé **à** l'anglaise; **<u>A</u>** mon arrivée, je me suis déshabille; Il a battu le garçon **<u>de</u>** toutes ses forces; Rien de comique **<u>dans</u>** ce spectacle; Ecris **<u>à</u>** ton père; On le traite **<u>de</u>** voyou; Quant **<u>à</u>** moi, je suis assidu.
The following are the commonly used one-word prepositions: à; après; avant, avec, chez; contre; dans; de; depuis; derrière, dès; devant; durant; en; entre; envers. hormis; hors; jusque; malgré; moyennant; outre; par; parmi; pendant; plein; pour; près; proche; sans; sauf; selon; sous; suivant; sur; vers; vu. The common mistakes in the use of **à** or **de** prepositions are well treated in the list of references provided at the end of this chapter.

Specific terminologies in surveying and geoinformatics including photogrammetry, remote sensing, instruments and devices
As found in other disciplines, there are specific terms and jargons used to express specific concepts, ideas and principles in surveying and geoinformatics and its specializations. We begin by unit of measurement:

Linear, **area**, **volume**, c**apacity and weight**.

Linear measurements: There are: 1millimètre (mm); 10mm = 1centimètre (cm); 10cm = 1decimètre (dm); 10dm = 1mètre (m); 1000m = 1kilomètre.

Area measurements: There are: 1mm^2; 1cm^2; 1dm^2; 1m^2; 1km^2; 100mm^2 = 1cm^2; 100cm^2 = 1dcm^2; 100dm^2 = 1m^2; 10^{6}m^2 = 1km^2; 10^{4}m^2 = 1 hectare

Cubic measurements: There are: 1000mm^3 = 1cm^3; 1000cm^3 = 1dm^3; 1000dm^3 = 1m^3; 1000m^3 = 1km^3

Capacity measurement: There are: 10mililitre (ml) = 1centilitre (cl); 10cl = 1decilitre (dl); 10dl = 1litre (l)

Weight measurement: There are: 10 miligrammes (mg) = 1centigramme (cg); 10cg = 1 decigramme (dg); 10dg = 1 gramme (g); 1000g = 1kg; 1000kg = 1tonne (t)

Some of the specific terminologies are:
Topographie – Surveying; **Géoinformatiques** – Geoinformatics; **Photogrammétrie** – Photogrammetry; **Télédétection** – Remote Sensing; **Absorptance** – Absorptance; **Absorbtion atmosphérique** – Atmospheric absorbtion; **Aéroporté** – Airborne; **Aérospatiale** – Aerospace; **Amortissement** – Attenuation; **Prise de vue aérienne** – Aerial photography; Altimètre – Altimeter; **Théodolite** – Theodolite; **Fond de carte** – Base map; **Faisceau** – Beam of light; **Levé topographique** – Traversing; **Point coté** – Height point; **Point de canevas** – Control point; **Courbe de niveau** – Contour line; **Repère** – Benchmark; **Balayage** – Scanning; **Triangulation** – Triangulation; **Trilatération** – Trilateration, **Point géodésique** – Geodetic point; **Borne** – Beacon; **Carte de vol** – Flight map; **Carte topographique** – Topographic map; **Coordonnées** – Coordinates; **Coordonnées géodesiques** – Geodetic coordinates; **Géoïde** – Geoid; **Corps noir** – Blackbody; **Ligne** – Line; **Ligne de base** – Baseline; **Cartographie** – Cartography, Mapping; **Chambre de prise de vues aériennes** – Aerial camera; **Radio positionnement par satellite** – Global position system; **Couleur réelle** – True colour; **Composition colorée** – Colour composite; **Echelle** – Scale; **Ordinateur** – Computer; **Informatique** – Computer science; **Calculatrice** – Calculateur; **Précision** – Accuracy; **Réseau** – Network; **Ressources terrestres** – Earth resources; **Onde** – Wave; **Longeur d'onde** – Wavelength; **Compensation des blocs** – Block adjustment; **Etalonnage** – Calibration; **Onde porteuse** – Carrier wave; **Erreur cumulative** – Closing error; **Traitement de données** – Data processing; **Horizon fondamental** – Datum; **Point de repère horizontal** – Horizontal control; **Niveau de référence** – Datum level; **Instrument/dispositif** – Device; **Ordinateur numérique** – Digital computer; **Programmation** – Programming; **Equipement électronique de mesure à distance** – Eletronic distance-measuring equipment (EDM); **Milieu/environement/embiance** – Environment; **Relevé géodésique** – Geodetic Surveying; **Orientation interne** – Inner (Interior) orientation; **Orientation relative** – Relative orientation; **Orientation absolue** – Absolute orientation; **Moindres carrés** – Least squares; **Relevé cadastral** – Cadastral surveying; **Courbes de niveau** – Contour lines; **Carte de courbes de niveau** – Topographic map; **Grille cartographique** – Map grid; **Carte à grande échelle** – Large scale map; **Carte topographique** – Topographic map; **Matrice** – Matrix; **Niveau moyen de la mer** – Mean sea level; **Système métrique** – Metric system; etc.

Summary

This chapter presents the basic rudiments of learning technical French language required for the purpose of broadening the students' scope and perspective of the surveying and geoinformatics profession at global level. Also, the learning of the technical French language has been provided from the alphabets and numbers to basic communication in French language.

Exercise

1. Write and read French full alphabets identifying the complete vowels, semi vowels and consonants
2. Read and Write numbers in words from 1 to 1000
3. As a potential Surveying and Geoinformatics professional, attempt to highlight some important scientific
   and technical reasons why you need to have the knowledge and understanding of French language
4. Identify the three groups of the French verbs and conjugate 15 of each in the simple present and past
   tense of them
5. Read a short scientific and technical journal article to identify the verbs, articles, nouns, pronouns,

adjectives as well as the prepositions
6. Write out the common French terminologies in Surveying and Geoinformatics

References

Ajiboye, T. (1981). Common Errors in French. University of Ife Press, Ile-Ife, Nigeria.ISBN 978-136-017-8. 126pp

Audet, H., Rochon, G., Laframboise, P., Drolet, B., Mc Gurrin, B. et GaumondJ-C (1977). Terminologie de la Télédétection: Anglais-Français, Français-Anglais. Document de Travail. 33pp.

Bénac, H et Burney, P. (1984) Guide de Conjugaison – Tous les verbes conjugués Publié par Hachette, Paris. ISBN: 2.01.010143.x. 252pp

Cours de Technologie Spatiale (1979) Cartographie Spatiale Cours organisé par le Centre National d'Etudes Spatiales avec le concours de L'Institut Géographique National (IGN), Publié par Centre National d'Etudes Spatiale (CNES), Toulouse, France. 644pp

Dominique, P.; Girardet, J.; Verdelhan, M. et Verdelhan, M (1989) Le Nouveau Sans Frontière 2 – Méthodes de Français Editions Clé International, Paris, France. ISBN 2.19.033460.8 223pp

Dyson, S.T. (1986) French – English Glossary on SPOT, Remote Sensing and their Applications (Working Document) First Edition, Miramont-de-Quercy, France. ISBN 2-9501571-0-6 194pp

Foin, P. (1988) Cours de Teledetection: Fascicule 1 Bases Physiques Ecole Nationale des Sciences Géographiques Imprimerie de l'Institut Géographique National, Paris, France 53pp

Girardet, J.; Cridlig, J-M et Dominique, P (1990) Le Nouveau Sans Frontière 3 – Méthodes de Français Publié par Clé International, Paris, France. ISBN 2.19.033471.3 239pp

Girardet, J.; Cridlig, J-M et Dominique, P (1990) Le Nouveau Sans Frontière 3 –Méthodes de Français. Cahier d'Exercises Publié par Clé International, Paris, France. ISBN 2.19.033472.8 175pp

Lasserre, E. (1987) Est-ce **à** ou **de?** Répertoire des verbes, Adjectifs et Locution – Se construisant avec une preposition. 63pp

Le Nouveau Bescherelle 1 (1980) L'Art de Conjuguer – Dictionnaire de 12000 Verbes Publié par Hatier, Paris. ISBN 2-218-04889-2. 157pp.

Le Nouveau Bescherelle 2 (1987) L'Orthographie Pour Tous Publié par Hatier, Paris, France. ISBN 2-218-07847-3. 223pp

Mergault, J. (1987) Dictionaire Français Anglais, Nouvelle Edition, Revue et Augemente Publie par Larousse, Paris, France. ISBN 2-03-401612-2 477pp

Ojo, S.A. (2002) A Comprehensive Revision Handbook of French Grammar. Published by Signal Educational Services Ltd. Ibadan. ISBN 978-2546-13-5. 489pp

Rabchevsky, G.A. (ed) (1984) Multilingual Dictionary of Remote Sensing and Photogrammetry. American Society of Photogrammetry, 343pp

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CHAPTER 22

Introduction to Computer Applications in Building Construction

By

DADA Martin Oloruntobi and AMEH John Oko

Overview

Human history of technological advancement moves from one level to another. Starting with the primitive cave-man, human beings live in houses having associated infrastructure that promote comfort and the quality of life. In a similar vein, from the use of animals in work, manual labour up to mechanical labour, man has developed in various spheres of life even up to the use of automation and computerization. The use of computerization has addressed the problem of drudgery and routinization of activities and documentation in all spheres of life including the construction industry. This course introduces the reader to computer software and their principles applicable for various activities in the building industry. While the software treated here are not exhaustive, this write-up provides a stimulant for students to pick interest and further develop themselves in the use of the software. Even at a higher level, students can develop interest in improvising local software and writing customized programmes to address one or more areas of need in the construction industry.

Objectives

At the end of this chapter, students should be able to:

1. identify the seven professional actors in the Nigerian building industry that contribute in one way or the other to project development
2. itemise the various possible software that are available for rendering a specified service in the Nigerian building industry
3. describe the interrelatedness of the professions, and the software in the realization of the final built environment project
4. discuss the basic rudiments of at least one software useful for design and construction
5. display competence and dexterity in the application of some software used by professional builders such as construction programme
6. recognize some current information technology (IT) applications or software and their use in building construction.

Building industry

The building industry is that part of the national economy that deliberately alters the earth's surface through the development of buildings and associated infrastructure. It is responsible for the provision of shelter for mankind and his resources. As a matter of fact, the growth and development of nations is tied to the industry (Ogunlana, 2015 and Dada, 2018). The advances in the industry distinguish the modern man from the early-man. The industry comprises many actors: public and private sector actors; client, consultant and contractor organizations in addition to such other actors as the equipment manufacturers or equipment leasing organizations, building materials manufacturers or marketers and many such. At the professional level, the industry comprises professionals who have distinct but complimentary roles to play in the realization of the building project. The history of the built environment professions is better understood in the context of Nigeria's socio-political and colonial experience. Nigeria remains a member of the Commonwealth of Nations and in the process inherited some professional tradition that existed in the United Kingdom. The seven built environment professions created by law in Nigeria thus include: Architecture, Building, Engineering, Quantity Surveying, Surveying and geo-informatic, Estate Surveying and Town Planning. In some other countries, especially non-commonwealth countries, some of these professions or their equivalents exist by other names. Nonetheless, in any building project, there are professionals that produce the architectural and engineering designs, and some professionals are responsible for the construction. It is worth knowing that each of these professions has core and distinct service to render in urban development in Nigeria. In a project development chain, in simple terms, the Town Planner is responsible for the planning of settlements at various levels and sublevels, the Surveyor gives the delimitation of the land, the Estate Surveyor is responsible for giving the value of landed properties for investment and any other decisions. Additionally, in Nigeria, the architect is responsible for the architectural designs, the engineer is responsible for engineering design, the builder is responsible for the building production and construction management of the building works. Each of these professions has services it renders with respect to physical planning and urban development. Each of these services is gradually experiencing a shift from the manual to the automated or computerized means. Additionally, it is worth noting that at every stage of the building project, information, communication technology (ICT) is playing and will continue to play major roles. The stages include pre-design, design, construction and post-construction and operations phases. This chapter acknowledges advances in ICT for use in the building industry through such means of artificial intelligence, Building Information Modelling, 3D printing and a host of other innovations, this chapter presently focuses on introducing students to just three software packages that are useful for design or planning or computing on projects. The percolation of the use of ICT in Nigeria building industry maybe slow but it is real. It is to be noted that computerization has radicalized man's activities in many sectors. While this chapter introduces the reader to some basic elements of computer applications for building project delivery, there are much more grounds that are emerging, that can be covered and that can be explored. The three types of software indicated or introduced in this chapter have the capacity for online-collaboration with their attendant advantages. The three software types are not exhaustive but they are meant to introduce the reader to the possibilities of computing in the building industry. As a matter of fact, the world of computerization is moving at a great speed. Building information modelling, as reported in Dada, Ebiloma and Oladokun, 2017 and such other concepts as augmented reality, visualization, 3D-printing and digital construction are changing the face of project delivery. The use of artificial intelligence, robotics is opening new vistas in computing. While the chapter is an appetizer, the authors would feel fulfilled if building students, researchers and practitioners are inspired to explore the world of computing and computer with respect to every aspect of the building industry including the development of computer programmes to solve existing or emerging challenges in the industry. In essence, this chapter should stimulate interest in the reader on how computing can promote greater efficiency and competitiveness in the building industry.

History of computer and computing

The earliest history of modern-day computing could be traced to the Chinese who invented the Abacus 5000 years ago that remained in wide use in China till the 1970s (Sun & Howard, 2004). In 1955, Charles Babbage developed the mainframe computer. Over time, the systems became smaller by the day that eventually manifests in so many small but powerful computer or computing devices. From 1951 when the UNIVAC (Universal Automatic Computer) was delivered to the US Bureau of Census, till present, advances in computers and computing technology have made the computers smaller, more versatile and more accessible to organizations and individuals. There is now an Information Technology (IT) revolution which, in the words of Ogunlana (2015), is irreversible

Areas of use of computers

The construction sector deals with and generates a lot of information. For a typical building project, there may be graphical communication of information through drawings, written communication of information such as specifications, cost information and other types of information relevant to the execution of the building project. Computers can be used in various aspects of construction. Such areas of application include: architectural and engineering designs, estimating and cost management, construction programming and scheduling, life cycle analysis and management including computer-aided facility management and professional office management. Computer application can enhance speed and thus efficiency, be amenable to creating and amending various proposed solutions, and also provide or access a world of information useful for future projects. The following sections give some capsules on some specific software that should be of interest to building students.

Notes on some software

Some notes or nuggets or capsules are given on specific software as follows:

Spreadsheet applications (Software 1: Microsoft Excel software)

Spreadsheets are primarily intended for applications involving computations whether arithmetical or mathematical. This is common to computations whose data can be arranged in rows and columns. For the purpose of this write-up, the spreadsheet used for illustration is Microsoft Excel. A Microsoft Excel file comprises a workbook for entering data and also many worksheets.

Uses of Microsoft Excel

Microsoft excel or equivalent spreadsheet are useful for several purposes, key of which is data management. Like other software, it saves time, effort and space. Apart from the use of Excel for scenario analysis or what-if analysis, Excel is used for basically data entry, data management, accounting, financial and investment analysis, charting and graphing, programming, time management, task management. Excel can be used to store, organize, analyze and report on especially large amount of data. The charts in an excel software include column chart, line chart, pie chart, doughnut chart, bar chart, area chart, XY (scatter) chart and bubble chart. With the use of the cells in the workbook, Microsoft Excel can be used for constructing formulas. Also, it can be useful in automatic calculations using a particular formula when an input data change. In the process, it saves time and resources. This ability is useful in predicting scenarios and what-if-analysis.

As an undergraduate student, you would be interested in making estimates like bill of quantities or any other schedule of materials. The Excel sheet comes handy. Payroll for workers on daily or monthly wages can be done by Excel. Valuation can be done using Excel. As a matter of fact, arithmetic and mathematical manipulations and analysis of data are possible with the use of Excel. There are many areas of application of Excel for both students and practitioners. Figure 1 shows a typical Excel sheet where some data have been inputted into the cells.

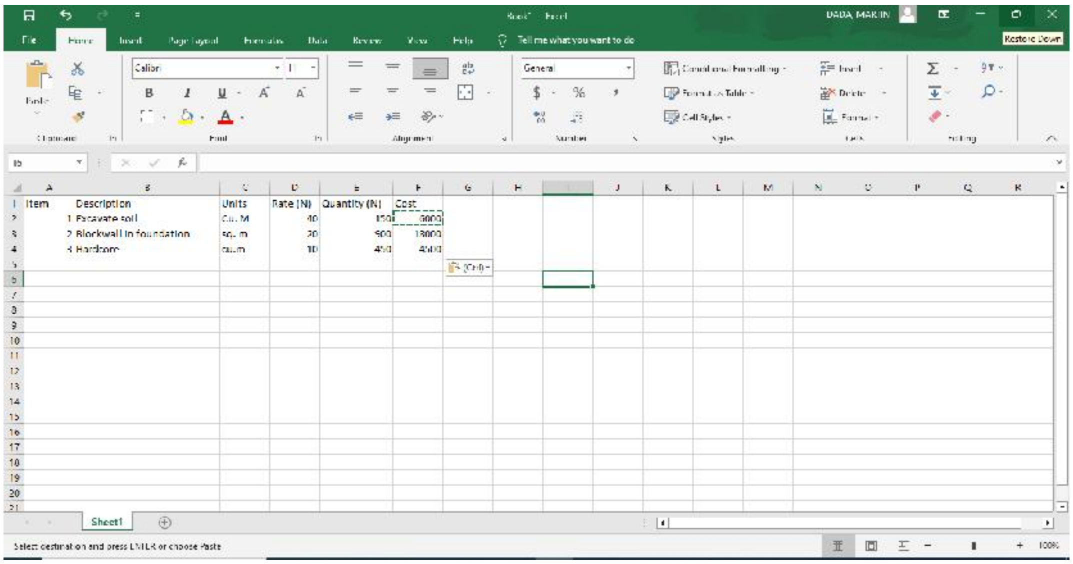

Figure 1: A typical Excel Workbook

Figure 1 shows a typical Excel page. Input data are entered into the cells and computations can be made by entering a formula. For example, the row numbers are indicated along the horizontal lines while the columns carry letters such as A, B and so on. Having input the data from columns A to E, it is possible to get the cost for both excavation of soil and block wall in foundation. This is obtained by inputting an equation in Cell F2 thus: F2 = (D2*D3). The answer gives a result for cell F2. To get results for the remaining costs vertically, the formula inputted in F2 can then be copied into cells under F and this gives answers automatically for all costs. The Excel can do other arithmetical and mathematical functions as addition, multiplication, division etc. Inputs in the cells can be numeric or seen as texts. There are commonly used functions in Excel such as ABS which implies return the absolute value of a number; AVERAGE (return the average value on a list); COUNT (return the number of items in a list); FLOOR (round a number down towards zero); CEILING (round a number to the nearest integer or nearest multiple of significance). Beyond the what-if or scenario analysis, Excel can also produce graphic outputs and displays. The graphics can show trend and better appreciation of the data. Excel too can be used to manipulate data in other applications. Data can be initially stored in Excel and then transferred to Microsoft Project or Statistical Package for Social Sciences for further manipulation. As indicated earlier, Excel is in the family of spreadsheet and dexterity with its use can save precious time and resources as applicable in other software.

Project management software: Microsoft Project (MSProject)

There are many projects management software available. Their use and application depend on cost, the environment of use and user or client familiarity. In recent past, planning and display of bar or Gantt charts of projects involved getting the hard copy of the bar chart and posting it to a board in the site office. This was the manual method of display. To track progress, a vertical line would be placed on the date concerned and tasks that are behind or ahead of the schedule would be known. Revision to the programme was problematic just like revision to drawings in the manual method. While the types of software vary, the principles subsist. A project planning software can also be used for monitoring, evaluation, control etc. and hence the omnibus name of using the word project management software. In this writeup, the focus shall be on the Microsoft Project Software. The software is part of the Microsoft Suite. Builders are required to produce construction programme on building projects. The MSProject is useful for creating schedules, distributing or allocating resources and managing the budgets of the project. It is necessary to understand the principles in the preparation of such programme.

Some basic principles in knowing or using Microsoft Project involve the following:

1. Every Microsoft Project has three calendars: standard, night and 24 hours. However, the default calendar is the standard calendar which has a 40-hour week, with 8 hours per day for 5 working days
2. It is possible however to customize the calendar
3. Microsoft Project has places to enter tasks, time, predecessors, resources etc.
4. The MS Project also has many views such as Gantt, Critical Path, Resource etc.
5. Project parameters having been determined,
6. There are basically four types of dependencies in MSProject and also four types of constraints. The dependencies address the logic of relationships of the tasks. They include FS (finish to start), FF (Finish to finish), SF (Start to finish), SS (start to start).
7. The constraints allow restrictions to be placed on the way MS Project calculates task start and finish dates. The constraints include: As late as Possible; As Soon as Possible; Finish No Earlier Than; Finish No Later Than; Must Finish On; Must Start On; Start No Earlier Than; Start No Later Than.
8. Constraints can be flexible (tasks not tied to a specific date), semi-flexible (which include earlier start dates or latest finish dates), or inflexible (which have specific start or finish dates)
9. On practical application to a construction programme, it is necessary to draw the attention of the student that the construction methodology will determine the logic and sequence of operations and thus the builder would still have to use his experience in determining the logic to be inputted into the programme.

Figure 2 shows a typical Microsoft Project open pane.

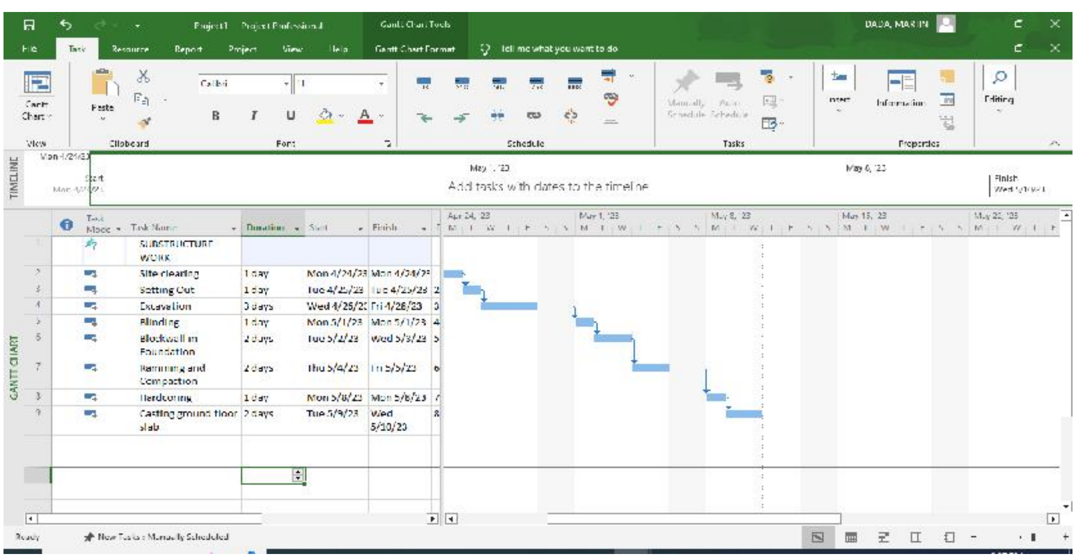

Figure 2: A typical Microsoft Project Gantt view

AUTOCAD

Sun and Howard (2001) observed CAD as a three-dimensional electronic drawing space which allows both 2D and 3D drawings to be drawn using the principle of the coordinate system analogous to the x-y-z coordinate system in mathematics. AutoCAD is in the family of software for computer aided design and drafting. It is good to understand the basic principles of some of the software. It should be noted that variants and progressions exist in the CAD software. For example, AutoCAD 2022 is a later day improvement over the features of the earlier day AutoCAD. For design of buildings, the software we are considering or focusing on this time is the AutoCAD. The basic principles in the use of AUTOCAD include:

Architectural draughtsman ship is the process of transforming design ideas or concept from human mind to graphical forms on paper for understanding and practical use. The process or metamorphosis of architectural concept in human mind up to computer aided design include:

1. Verbal explanation/gesticulation;
2. Graphical presentation through free hand sketches;
3. Use of mechanical aids through drawing boards;
4. Wooden drawing board;
5. Adjustable metal drawing board;
6. Hydraulically controlled type drawing board; and
7. Computer Aided Design (CAD) or Computer Aided Drafting.

It is worthwhile to know a short or brief history and concepts of Computer Aided Design (CAD) or Computer Aided Design and Drafting (CADD). CAD was invented by an American – Ivan Sutherland in a doctoral thesis at Massachusetts Institute of Technology (MIT) in 1961. CAD is a generic term for any software that can create 2D and 3D technical drawing. AutoCAD is a software for 2D drawing, created by Autodesk incorporation and first released in 1982. Since 1982, several versions of AutoCAD have been released such as Release 13, 14, AutoCAD 2000-2019.

Other CAD application software include:

1. Corel draw: for professional artworks, logos etc. produced by graphic artists;
2. ArchiCAD: architectural and engineering drawing;
3. TurboCAD: drawings;
4. 3D Home Architect;
5. Accurender, among others;
6. Revit; and
7. BIM 360 and Naviswork

While Corel-draw is a graphics arts professional artworks tool, ArchiCAD, TurboCAD, 3D Architecture, 3D Home Architect, AutoCAD are for architectural and engineering drawings. Accurender –introduced by Roy Hirshiconitz, is a rendering package for enhancing aesthetic value of the drawings created using some of the software packages. Building Information Modelling (BIM) – is an intelligent 3D model-based collaborative process that allows multiple stakeholders and construction professionals to collaborate on the planning, design, and construction of a building. BIM can be used up to the nth dimension. It should be noted that BIM is not a software per se but a shared and collaborative platform of understanding

Advantages of CAD over manual drafting

The following are the advantages of CAD over manual drafting:

1. It is faster;

2. It is smarter (layers with colour) and more precise;
3. Easier to store for longer period;
4. Easier to modify or revise; and
5. Easier to communicate across distance via email

Meanwhile, it is worth knowing the composition of the AutoCAD system. The AutoCAD system consists of the CAD user who is a human being; the CAD Hardware consisting of the CPU, memory, storage, input device (keyboard, optical pen, etc), output device (screen, printer, plotter, etc); the CAD Software comprising system software and application software the operating System and the CAD software.

Steps and procedures

There are steps and procedures to follow in the use of the CAD system. These steps and procedures are outlined below:

Using the mouse

Your mouse, most likely, has two buttons (left or right) and a scroll wheel. The left mouse button is used to choose menus, commands, and options, and you've held it down to drag menus, toolbars and windows. It is is the one you'll be using most often, but you'll also use the right mouse button. Note that while drawing, you will use the right mouse button for the following three operations:

1. To display a menu containing options relevant to the particular step you're in at the moment;
2. To use in combination with the Shift or Ctrl key to display a menu containing special drawing aids called object snaps; and
3. To display a menu of toolbars when the pointer is on any icon of a toolbar that is currently open.

Meanwhile If you have a mouse with a scroll wheel, you can use the wheel in several ways to control the view of your drawing. On the other hand, if you have a three-button mouse, the middle button is usually programmed to display the Object Snap menu, instead of using the right button with the Shift key.

Launching AutoCAD

The steps are outlined below:

Start the program by choosing: **Start ➢ Programs ➢ Autodesk ➢ AutoCAD 2016**

Alternatively, find and click the AutoCAD 2016 icon on your desktop ➢Start Drawing/Open existing file

Note: This may vary depending on your OS. Note too that AutoCAD 2016 is just used here for example. There could be other versions. Figure 3 shows a typical graphic user interface for CAD file

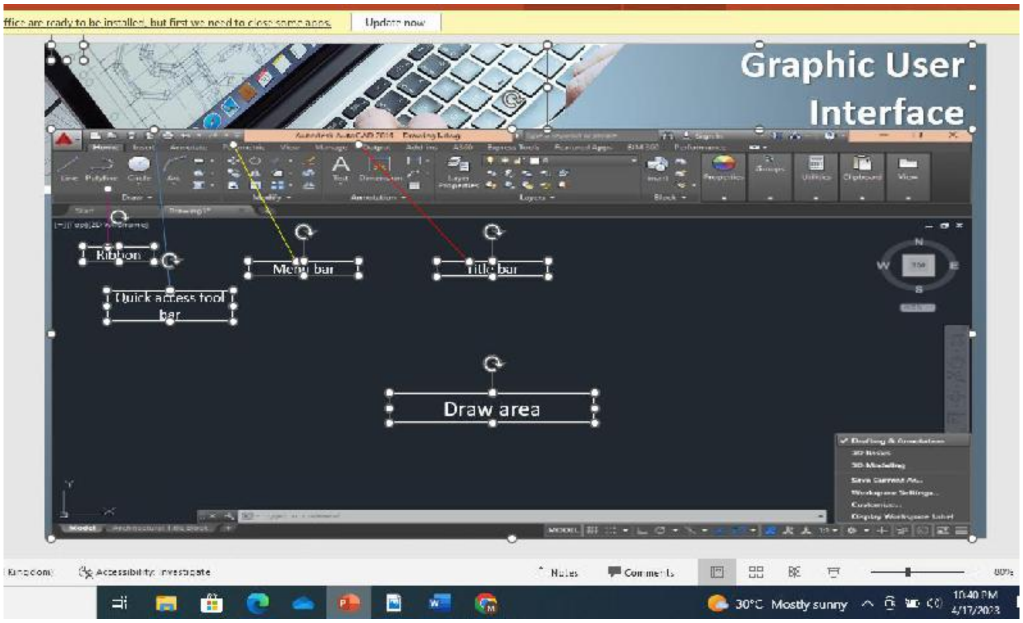

Figure 3: Graphic User Interface in AutoCAD

Screen features

Title bar: This is similar to the title bar in any Windows program. The title bar contains the program name (AutoCAD or AutoCAD LT) and the title of the current drawing with its *path*. It is worthwhile to note the following:

- **Quick Access toolbar** (**BOLD** pictured below) is a space where you can store buttons for tools you use very often.
- Located on the top left-hand corner of the screen
- To add a tool to the Quick Access Toolbar, right click on the tool and select ADD to quick access toolbar

Figures 4 and 5 show a quick access toolbar and other features

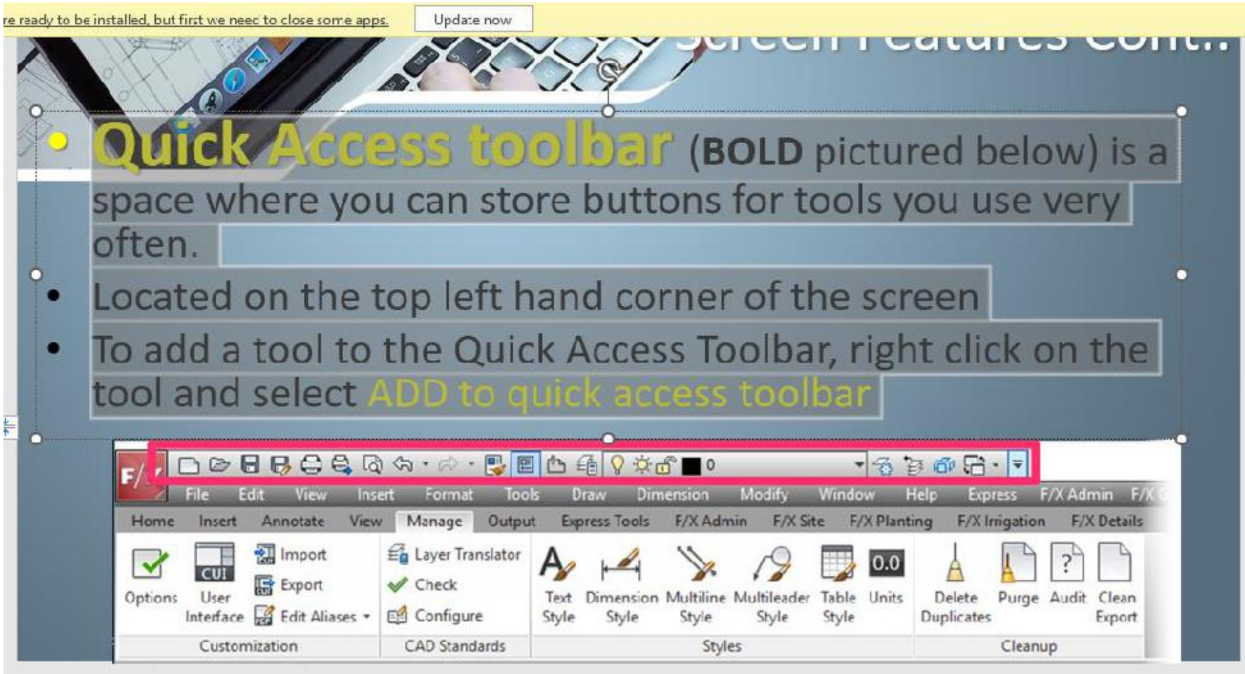

Figure 4: Quick access tool bars in a CAD template

Menus bar

Below the title bar is the menu bar, where you will see the drop-down menus. Among the drop-down menus, the first two (FILE and EDIT) on the left and the last one on the right (EXPRESS) are Windows menus (meaning that they appear on most Windows applications). These Windows menus also contain a few commands specific to AutoCAD. The rest of the menus are AutoCAD menus.

AutoCAD menus

Below the menus bar is the Ribbon, where you'll find most of the AutoCAD commands and tools needed to complete any drawing task. Tabs on the ribbon are organised by tasks and grouped under the same ribbon/tool bar (e.g., draw, modify, etc). Related tasks are further segmented into panels (draw/modify)/ribbon tab (Home, insert etc) containing similar tools.

Tool bar

The tool bar contains different types of tools in the form of small pictures (icons) which represents a command. To restore tool bar, go to AutoCAD icon **'A'** top left➢ option➢ profile➢ reset

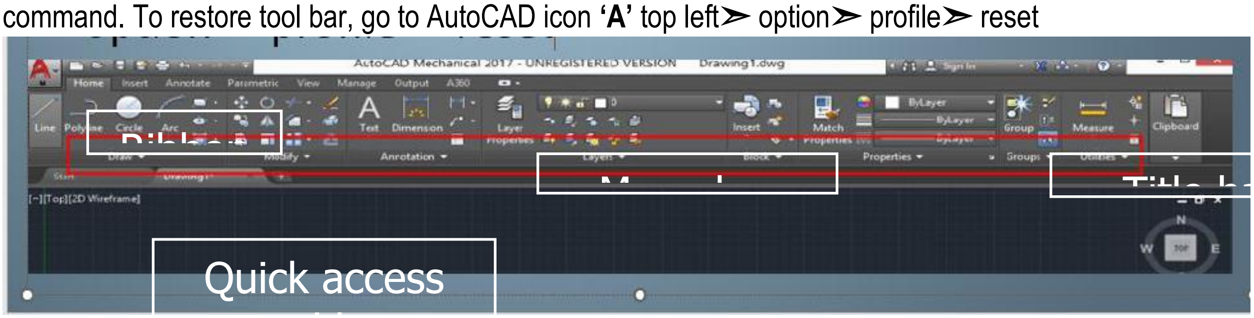

Figure 5: Quick access tool bars in a CAD template

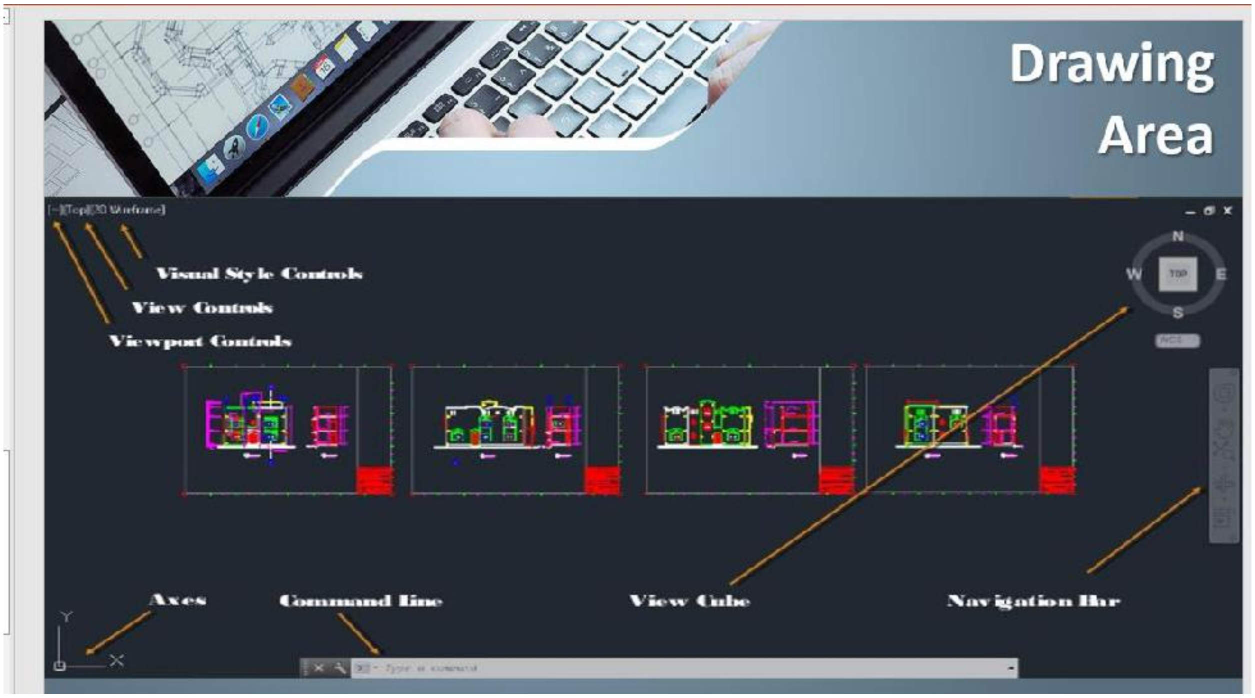

Figure 6: A typical CAD drawing area

Drawing area

Figure 6 shows a typical drawing area in a CAD file or template. The blank middle section of the screen is called the drawing area. It might however need adjusting. Enter *visual styles* to open the Visual Styles Manager. The command line will prompt you to enter an option, select "set Current" and then *click the 2D* wireframe option. Thereafter, notice the movable crosshair cursor. When you move the cursor off the drawing area, it changes to the standard Windows pointing arrow. The crosshairs on your cursor might extend completely across the screen (another day discussion). As one begins using commands, the crosshairs will take on other forms, depending on which step of a command one is performing. (e.g., try line and copy command). The icon with a double arrow in the lower-left corner of the drawing area is the User Coordinate System (UCS) icon. It indicates the positive direction for the x- and y-axes as shown in figure 7.

Figure 7: Coordinate points in a CAD template

Below the drawing area is the Command window. The Command window is where you interact with the program. Instructions to the computer and feedback from the computer are displayed at the command line. It is good to always look at the command line. It is worthwhile to note that while drawing with CAD, the following activities are possible: creating objects, editing, annotations, blocks and external references, grid and snap, layering. There are however other developments beyond CAD such as virtual reality. CAD surpasses virtual reality in that VR is able to place users inside the model, allowing them to interact with the objects.

Summary

This chapter has introduced the students to the nature of the building industry and its transition from manual dissemination and communication of information (including pictorial and numerical information) to computerized methods. The transition has led to the development of a series of software that promote efficiency in design, planning, execution and management of projects. Three types of software have been touched in this write-up for readers to appreciate the subject matter. The three types are the Excel Spreadsheet, Microsoft Project and AutoCAD. The Excel software is a spreadsheet for the management and manipulation of data; the Microsoft Project is a software primarily for project management (especially for project planning and control), while the AutoCAD is for computer aided design/drafting. The software types are not exhaustive but rather indicative. The building student can develop himself to understand the fundamentals and applications of those software types and even go ahead to excel in emergent types of software.

Exercise

1. In a construction site, three workers were employed and are paid wages on a weekly basis. The workers are Ojo Ale, Adamu Haruna and Nna Chukwudi. Their daily wages are respectively N3000, N4300 and N5000. Use the Excel spreadsheet to compute:
   i. The total wage due after five working days
   ii. 10% of the total wages
   iii. The difference between Nna's total pay and Ojo's at the end of the 5 days
2. The default dependency in Microsoft project with respect to starting and finishing a task is………
3. The foundation of a fence will have to be completed before the concrete in foundation. Which task is the predecessor of the other?
4. The acronyms CAD and CADD indicate ………………… and …………..……..………..… respectively.
5. CAD was invented in a doctoral thesis in 1961 by an American known as…………...………………
6. AutoCAD, a CAD application package was designed by ………………… with the first release in the year …………. under the name MicroCAD
7. Mention two advantages of AutoCAD over manual drafting:

References

Dada, M. O. (2018). Policy issues and management challenges in Nigerian construction industry, Paper presented at the 48th Annual General Meeting and Conference of the Nigerian Institute of Building held at NAF Conference Center and Suites, Abuja, Nigeria between July 30-August 2, 2018

Dada, M. O., Oladokun, M. G. and Ebiloma, D. O. (2017). Analysis of the utilization of building information modeling for building projects. Paper presented at the 47th Annual General Meeting and Conference of the Nigerian Institute of Building held at Bauchi, Nigeria between August 8-11, 2017

Ogunlana, S. O. (2015). The building industry: a strategic sector in Nigeria's economic revival, Keynote Paper presented at the Builders Congress organized by the Council of Registered Builders of Nigeria, at Abuja.

Omura, G. (2008). Mastering AutoCAD 2008 and AutoCAD LT2008. Wiley India Pvt. Ltd. New Delhi

Sun, M. and Howard, R. (2001). Understanding I.T in Construction Spon Press, London.

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CHAPTER 23

Building Graphics, Lettering and Modelling

By

AMEH John Oko and ADEAGBO Dorcas Omolola

Overview

Building graphics, lettering and modelling focus on the techniques and graphic tools used for communicating building drawings for accurate interpretation on construction sites. They essentially comprise the combination of lines, letters and images to convey design ideas between the designers and the construction site team. Building graphics is fundamental to interpreting architectural, structural, electrical and mechanical services drawings on construction sites. Computer software such as AutoCAD, Rrevit and ArchiCAD, which would be discussed in another chapter, is a modern tool for drafting.

Objectives

At the end of this chapter, learners should be able to:

1. describe types of building drawings;
2. identify the various types of instruments/equipment and materials used in building drawings;
3. describe the various lines used in graphical communication and their application;
4. demonstrate lettering skills;
5. explain the use of scale in building drawing; and
6. illustrate architectural projections in isometric and oblique drawings to scale.

Drawing

Drawing may simply be defined as a technical language for communicating design ideas among professionals in the built environment and the clients. It essentially comprises lines, lettering and symbols. Technical drawing may be an architectural drawing, structural drawing and building services (electrical and mechanical) drawing. As a communication language, it is expected that technical drawings are easily understandable, standardized, unambiguous and clearly arranged.

Brief description of types of drawings

Architectural drawings

Architectural drawings are technical drawings of a house or any type of building. They are created as a set of drawings which could be presentation drawings or working drawings. They are used to guide builders or building contractors or building professionals throughout the building production or construction phase of a project. Architectural drawing describes, in details, the actual sizes and dimensions of the spaces in the building, construction details like roof heights and dimensions of roof members among others used to provide a guideline for the construction team. Also, architectural drawing provides the schedule of doors and windows and specifications of materials used in the building among others. The drawings may be used to show the overall appearance, inside and outside of a building. They may be used to show the precise measurements of the construction plan. No standard building can be constructed without a clear and detailed set of architectural drawings. The six types of architectural drawing are:

1. Site plan;
2. Floor plan;
3. Elevations;
4. Sections (cross and vertical);
5. Isometric projections; and
6. Axonometric projections.

Structural drawings

Structural drawings are used to prepare details of reinforcement in building construction. They are derived from structural analysis which is used to determine the effects of loads on the physical structures and their components. They are used to guide the builder or building contractor on structural detailing, fabrication and installation of building structures. They give details on how to produce structures that are capable of resisting all applied loads and dead loads, without failure, throughout the building life cycle. The objective of structural design and drawing is to have a structure that meets the requirement of stability, strength and serviceability. A typical structural drawing comprises foundation, floor, beam and column details, stairs and lift shaft details among others.

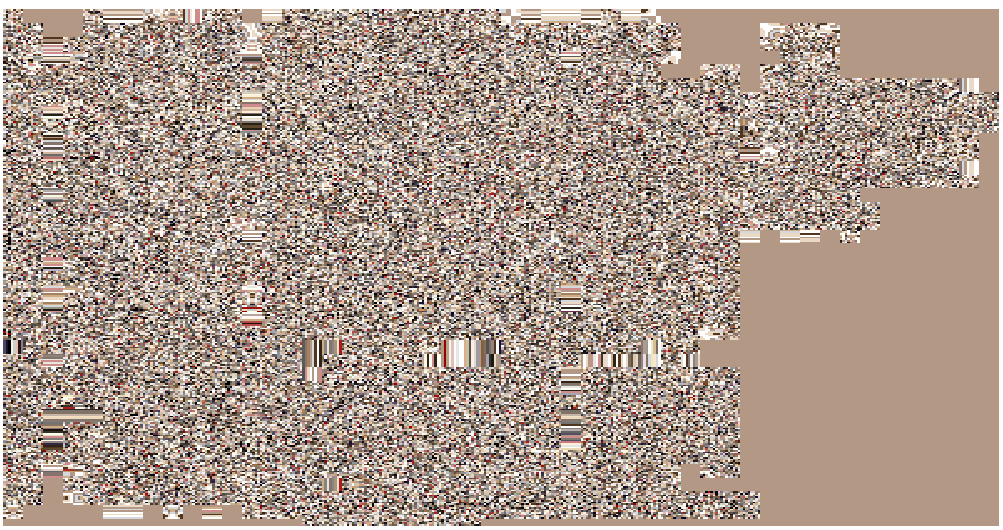


Figure 1: Structural design foundation detailing
Source: Ameh and Soyingbe (2023)

Electrical drawings

An electrical drawing is a type of technical drawing that shows information about power and lighting features for use in engineering or construction projects. It consists of diagrams showing electrical systems or electrical circuits. Electricians use electrical drawings to install or repair electrical systems. Electrical drawings help builders to understand how different electrical parts function together. In the electrical drawing of circuits, there are three components. These are source of voltage, conductive path and a resistor.

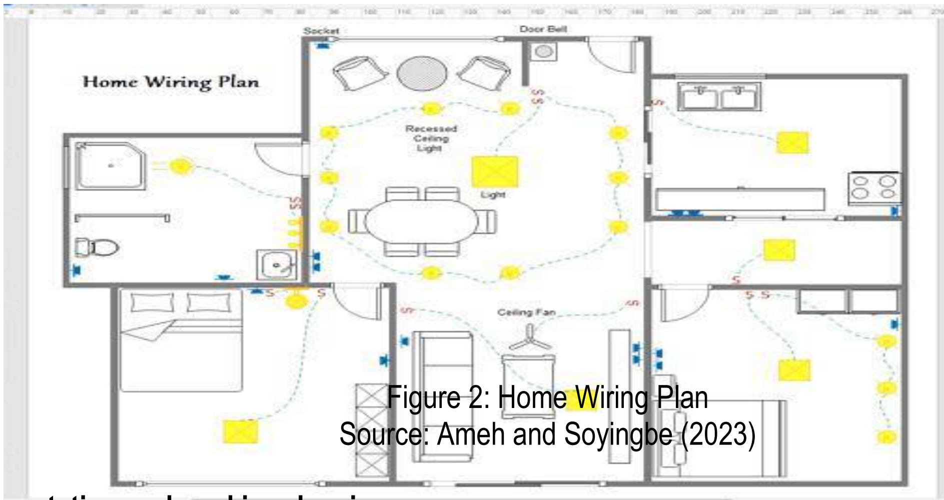


Figure 2: Home Wiring Plan
Source: Ameh and Soyingbe (2023)

Presentation and working drawings

Presentation drawings

Presentation drawing is an architectural drawing produced for the purpose of making proposals to the client. It often shows the overall appearance, inside and outside of a building and materials to be used but it does not involve details and specifications at the construction stage. Presentation drawings are only for the clients and not for building construction purposes. They are used to sell design ideas to prospective clients as shown in figure 3.

Figure 3: Architectural Presentation Drawings
Source: Ameh and Soyingbe (2023)

Working drawings

Working drawings are comprehensive set of drawings used for the construction of building projects. They include architectural drawings that are detailed with dimensions, specifications and other engineering drawings. Also, they include site plans (Figure 3), floor plans (Figure 4), sections, roof details, material schedules and other engineering details (Figure1).

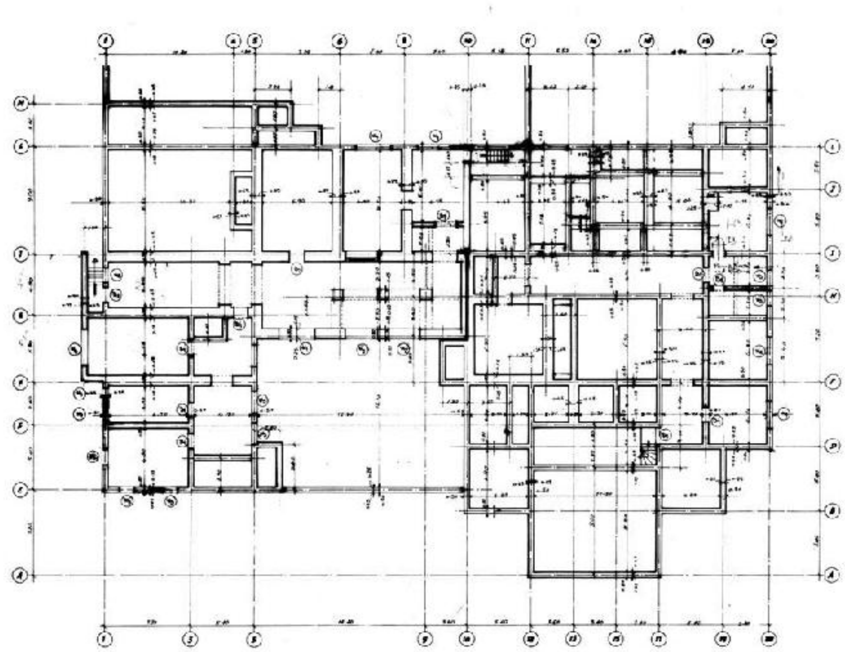


Figure 4: Working Drawing
Source: Ameh and Soyingbe (2023)

Drawing equipment and their uses

1. **T-Square**: Used to draw straight horizontal lines. The head of the square is placed firmly along the edge of the board while the square blade is across the board, over the drawing paper (Fig. 6). The drafter slides the T-square up and down as required, then draw a horizontal line with a pencil tip atop the square blade (with slight pressure on the blade) made of clear plastic, wood or metal.

Figure 5: T-Square

2. **Drawing board/Drafting board**: Paper is attached for drawing purposes on flat smooth board which could be portable or fixed to a metal frame. This may be made of wood, plastic or metal which are available in different sizes. The size of the board is described by an alphabet "A" subscript 0 to 4 as described in Table 1.

Table 1: Drawing paper sizes

Designation	Size[mm]
A_0	841 x 1189
A_1	594 x 841
A_2	420 x 594
A_3	294 x 420
A_4	210 x 297

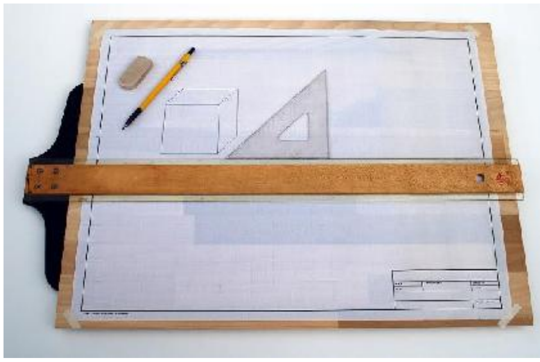


Figure 6: T-Square on Drawing Board

3. **Set-square**: A set square is made of clear transparent plastic triangle. The commonly used triangles are 30^0, 45^0, 60^0 and 90^0 set square. Figure 7b shows a typical 45^0 set square. They are mainly used for drawing vertical lines and inclined lines by placing them firmly atop the square edge of the T-Square. By sliding it along the horizontal, vertical or incline, lines could be produced. Adjustable set square, shown in figure 7a is available for all possible angles.

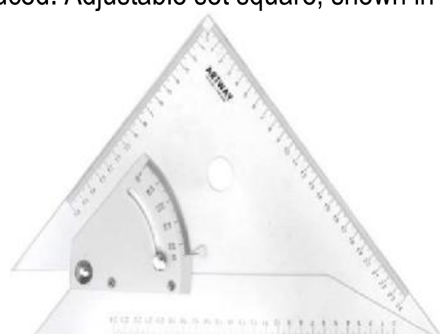


Figure 7(a) Adjustable Set-Square Figure 7(b) 45^0 Sets Square

4. **Scale rule:** This is a tool for measuring the length and transferring measurements at a fixed ratio of length. Architectural scale rule consists of three-sided ruler with different scales on each side such as 1:100; 1:50; 1:20 etc. as shown in figure 8. Scale 1:50 means you are using 1 unit on paper to represent 50 units on ground. It is usually made of plastic.

Figure 8: Scale rule

5. **Drawing sheet/paper**: An object is drawn on the sheet of paper. They are available in various sizes as described earlier in the case of drawing board. They are available in different colours. White- coloured papers are usually used for the main drawing while other-colours papers, especially grey-coloured papers are used for drafting or sketches.

6. **Drawing compass**: A compass is used to draw arc or circle with known dimension. It is generally made of steel and consists of two legs. One leg contains a needle at the bottom and the other leg contains a ring in which the pencil is placed as shown in figure 9.

Figure 9: Drawing Compass

7. **Divider**: A divided looks like the compass but the difference is that the two legs of a divider are provided with needles. It is used to divide a line or curve into equal parts/intervals. It is also used to check measurements between points as shown in figure 10.

Figure 10: Pair of Divider

8. **Protractor:** This is made of clear transparent plastic with the shape of a semi-circle. It is used to measure the angles of lines in the drawing as shown in figure 11.

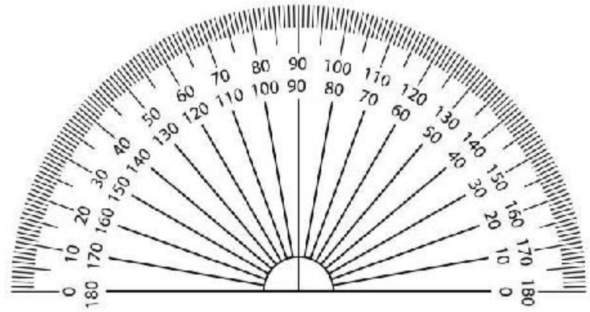


Figure 11: Protractor

9. **French curve:** It is an irregularly shaped transparent plastic. Sometimes, the drawing requires irregular curves or shapes or arcs which cannot be drawn with a compass. Hence, French curves are more suitable for such small curves as shown in figure 12.

Figure 12: French curves

10. **Spline**: This is an open or closed smooth curve for drawing larger curves as shown in figure 13.

Figure 13: Spline

11. **Drawing template**: This consists of a plastic or wooden board which contains pieces of several shapes or letters such as those in a mathematical set. Drawing templates contains shapes of dining table, chairs, wash-hand basin, etc.

12. **Pencil:** A pencil is used to draw on white paper. It should be noted that not all types of pencil are suitable for drawing. Pencils can be categorized based on the degree of hardness as H (Hard), B (Soft) and HB (Medium Hard and Soft). Pencils are classified into 18 grades as:

a. 9H- The Hardest
b. 6H,5H,4H- Extremely hard
c. 3H- Very hard
d. 2H- Hard
e. H- Moderately hard
f. HB- Medium hard
g. B- Moderately soft and black
h. 2B- Soft and black
i. 3B- Very soft and black
j. 4B,5B,6B- Very soft and very black
k. 7B- Softest.

Out of the above, grades c, d, e and f are used for construction drawings.

13. **Eraser**: This is used to remove lines drawn by mistakes. It is made of rubber.

14. **Masking tapes**- This is made of thin and easy-to-tear paper and an easily released pressure-sensitive adhesive. It is used to grip paper on the drawing board.

15. **Drawing pen**- It is used for drawing in ink on a tracing paper. It is available in different sizes of ball heads. A pen set of eight contains 8 pens ball heads with sizes: 0.1mm, 0.2mm, 0.3mm, 0.4mm, 0.5mm, 0.6mm, 0.8mm and 1.2mm.

Format for presenting drawing

Figure 14 shows the general layout of drawing. The layout for student’s exercise consists of a 10mm borderline round the drawing paper. These are spaces at the bottom of the drawing sheet to accommodate: Names, matriculation number, department, title of drawing, drawing scale and date. The dimensions of the spaces depend on the information required.

Drawing space

Name/Matric. No	Drawing Title	Scale:
Department		Date:

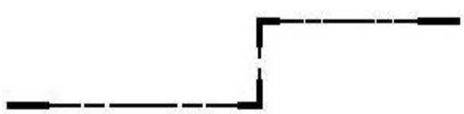
Figure 14: Drawing title block.

Understanding the use of lines in graphical communication

Lines can be considered the most expressive aspect when dealing with drawings**.** The structure that is planned to be built is described by using lines, symbols and notes in architectural, civil and engineering drawings. This method is a universal language of describing a structure to be built and is known as Drafting. Every line that is used in the drawing must have a certain significance. The significance of the lines is mostly conveyed through the weight or thickness of the lines. If the thickness of the line is thin, it is less significant. If the line width is thick, it is more significant as shown in table 2. Before drawing a line, its significance must be kept in mind.

Table 2: Line types, description and uses

Line type	**Description**	**Uses**
	Continuous Thick Line	To show visible outlines or edges of a component or assembly
	Continuous Thin Line	Most frequently used line type on Engineering Drawings for: Imaginary lines of intersection, dimension lines, projection lines, leader lines, hatching, outlines of revolved sections, short center lines (as opposed to the chain line), bending lines

	Continuous Thin Freehand Line	The edge of the partial or interrupted view is indicated with a freehand line.
	Continuous Thin Zigzag Line	If a part needs to be shortened with a break for ease of visibility, a break can be made using this line. Break line indicates continuity
	Thick or Thin Dashed Line	Used to indicate hidden details like hidden outlines and hidden edges. However, they can also be used to denote other things like door turning radius, ceiling height changes on a floor plan
	Thin Chain Line	Used to indicate center lines, the lines of symmetry and also trajectories
	Thin Chain Line with Thick ends	Sectional cutting planes are indicated with a Thin Chain Line with Thick ends. Sometimes, the thick ends are in the form of arrowhead.
	Thick Chain Line	Used to indicate special requirements on a surface
	Thin Chain Double Dashed Line	Used to show adjacent components

Line weight and their uses

Line weight refers to the blackness (intensity) and width of a line on the drawing surface.

a. Heavy dark lines are used to represent cutting planes and contours (or outer boundaries) of an object. In floor plan view, it is often the walls that are drawn with the darkest lines in order to define the spaces. Dark thick lines are commonly used in building sections to denote where a plane is cut.
b. Sometimes, it is useful or necessary to indicate materials using a variety of line weights. Heavier materials are given heavier line weight while lighter materials are given lighter line weight.

Lettering
There is a need for descriptive words and notes in order to specify details of an object on a drawing and to distinguish one part of the drawing from the other. This necessitates the use of lettering. All information on drawings are mentioned through lettering. For example, lettering is used for: writing title, inscribing dimensions, description of spaces (toilet, kitchen, bedroom, etc.) within the building, material specifications on drawing among others.

Types of lettering
Sans Sherif: This is commonly used because of their simplicity, clarity and ease of execution. Each row of these letters are of the same height as shown in figure 15.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ
abcdefghijklm
nopqrstuvwxyz
1234567890

Figure 15: Sans Sherif Lettering Style

Sherif: This type of lettering shares almost the same form with San Sherif letters. The only difference is in the small decorative strokes at the end of each letter and the difference in the thickness of the strokes as shown in figure 16.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ
abcdefghijklm
nopqrstuvwxyz
0123456789
!@#$%^&*()

Figure 16: Sherif Lettering Style

Other lettering styles include: cursive/script, vintage, gothic, graffiti among others.
Lettering is mostly done by freehand. The following are the procedure for setting out letters:

1. The guide-lines and principal construction lines are drawn lightly;
2. The letters are lightly completed and the sheriffs drawn in freehand in the final line;
3. The letters are completed in the final line, curve lines being put in before straight lines; and
4. Stencils can also be used for titling drawings.

Use of scale in technical drawing
In order to draw a building in its true size on paper would be a difficult task. Scales are introduced in drawing to allow one to draw building on a small piece of paper to their true size. Scale drawings are usually presented in the same units of measurement. Scale 1:100 in mm, means 1mm on paper denote 100mm on ground and 1 : 50 in cm means 1cm on paper denote 50cm on ground. That is, the smaller the scale used, the larger the object to be drawn. For example, an object drawn to scale 1 : 50 is twice as large as an object drawn to scale 1 : 100. In the same vein, an object drawn to scale 1 : 25 is four times as large as an object drawn to scale 1:100. Therefore, before drawing 'to scale', it is required to consider the size of the object to be drawn and the size of the paper on which the object is drawn. That is, if the object to be drawn is large but the paper size is not, there is the need for an appropriate scale that can turns large object to fit the small paper. The scale rule described earlier is used to achieve scale reduction or enlargement in building drawings.

Projection
Projection is a detailed and accurate way of representing points, lines and surfaces on plane(s). Projection in architectural and engineering drawing include: orthographic, isometric, oblique and perspective projections.

Orthographic Projection
Orthographic projection, also known as right angle projection, represents a three-dimensional (3-D) object in three coordinates (horizontal, vertical and side vertical) planes. These three coordinate views are sub-divisions of the two principal planes of projection (horizontal and vertical) which intercept to produce the four angles or quadrants. However, in practice, only the first and third angles or quadrants are used since views in the second and fourth angles may overlap. The difference between the first angle and the third angle projection is in the position of the plan view, in relation to the front view as shown in figure 17. In the first angle projection, the plan view is below the front view while in the third angle projection, the plan view is on top of the front view.

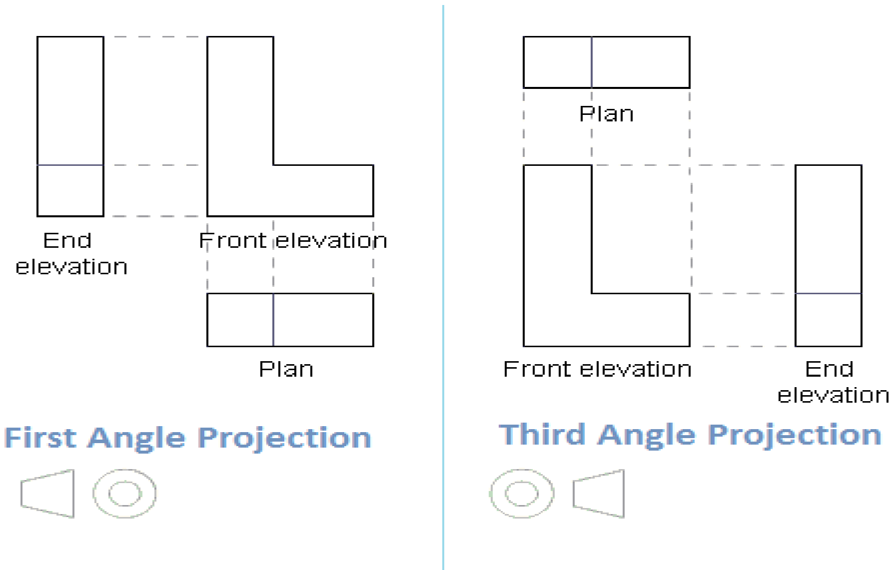


Figure 17: Orthographic Projection

Isometric Projection

Isometric projection is a method for visually representing three-dimensional objects in two dimensions in technical and engineering drawings. Isometric drawings show an object from three different views (usually the front, top and right sides). Each of the views is drawn in 2-D (two- dimensional) and has dimensions labelling the length, width and height of the object. Two lines are involved in isometric drawing: vertical lines and inclined (receding) lines. The plane is placed in such a way that all the three visible sides of the object make the same angle (30 degrees) with one another as shown in figure 18. The same scale is used in all the axis resulting in non-distorted image.

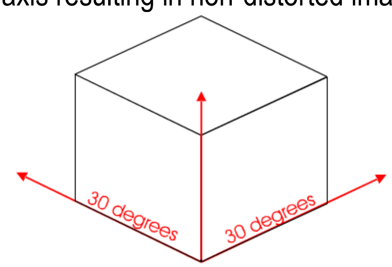


Figure 18: Isometric Projection

Oblique Projection

Oblique projection, like isometric projection shows an object from three different views. Three types of lines are involved in oblique drawing: horizontal lines, vertical lines and inclined (receding) lines. The vertical and horizontal lines make an angle 90 degrees with each other while the inclined (receding) line makes an angle 45 degree with the horizontal line as shown in figure 19. When the receding line is inclined at angle 30 degrees, its length is drawn to half of its true length to avoid distortion.

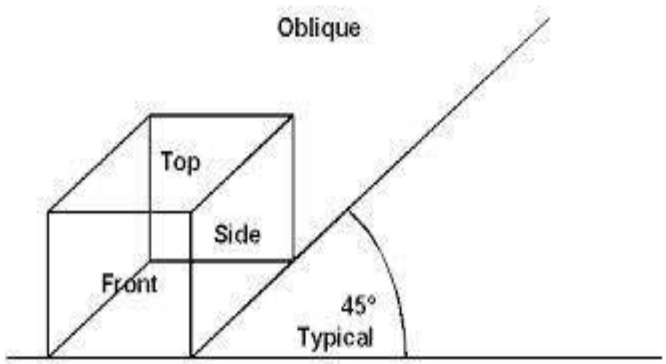


Figure 19: Oblique Projection

Summary

Building drawing is a technical language used for conveying design ideas among professionals in the built environment. It is a global language and as such, must be clear to avoid ambiguity and conform to acceptable international standard. A builder is the professional that translate the designers' ideas to reality and so he must be conversant with architectural drawings, structural drawings, electrical and mechanical drawings to be able to interpret them on the construction site. In this chapter, we have provided an abridged version of the scope of building graphics, what the learner is expected to know after going through the course as well as the knowledge of graphics as essential requirements for computer software used in building design.

Exercise

1. On A3 size paper, draw a rectangle with length and breadth measuring 50cm by 30cm. Divide the length and breadth into equal space of 1 cm. Join each of the division to the other using 3H pencil.
2. Write your names using sans sheriff and sheriff techniques.
3. Draw a 450mm by 225mm concrete block in isometric and oblique projections to the scales of 1:50 and 1:25 respectively.

References

Ameh, J. O. and Soyingbe, A. A. (2023). Building graphics lectures Note, University of Lagos, Nigeria

Evan, W. T and Wiliam, G. H. (2013). Technical Drawing for Senior Secondary Schools. Newnes Education Publishing, London

Sankar, P. D. (2015). A Textbook of Technical Drawing (WBSCTE). Vikas Publishing House, New Delhi.

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CHAPTER 24

A Chronological Perspective of Design History

By

AKINBOGUN Tolulope Lawrence

Overview

The chronological perspective of design history encompasses the study of design and its evolution across different cultures and regions worldwide. Design is a plan, process and provision of a solution to a problem. Design is not limited to a particular time or place but has a rich and complex history that reflects different societies' diverse experiences and perspectives. It can be said that design is as old as man. Right from the stone age, man manipulated objects to suit his purpose. In the quest to survive the harsh weather, the wandering man found himself a shelter in the cave; in the bid to protect himself from wild animals, he found himself weapons from stone and animal bones. Also, to feed himself, he hunted animals with crude weapons. Incidentally, the existence of man and civilization have been delineated and calibrated by the objects and the materials that man used to ensure survival. This was chronologically time-lined thus: stone age, bronze age, iron age, classical era, renaissance era, first industrial revolution, modern period, second industrial revolution, post-modern period, third industrial revolution and the fourth industrial revolution. Design continues to evolve along man's civilization and culture. Today, design has fostered the relationship between art, architecture, science and engineering.

Objectives

By the end of this chapter, students should be able to:

1. explain the fundamental needs of man that led him to design objects that could aid his survival at the pre-historic time;
2. discuss the basics of aesthetics that became parts of products design as civilization crept into man's existence;
3. describe important innovations and breakthrough technologies that have shaped the evolution of visual communication;
4. analyze the parameters that influence ancient and contemporary designs; and
5. identify the relationship of art, product design, architecture, science and engineering in design evolution.

Meaning of design

The word 'design' appears simple but is very complex to define. It has various meanings as a verb and many as a noun. Out of the many purposes of design, as listed in the Merriam-webster dictionary, the three that are closely related to this paper are thus presented as:

1. Design as a verb means to create, fashion, execute or construct according to plan.
2. Design, as a noun, means the arrangement of elements or details in a product or work of art.
3. Design is also the creative art of executing aesthetic or functional designs.

This paper considers these meanings germane to the context of product design or industrial design. To clarify the concept of this topic, design is succinctly defined as a systematic or methodical provision of a solution to a problem to achieve optimum function and satisfaction. Therefore, this definition provides the lens through which the history of design is viewed and presented in this chapter.

Evolution of design

For the purpose of this paper, design will be defined as the adaptation or manipulation of objects to suit our needs. It is not man only that does this; animals such as insects, birds and reptiles build their homes, some of which are phenomenal in structure and beauty. For instance, beavers build lodges, bees build beehives, and termites build mounds and live in colonies. Rodents burrow on the ground or trunk of trees. Spontaneously, the quest to survive was the first necessity for design creation. Rising from this, it is logical to say, therefore, that design is as old as humans based on the spontaneity of their instincts.

Classifications of design by the era of production

Design did not just evolve at once it has changed phases and has been the bedrock of man's advancement in civilization. Man's needs dictate his inventions which form his material culture. Therefore, it becomes paramount to look at the design activities of man at different ages. It has to be acknowledged that there were limitations in correlating the timeline of material cultures in the West and Asia with that of Africa because the materials culture of the African South of Sahara was undocumented before the colonial occupation of the zone. This explains why the African South of Sahara was only mentioned in a few ages which archaeological findings in the zone could ascertain. Therefore, most documentations on African arts and culture usually treat their subject under two epochs; the early time to pre-colonial influence and the colonial period to the post-colonial era. This was done because Africa South of the Sahara, before foreign contact, was an agrarian society of woodcarving, pottery, blacksmithing and weaving where a community had one deity or the other it worshipped (Akinbogun, 2002).

The prehistoric era

1. **Stone age**

This period was about 3.3 million to 5,000 years ago. The period was further divided into Paleolithic (early lithic period or early stone age), Mesolithic (Middle lithic period or middle stone age), and Neolithic (late lithic period or late stone age). The Paleolithic man was a wanderer and lived a nomadic life; he was a food gatherer and his material needs were simple tools fashioned out as weapons to defend himself as he roamed around. This stone age period was characterized by crude lithic technology where early man sharpened a stone against a stone to produce choppers. Archaeological findings have established the culture of stone age man by studying the materials culture of that period which came mainly from stone.

a. The early man found himself in a situation where he was exposed to very harsh cold weather. He needed shelter which he improvised through caves. With this, the first architecture given by nature was discovered and the need for stone became paramount.

b. He needed weapons to protect himself from wild animals. He fashioned out weapons from flint as the head of the spear tied to a wooden handle. With this, a weapon was made. Also, pointed flint was used as the head of the arrow, so another weapon was invented. Stone became paramount.

c. Man needed body covering for protection from the elements. He fashioned out flint with which he scrapped the fur from animal skin. Stone became paramount.

Design and technology during the stone age period

(a) Acheulean industry: Acheulean industry was the first standardized tradition of Homo erectus and early Homo sapiens toolmaking (Encyclopedia Britannica, 1998). Acheulean tools were made of stone with good fracture characteristics, including chalcedony, jasper and flint. The most characteristic Acheulean tools are termed hand axes and cleavers. Acheulean industries, though may not have occurred at the same time, were found in different continents of the world. Archaeological findings in Olduvai Gorge in Tanzania showed that Acheulean industry was practiced in Africa in the very early era of human existence. Some of the findings in Olduvai Gorge were crude pointed bifaces. Figure 1 shows the prehistoric stone age tools and weapon sets.

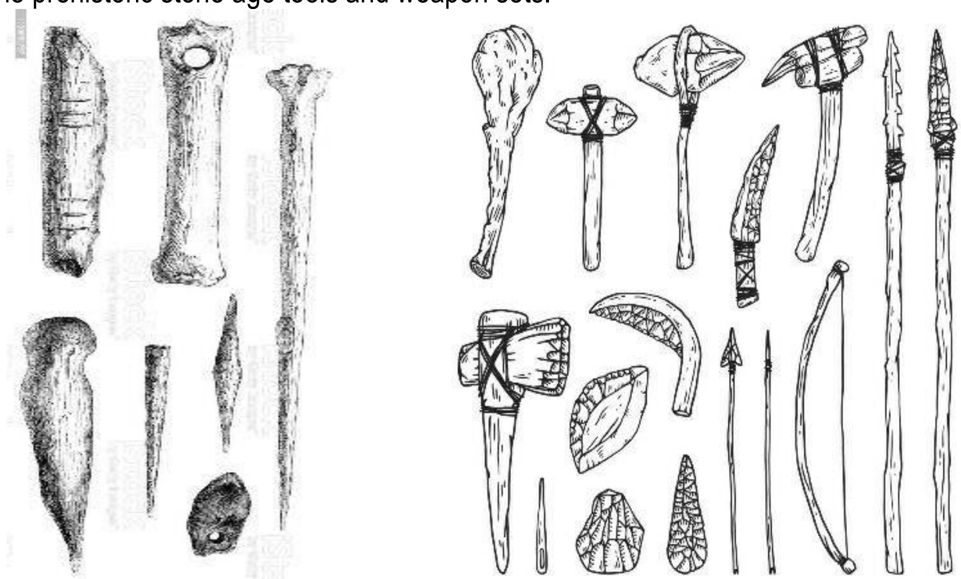

Figure 1: Prehistoric Stone Age Tools and Weapon Set.

Source: Sabelskaya (2021)

(b) The Stonehenge: Stonehenge, the stone circle on Salisbury Plain in Wiltshire, England, was particularly interesting for the mystery behind its erection and composition. It was erected during the Neolithic era, around 2500 B.C. when technology was unavailable. It is an outstanding monument that has stood the test of time. It was said to have been used for ceremonial purposes during the Neolithic era around 2500 B.C. Stonehenge is now a popular tourist attraction site, designated by UNESCO World Heritage in 1986. Figure 2 present the picture of Stonehenge.

Figure 2: The Stonehenge
Source: Akinbogun (2007)

2. **Bronze age**

This period was about 5,000 to 1,400 years ago (1,200 BC). The timeline of the bronze age varies according to different authors. It was characterized by the discovery of metals and different bronze alloys, the beginning of working with metal smelting of metal, the development of simple tools and weapons from bronze and the making of simple necklaces as shown in Figure 3.

Figure 3: Bronze Age Warriors kit
Source: Resavac (2019) and Gannon (2019)

Design and technology during the bronze age

(a) Wheels Invention

Wheels invention alluded to the Sumerians in Mesopotamia, now Iraq. Wheels in different forms, potters- wheels, wheels for grinding and wheel for carts. These rudiments have now become what the technology of later ages developed on. First wheels made in Mesopotamia were constructed from separate planks of wood secured with two or more separate wooden cross pieces because large trees were difficult to find in the Middle East. Figures 4 and 5 show how the wheel changed history and early potter’s wheel respectively.

Figure 4: How the Wheel Changed History
Source: Haggins (2016)

Source: Wilson-Carmichael (2009), Bryant (2000) and Qhurra (2022)

(b) The construction of Egyptian pyramids (2600 B.C.– 2400 B.C.**)**

The technology behind the construction of the Egyptian pyramids has remained a matter of speculation. No doubt, the engineering work in it is quite deliberate and mathematical. How the blocks were moved in place and arranged during construction remains a mystery, though some researchers opined that a ramp device must have been used to move the blocks into place during construction (Hemeda and Sonbol, 2020). Figure 6 shows an example of the Egyptian pyramid.

Figure 6: Egyptian Pyramid
Source: Chen and Ja'faruddin (2021)

3. Iron age

This period was about 1,200 B.C. to 500 B.C. At the late bronze age, man discovered the use of steel and alloys as an alternative to bronze. Iron was cheaper to acquire than bronze. The products were also lighter than bronze. Even though the time 1,200 B.C to 500 B.C. has been time-lined as iron age, the period did not occur at the same time in different parts of the world. Archeological findings have established that Iron products were made on the world's continents. The carbon 14 dating analysis has established overlaps in the production date of iron products in different regions of the world. Little (2021) noted that there is not really one iron age but multiple ones across different regions of the world because the adoption of iron did not happen simultaneously in every part of the world. During the iron age, man invented cast iron and quenching technologies. These were the processes making iron alloy in order to produce harder iron. This enabled man to produce steel weapons. Also, he was able to make coins. Although, gold and silver weights existed during the bronze age, but the first imprinted metal pieces for exchange seem to have emerged in iron age Anatolia. Figure 7 shows the iron age coin of the Corieltavi.

Figure 7: Iron Age coin of the Corieltavi

Source: British Broadcasting Corporation (2014)

Iron age in Africa

Iron and copper smelting appeared around the same time in most parts of Africa. As such, most classical African civilizations outside of Egypt did not experience a distinct bronze age. Evidence for iron smelting appears earlier or at the same time as copper smelting in Nigeria (900–800 B.C.), Rwanda and Burundi (700–500 B.C.) and Tanzania (300 B.C.) (Humphris, 2010). Iron smelting and forging technologies existed in West Africa among the Nok culture of Nigeria as early as the sixth century B.C. However, much of the iron works that were recorded in Africa afterwards were from the fifteenth to seventeenth century. Iron was helpful for the production of farm implements in the continent of Africa. In the West African region, iron was helpful in the production of war weapons. This led to the emergence and fortification of kingdoms such as Oyo, Ife, Benin and Dahomey (Ross, 2002).

Classical era: 500 B. C. to 500 A. D.

This period marks the peak of the invention of architecture, art, theatre and literary works. According to Costa (2022), the enduring impact of the classical period's cultural contributions on Western civilization can be seen in various forms, including magnificent classical architecture exemplified by iconic structures like the Parthenon. The period also boasted remarkable achievements in sculpture, highlighted by Phidias's statue of Zeus at Olympia which was one of the seven wonders of the Ancient World. More so, theatre thrived in Athens during this time, featuring the tragic works of Aeschylus, Sophocles, Euripides and the comedic works of Aristophanes. Six of the world's seven wonders were made during the ancient classical age. The seven wonders of the world are:

1. Great Pyramid of Giza: Egyptian Pyramid I, the first of these seven wonders, was built during the bronze age.
2. The Colossus of Rhodes: The Colossus of Rhodes was built with bronze, reinforced with iron, and weighted with stones in 282 BC and was destroyed by an earthquake in 226 BC.
3. The Lighthouse of Alexandria in Egypt (c. 300 - 280 BCE): The Lighthouse of Alexandria had a height of over 100 metres on the island of Pharos outside the harbour of Alexandria. It was a tower with a light designed to guide mariners to the harbour of Alexandria at night.
4. The Mausoleum at Halicarnassus: This was an imposing large tomb built and named after King Mausolus who ruled Caria. The tomb marked the origin of the word 'Mausoleum'. It was constructed by a collective- multitalented artists around 352 BC. The Mausoleum was surrounded by buildings and sculptural figures. The mausolum which is no longer in existence was destroyed by earthquakes having being in existence for about one thousand seven hundred years.
5. The Temple of Artemis: The Temple of Artemis at Ephesus was significant for the value added to it through the use of precious stone and precious metal such as marble and gold respectively, it could be deduced that the temple was associated with wealth and opulence. This quality differentiated the temple of Artemis from temples that were constructed before it. The temple was constructed in 500BC and was in existence for about 200 years before it was ruined by fire.
6. The Statue of Zeus at Olympia: The seated sculptural piece was carved from ivory around 430 BC. It was significant for its size and height which was over 40 feet. It was made in the temple of Zeus to represent Zeus the god of sky and thunder. It was a rare feat to accomplish the task of making the gigantic statue such as the statue of Zeus at Olympia going by the technology of that period.
7. The Hanging Gardens of Babylon: This was a large and tall building of about five storeys, built around 600 BC. It had terraces on which assorted trees were grown. It was destroyed by an earthquake in 226 BC.

Using modern-day countries, two of the wonders were located in Greece, two in Turkey, two in Egypt and one in Iraq. Out of the seven wonders, the Pyramid of Giza stands as the only surviving wonder and is also the oldest among them. Over the centuries, the remaining wonders have been destroyed.

Middle age or medieval era (500 AD to 1500 AD).

This era produced a wide range of art and architecture that emerged from the artistic heritage of the Roman Empire and the iconographic style of the early Christian church, fused with the "barbarian" culture of Northern Europe. The ten centuries of this era yielded diverse artistic styles and periods, including the early Christian and Byzantine, Anglo-Saxon and Viking, Romanesque and Gothic (Buis, 2022).

Grand monuments and architectural masterpieces such as the Hagia Sophia in Constantinople, celebrated mosaics in Ravenna and illuminated manuscripts like the Lindisfarne Gospels all emerged from the medieval period. Because the period produced a high volume of art bearing historical significance, it remains a rich area of study for scholars and collectors and is viewed as an enormous achievement that later influenced the development of modern genres of Western art (Buis, 2022). The early Medieval period, from about AD 500 to 1000, is regarded as the true Dark Ages, where medieval society slipped into barbarism and ignorance through the raiding by Saxons, and Vikings (Shuttleworth, 2010).

Print evolution and revolution

Printing has been practiced for a long time; since the seventh century in China and Japan, but the method generally used was known as 'block printing. The carved woodblock used to print a sing page of a specific text. This method was appropriate for cultures which used thousands of ideograms rather than an alphabet of 20-30 letters. It was probably for this reason that the Chinese invention of movable type in the eleventh century had few consequences. In the early fifteenth century, however, the Koreans invented a form of movable type with what has been described by the French scholar Henri-Jean Martin (1924-2007) as an almost hallucinatory similarity to Gutenberg's (Briggs & Burke, 2009). The year 1450 is the approximate date for the invention in Europe by Johann Gutenberg of Mainz of a printing press. The Western invention may have been stimulated by news of what had happened in the East. 'Print Capitalism' existed in East Asia before Gutenberg, especially at the popular level. In China, where full literacy was confined to the elite, ordinary people, including some women, especially in cities, could recognize some 2,000 ideograms. In order to meet the demand from this kind of reader, commercial printers, especially in the province of Fukien, produced songs, stories and simple encyclopedias, especially from the sixteenth century onwards (Briggs & Burke, 2009).

The modern era

This period began in the sixteenth century after the middle age. It was a period of unprecedented transformation. It should be noted that the transformation witnessed during the modern era was heterogenous, thus it was classified into the Early Modern Period and the Late Modern Period (Henry, 2023).

The early modern era (1500 to 1800**)**

This era witnessed three sub periods; Renaissance, Reformation and Enlightenment. This chapter will only focus on the renaissance period since it is the most prominent of the three.

Renaissance period

Renaissance period took place from the 14th century to the 17th century. It was a period of cultural and artistic rebirth after the Dark age. The renaissance bridged the gap between the middle ages and modern-day civilization. Great artists in human history flourished during this period notable among them were Leonardo da Vinci (1452–1519), Michelangelo (1475 -1564), Raphael (1483 -1520), Titian (1488 - 1576), Hans Holbein (1497-1543), Giorgio Vasari (1511-1574), Tintoretto (1518-1594) and El Greco (1541-1614). Classical art was rediscovered and there was the rebirth of naturalism as well as perspective and depth in the art.

The Interrelatedness of Science, Engineering, Architecture and Art during the Renaissance period

During the Renaissance, it was common for genius to cross boundaries of skills and professions. It was common for artists to be familiar with weaponry. A man who could cast a bronze statue could make a cannon with equal facility. Also, at this period, fortifications were a branch of architecture. Therefore, it was easy to turn from the design of palazzi and chapels to turrets and bastions (Wallace, 1966). Two among such artists are Leonardo da Vinci and Michelangelo di Lodovico Buonarroti.

Leonardo da Vinci was very talented in virtually all areas of human endeavours and has been described as a genius by many authors. Leonardo wrote about his intellect and capability in a letter to Sforza; what looks like his resume when he wanted patronage from Sforza.

> "I have plans for bridges, very light and strong, and suitable for carrying very easily… I have plans for destroying every fortress or other stronghold unless it has been founded upon rock. I have also plans for making cannon, very convenient and easy of transport, with which to hurl small stones in the manner almost of hail… I have ways of arriving at a certain fixed spot by

caverns and secret winding passages, made without any noise even though it may be necessary to pass underneath trenches or a river… I will make covered chariots, safe and unassailable, which, entering among the enemy with their artillery, there is no body of men so great but they would break them… I can make cannon, mortars, and light ordnance, of very beautiful and useful shapes, quite different from those in common use...I can supply catapults, mangonels, trebuchets, and other machines of wonderful efficacy" (Wallace, 1966, p.56).

Figures 8 to 11 present the works of Leonardo da Vinci as a creative painter and as a versatile engineer**.**

Figure 8: Mona Lisa (1503)

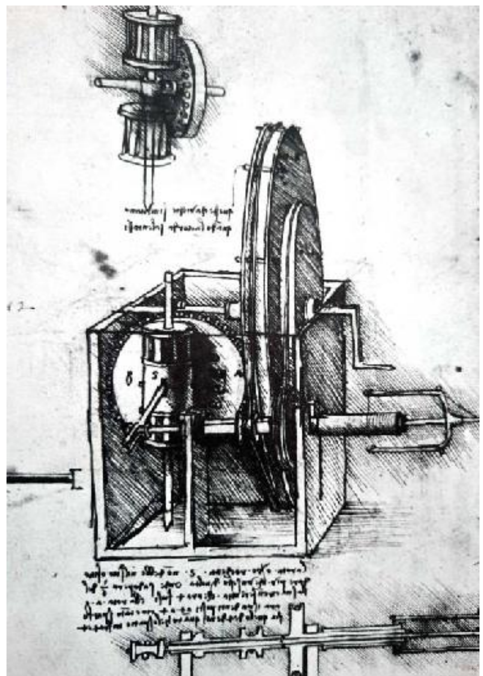

Figure 9: Spinning wheel (1490)

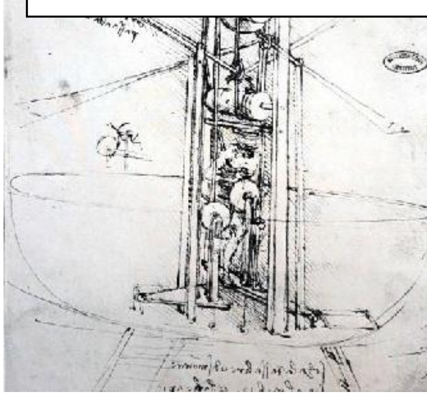

Figure 10
Flying machine (1488)

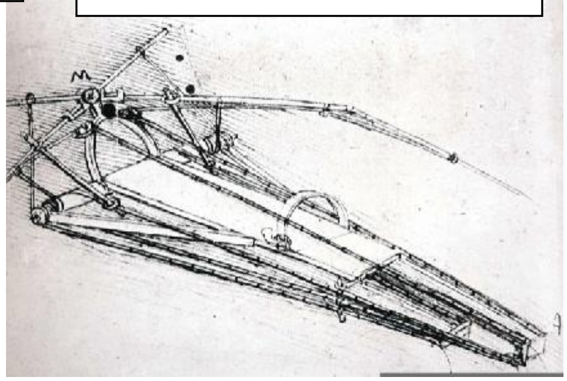

Figure 11
Flying machine (1488)

Source: Wallace (1966).

Michelangelo di Lodovico Buonarroti Simoni (1475- 1564): He was a renaissance artist, painter, sculptor, poet and architect. Some of Michelangelo's artworks are Dying Slave in 1516, Crucifix in 1492, Adam and Eve in 1512, Madonna of the Stairs in 1492, Statue of Lorenzo de Medici, Sistine Chapel Ceiling Creation of Eve in 1510, The Fall and Expulsion from Garden of Eden in 1512, Sistine Chapel Ceiling: Cumaean Sibyl in 1510 and David and Goliath in 1509. Michelangelo was also a self-taught architect. His architectural style was rather unusual for the time. His profound self-administered training in architecture coupled with his artistic background helped him to accomplish great building designs. He used to produce a clay or wax model of his architecture design, through this process, he was able to modify his designs freely until he is satisfied that they meet the desirable standard. Some of his architectural contributions include the St. Peter's Basilica, Rome, imposing arched entry into the historical center of Rome called Porta Pia. Pope Clement VII commissioned Michelangelo to design the Laurentian Library for his family collection of books in Florence in 1523 (McFadden, 2018).

The first industrial revolution era

The first industrial revolution started in Britain in 1760 and spread to other parts of Europe. It marked the period when production transited from manual to industrial method. This affected the way in which products were designed and the speed at which they were produced. Industrial revolution changed man's technological, socioeconomic and cultural settings. This led to the following technological changes:

(1) the use of new basic materials, chiefly iron and steel;
(2) the use of new energy sources which include fuels and motive power such as coal, steam engine, electricity, petroleum and the internal-combustion engine;
(3) the invention of new machines for textile production;
(4) emergence of factory system which consequently removed production processes from the hands of individuals to the hands of specialists (division of labour);
(5) emergence of new means transportation including the steam locomotive, steamship, automobile and airplane;
(6) emergence of new means of communication which include telegraph and radio; and
(7) the increasing application of science to industry.

As a result of these developments, mass production of goods through industrial process revolutionized the manual way of goods production. Among the personalities that influenced design during the industrial revolution era was Josiah Wedgwood, born in 1730 in Burslem, Staffordshire. He was well known for establishing varied pottery traditions. Trained to throw vessels on the potter's wheel from the beginning of his apprenticeship but later prevented from practicing by a knee injury. Josiah turned his talents to experimenting with different materials, shapes, techniques and finishes, thereby laying the foundations for the phenomenal success of the firm of Wedgwood (Wills, 1999).

The second industrial revolution era

The second industrial revolution lasted from the late 1800s to the early 1900s and saw a surge of new technology and inventions that led to dramatic changes in the economy and how people lived and worked especially, in Europe and United States. The transformation brought about by electricity, easier and faster means of transportation and communication made connection among people to be faster and higher. There was a rise in the production and consumption of consumer goods. Also, it was a period when innovators devised new inventions, finding new ways of improving existing products (Kiger, 2021).

The Bauhaus

The first and second industrial revolutions brought in new ways and processes of product development and manufacturing through mass production in the industry. Invariably, a void had been created between the artists, craftsmen, architects and engineers who hitherto had the responsibility of manual production of products. Walter Gropius identified this gap and attempted to bridge it. In 1919, he founded the Bauhaus.

Bauhaus combined handicrafts with industrial/technical processes and uniting artistic, scientific and technological processes. Through these efforts, Bauhaus reshaped the daily life of people with the invention of new materials and products such as tubular furniture, modern lighting fixtures, practical household appliances, new types of hardware, electrical contrivances, textiles, new typography, modern photography, etc. are the functional results of this work (Moholy-Nagy, 2012). The objectives of Bauhaus were to:

1. abolish the supremacy of intellectual work over handwork;
2. emphasize the great educational value of craftsmanship that machine cannot be used as a shortcut to escape the necessity for the organic experience;
3. offer manual training in part as an educational factor;
4. offer manual training in part as the necessary tool for the industrial model; and
5. reintegrate the artists into the daily work of the nation.

Gains of Bauhaus

It combined handicrafts with industrial/technical processes and joining artistic, scientific and technological processes. It organized workshop training with tools and basic machines. It became the focus of the new creative forces in Germany, accepting the challenge of technical progress. It became the experimental shop, the laboratory of the new movement with its recognition of social responsibility. The teachers and students of the Bauhaus were able to turn out designs that had a decisive influence on industrial production. Figure 12 is an example of Bauhaus design.

Figure 12: Bauhaus Steel pipe furniture. (designed by Marcel Breuer and Ludwig Mies van der Rohe)
Source; Stefan (2019).

THE late modern era

This primarily focused on key historical events that happened in the 19th and 20th centuries, concluding with the end of World War II in 1945.

Postmodernism

It is an ideological movement of the late twentieth that also dovetailed into the twenty-first century. Postmodernism has been a very complex concept to define. The concept was a vibrant ideological movement that challenged the concept of modernism in different endeavors of man as could be seen through architecture, industrial design, visual arts, music, literary works, politics etc. In the field of design, the concept of modernism promotes systematic approach to design in order to create functional products that are aesthetically satisfying. Contrary to the concept of modernism, postmodernism has plural approaches to design production. It doesn't believe that there should be a particular order of design creation, neither should there be any rules of thumb. Postmodernism believes that there is no absolute truth but there are relativities. It believes that individuals should seek and create their own truth as it appears to them. Postmodernism affected design creation of its period in the sense that artists, designers and architects were at liberty to create their designs without been constrained or limited by the traditional rules and formalities in design creation of the previous eras. Figures 13 and 14 are graphic design posters with the concept of postmodernism.

Figure 13: Postmodernism graphic design Figure 14: Postmodernism graphic design

Source: Victoria and Albert Museum (2023)

Art Deco design

Art Deco was an art movement of 1920 and 1930 in Europe and the USA. Like the Bauhaus philosophy, Art Deco movement dealt with manually and mass-produced items. Art Deco designs were characterized by ornaments composed of simple geometrical forms. The end products were normally elegant, sophisticated, and opulent. Art Deco designs were prominent in architecture, interior decoration, furniture, glass and fashion of 1920 and 1930 in Western Europe and the United States of America. A typical Art Deco interior design is shown in Figure 15.

Figure 15: Art Deco Interior Design
Source: Homemakers (2019)

Minimalism
Minimalism was an art movement that emerged in the USA in the 1960s and 1970s. Minimalism concept was concerned with the essentials and fundamental elements in the design rather than the lavish ornamental decoration that was found in the previous artistic styles. It was based on the simplicity of forms and the surface treatment of forms. The use of monochromatic expression became prominent over colours that are sparsely used. It was used in architectural designs, interior designs, visual arts, music, literature, cooking, and other parts of human endeavours. Figure 16 shows a typical Minimalist interior design.

Figure 16: Minimalist Interior Design
Source; Nazmiyal Collection (2023)

The third industrial revolution era

This is also known as digital revolution which started in the late 20th century. The third industrial revolution was characterized by the transition of manual processes to automation or digitization through the use of electronics and computers. The invention of the Internet of Things (IoT), discovery of nuclear energy, adoption of renewable energy otherwise known as green technology. The third industrial revolution is considered the move from mechanical and analogue electronic technology to digital electronics.

The fourth industrial revolution era

This is also known as the Artificial Intelligence (AI) era, characterized by artificial intelligence with advanced products and services quickly becoming crucial to modern life. This has been achieved through the interrelationship of the computer, IoT, robotics, Web3, blockchain, 3D printing, genetic engineering, Nanotechnology and quantum computing. The fourth industrial revolution is the ongoing era of digitization, encompassing a range of digitally connected products and services and advancements in smart cities and factories. Additionally, there is a growing trend toward automating tasks and services in both personal and professional settings.

Example of design evolution

Notably, different genres of such products or styles exist for every material designed and produced in each of the eras. Design has always been dynamic. It will continue to change as long as man continues to explore his environment. Figure 7 shows the evolution of telephone design. Here, the telephone is a product of the modern era. Its transformation is a good illustration of the dynamics in product design.

Figure 17: Evolution of telephone design

Summary

This chapter has presented design history at a chronological perspective of design history. It has established that design is as old as man. The history of design is the history of man's survival strategy. It looks at the broad definition of design and project a contextually suitable definition for the improvisation of materials in the prehistoric period and product design of the modern era. It attempted to simplify the methodology of presentation of the subject. It should also be noted that the study of design history across the globe in the stylistic contexts of the products will be too elaborate and cumbersome for foundation classes in the university. Therefore, the chapter treated design history broadly based on the civilization eras of man.

Exercise

1. Define design and relate it to product design.
2. How can you establish the line between art history and design history?
3. Discuss the different ways by which man made use of stone during the stone age.
4. Explain the following terms: (i) lithic technology and (ii) the Acheulean industry.
5. Relate the iron age in Africa with the iron age in other parts of the world.
6. Leonardo Da Vinci was an artist, architect, scientist and engineer. Discuss.
7. Discuss the four levels of industrial era and their impact on design.
8. Discuss the influence of the Bauhaus movement on industrial production.
9. What is the basic philosophy of postmodernism? What influence does it have on design making?

References

Akinbogun, T. L. (2002). "Critical Issues in Earthenware Vessel Production Patronage in a Society of Change; Nigerian Situation". *Book on Design History of Nigeria*, UNIPORT, Port-Harcourt, 87-96.

Buis, A. (2022). Art and Visual Culture: Prehistory to Renaissance. https://pressbooks.bccampus.ca/cavestocathedrals/

Briggs, A., & Burke, P. (2009). *A social history of the media: From Gutenberg to the Internet*. Polity Press.

British Broadcasting Corporation (2014). Iron Age coin of the Corieltavi, Contributed by Harborough Museum. https://www.bbc.co.uk/ahistoryoftheworld/objects/xzvfJLCDS3Cud47dFY1IrQ

Bryant V. (2000). A reconstruction of an ancient Egyptian potter.

https://www.ceramicstudies.me.uk/frame1tu2.html
Chen, W.-H., and Ja'faruddin, (2021). Traditional houses and projective geometry: Building numbers and projective coordinates, *Journal of Applied Mathematics*, 9928900, 1-25. https://doi.org/10.1155/2021/9928900
Costa, D. (2022). *Classical antiquity*. *Encyclopedia Britannica*. https://www.britannica.com/event/Classical-antiquity
Dvorsky G. (2019). Discovery of Bronze Age Warrior's Kit Sheds New Light on an Epic Prehistoric Battle. https://gizmodo.com/discovery-of-bronze-age-warrior-s-kit-sheds-new-light-o-1839071107
Encyclopedia Britannica (1998). Acheulean industry. https://www.britannica.com/topic/Acheulean-industry. Accessed on 18/4/2023
Henry, E. (2023). Modern Age History, Timeline & Facts: What is the Modern Era? https://study.com/academy/lesson/modern-age-history-timeline-facts-era.html. Last updated on 13/02/2023. Retrieved on 17/04/2023.
Gannon M. (2019). What a warrior's lost toolkit says about the oldest known battle in europe. *Smithsonian*. https://www.smithsonianmag.com/history/what-warriors-lost-toolkit-says-about-oldest-known-battle-europe-180973353/
Haggins, M. (2016). How the Wheel Changed History. Abdo Publishing.
Hemeda, S., and Sonbol, A. (2020). Sustainability problems of the Giza pyramids, Heritage Science, 8(8), 1-28. https://doi.org/10.1186/s40494-020-0356-9
Homemakers (2019). Interior Design Style Guide: Art Deco Style. https://www.homemakers.com/blog/inspiration/interior-design-style-guide-art-deco-style.html
Humphris, J.E. (2010). An archaeometallurgical investigation of iron smelting traditions in Southern Rwanda. Ph.D. Dissertation, Institute of Archaeology, University College London. https://discovery.ucl.ac.uk/id/eprint/20461/1/20461.pdf
Jarus O. (2022). Pyramids of Giza and the Sphinx: Facts about the ancient Egyptian monuments. https://www.livescience.com/22621-pyramids-giza-sphinx.html#section-bibliography
Kiger, P.J., (2021). Eight (8) Groundbreaking Inventions from the Second Industrial Revolution. https://www.history.com/news/second-industrial-revolution-inventions.
Little, B. (2021). Five (5) Iron Age Tools and Innovations. https://www.history.com/news/iron-age-tools-innovations.
Sabelskaya (2021). Prehistoric stone age tools and weapon set. https://www.istockphoto.com/vector/prehistoric-stone-age-tools-and-weapon-set-sketch-vector-illustration-isolated-gm1315453502-403428846
Shuttleworth M. (2010). Middle-Ages Science. Retrieved Apr 09, 2023 from Explorable.com: https://explorable.com/middle-ages-science
McFadden. C. (2018). Michelangelo the Architect: The Hidden Talents of the Renaissance Genius. https://interestingengineering.com/culture/michelangelo-the-architect-the-hidden-talents-of-the-renaissance-genius
Moholy-Nagy, L. (2012). *The new vision: fundamentals of Bauhaus design, painting, sculpture, and architecture*. Courier Corporation.
Nazmiyal Collection (2023). Minimalism and the Minimalist Interior Design Trends: Simplicity at its Finest. https://nazmiyalantiquerugs.com/blog/minimalism-minimalist-interior-design-are-rugs/
Qhurra M. (2022). Our Heritage: Potters of Bygone Days. *Rising Kashmir*. http://risingkashmir.com/-our-heritage-potters-of-bygone-days. Accessed on 17/4/2023
Resavac (2019). Roman spears and arrows. https://www.istockphoto.com/photo/roman-spear-and-

arrows-ancient-gm1074969264-287765365
Ross, E. G. (2002). “The Age of Iron in West Africa.” In: Heilbrunn Timeline of Art History. New York: The Metropolitan Museum of Art, 2000–. http://www.metmuseum.org/toah/hd/iron/hd_iron.htm.
Stefan D. (2019) Bauhaus ideas become design icons. DW Made for minds https://www.dw.com/en/ingenious-minds-the-bauhaus-artists-whose-designs-became-icons/a-44876363
Wallace, R. (1966). *The World of Leonardo: 1452-1519*. Little Brown Publication Victoria and Albert Museum. Postmodernism: about the Exhibition .http://www.vam.ac.uk/content/exhibitions/postmodernism/about-the-exhibition/. Accessed on 28/4/2023
Wilson-Carmichael, A. (2009). Things as they are: Mission work in Southern India. https://www.gutenberg.org/files/29426/29426-h/29426-h.htm.
Wills, G. (1999). Wedgwood, Bounty Books, Octopus Publishing Group.
Woods, T. (1999). *Beginning of Postmodernism*. Manchester University Press.

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CHAPTER 25
Computer-Aided Industrial Design
By
ADELABU Oluwafemi Samuel

Overview

Industrial design is a trans-disciplinary field that is evolving in response to changing times and technological progress. Therefore, it demands the adaptation and assimilation of new skills and sophisticated design tools. An area of technological applications that is prominently required today in industrial design practices is the use of Computer-Aided Design (CAD) tools and systems to enhance and manage the design processes. CAD or Computer-Aided Design and Drafting (CADD) is a broad term used to represent the use of computers or computing technology in designing. It is a part of the broader area of computer graphics which involves the use of computer applications developed as a form of automation that helps designers and engineers prepare drawings, specifications, parts lists and other design-related elements using special graphics- and calculation-intensive computer programs (Ennis-Cole, 2023). In a concise definition, CAD is described as the use of computer systems to help in the creation, modification, analysis or optimization of a design (Groover, 2023 and Narayan, 2008). Today, the scope of CAD tools covers their use in the whole spectrum of design initiation and decision-making to technical design with the subsequent link to the production plant and machinery. Computer-Aided Manufacturing (CAM), which involves the use of computers to assist in the production process, can be integrated with CAD systems to plan, manage and control machine tools in the manufacturing of workpieces through a direct or indirect computer interface (Elanchezhian et al., 2007 and Mourtzis et al., 2018). This chapter is an introduction to the fundamental concepts of computer-aided industrial design. It includes the basics of CAD, CAM, computer aided drawings, CAD software, basic features and requirements which include CAD/CAM applications for respective areas of industrial design specialization in Nigeria. Students will learn to identify CAD tools for applications in their industrial design projects and will gain an understanding of the potential of CAD software to enhance the design process and productivity.

Objectives

By the end of this chapter, students should be able to:
1. explain the fundamental concepts of computer-aided industrial design;
2. describe the significance of CAD as a design tool in the fields of industrial design;
3. demonstrate an understanding of the basic requirements for the use of CAD software for industrial design and their key features;
4. identify various CAD/CAM applications that have been developed to enhance the design processes and management in respective areas of industrial design specialisation; and
5. illustrate the basics of CAD tools for concept development and rapid prototyping.

Computer-Aided Design and manufacturing

Computer Aided Industrial Design (CAID) is a term that simply denotes the use and applications of computer systems and CAD tools to automate the industrial design process. In other words, it can be defined as the use of computer software and technology to assist in the creation, modification and optimization of industrial design processes and outcomes. With the availability of CAD tools and systems, designers can create, develop and test digital or virtual representations of their ideas and concepts as shown in figure 1. These representations can be visualized both in two-dimension (2-D) or three-dimension (3-D), altered, tested and optimized for functionality, aesthetics, performance and manufacturability and modified as needed. As opposed to the traditional method, CAID helps designers to enhance their design tasks before production thereby saving time, reducing errors and costs (SURFACEID, 2017). Also, this can facilitate communication between the design and production teams, making the design process more efficient. CAD tools apply to various areas of industrial and product design fields and specializations (Ulrich Eppinger and Yang, 2020). This includes ceramic and glass product designs, textile and fashion designs, graphic designs, jewellery designs and interior design. Examples of 2-D CAD software commonly used for various visual designs and illustrations are CorelDRAW, Adobe Illustrator, Inkscape etc. while those of 3-D CAD software for digital modelling and prototyping includes Blender, Rhino, Fusion 360, SolidWorks, SketchUp, Rhino etc.

CAD is a critical tool for industrial designers for a variety of reasons. The following are the key ways, amongst others, in which CAD are significant:

1. Increased accuracy and precision: CAD software enable designers to create precise, accurate designs with a high level of detail. This level of accuracy is difficult to achieve with traditional drafting techniques.
2. Increased productivity: CAD software can automate many of the tasks involved in design such as dimensioning, scaling and labelling. This can significantly reduce the time required to create a design and improve productivity.
3. Enhanced visualization: CAD software enables designers to create 3-D models of products which can be viewed from any angle. This allows designers to visualize the final product before it is manufactured, reducing the risk of errors and ensuring that the design meets the desired specifications.
4. Improved collaboration: CAD software makes it easier for designers, engineers and manufacturers to collaborate on a project. CAD files can be shared electronically, allowing team members to review and provide feedback on the design in real-time.
5. Reduced costs: CAD software can help reduce the costs of industrial design projects by reducing the need for physical prototypes and allowing designers to test and refine the design virtually.

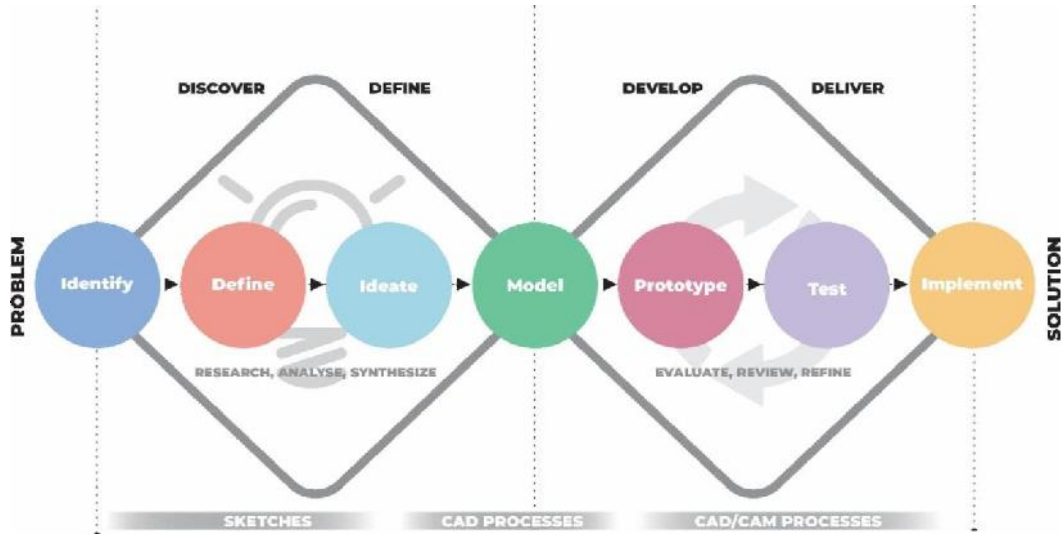

Figure 1: A CAD/CAM Integrated Design Process within the Double Diamond Framework

CAD is not limited to drawings but covers many aspects of designing like design calculations, data analysis and simulations. It encompasses all the activities involved in the product design cycle in which a workable concept is developed into ready-to-manufacture product specifications (Bi and Wang, 2020b). Tools and operations in CAD application can aid in achieving various tasks such as:

a. Two-dimensional (2-D) vector-based drafting;
b. Three-dimensional (3-D) solid and surface modelling (including two types of 3-D solid modelling such as parametric modelling and direct modelling);
c. Geometric Modelling;
d. Three-dimensional rotations of a designed object;
e. Dynamic mathematical modelling; and
f. Design planning, analysis and optimization etc.

CAD occupies part of the whole Digital Product Development (DPD) activity within the Product Lifecycle Management (PLM) processes and as such is used together with other tools which are either integrated modules or stand-alone products. These are:

1. Computer-Aided Engineering (CAE) and Finite Element Analysis (FEA);
2. Computer-Aided Manufacturing (CAM) which includes instructions for 3-D printers and Computer Numerical Control (CNC) machines;
3. Photorealistic rendering and motion simulation; and
4. Document management and revision control using Product Data Management (PDM) (Narayan, 2008, Groover and Zimmers, 2013 , Bi and Wang, 2020).

While CAD represents the use of computers in designing, CAM denotes the computerized control of the manufacturing process. CAM is the use of computer systems to plan, manage and control the operations of manufacturing through either direct or indirect computer interface with production resources. Also, it refers to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage. CAM software is used to control machine tools and related machinery in the manufacturing of workpieces (Elanchezhian et al., 2007and Mourtzis et al., 2018).

CAD/CAM system is a term that is used for designing a product and controlling manufacturing processes. CAD and CAM systems and technologies are extensively used in many applications including but not limited to industrial design. In industrial design, CAD tools are widely used to develop digital models and prototypes for designed objects and patterns, graphic imaging for visual design and multimedia content, animation for special effects in movies, advertising and digital content creation. CAM technologies are being used to control machine tools and related machinery in the manufacturing process for rapid prototyping, machining and digital fabrication of physical objects (Roth, 2012 and Zeid, 2014).

Computer-Aided Drawings

There are three basic types of computer-aided drawings created using specialized software 2-D and 3-D CAD software programs for industrial designers.

1. 2-D drawing is a flat representation of an object or scene that is created using only two dimensions: length and breadth. It is a drawing that appears to have no depth or third dimension. In 2-D drawings, objects are represented by lines, curves, and shapes which are arranged in a specific way to convey information or create a visual image. They also include detailed measurements, annotations and other information that can be used to guide the manufacturing process of a product. This type of drawing is commonly used in many design fields. Examples of 2-D drawings include illustrations, patterns, blueprints, diagrams, maps, sketches and technical drawings as shown in figure 2.
2. 2 ½-D drawing, also known as pseudo-3-D drawing or 2.5 drawing, is a type of drawing that uses two-dimensional images to create the illusion of three-dimensional depth. This includes isometric, planimetric, oblique and perspective views which show all three (i.e. length, breadth and height) dimensions of an object on a pictorial drawing as shown in figure 3. In 2 ½-D drawing, objects are drawn in a way that gives the impression of depth and perspective using techniques such as shading, texture and layering. However, the objects themselves are still 2-D and do not have true depth. This technique is commonly used in computer graphics, video games and animation to create the appearance of 3-D environments without the need for complex 3-D modelling software. An example is design drawings that use shading and perspective to create the illusion of 3-D space even though the drawing itself is flat.
3. 3-D drawing is a type of drawing that creates the illusion of depth and space by representing an object or scene in three dimensions: length, breadth and height. In 3-D drawing, objects or models appear to have volume and can be rotated on screen and viewed from any angle. These models are typically created using software that allows designers to manipulate the model in real-time, viewing it from different angles and making changes as needed as shown in figure 4. Several different techniques and mediums can be used to create 3-D products. These include sculpting, modelling with clay, CAD software and 3-D printing. 3-D CAD models can be created to simulate the behaviour of the product or machine under different conditions, allowing designers to test the design before it is manufactured. With the advent of 3-D printing technology, 3-D drawings have become increasingly popular for creating prototypes and manufacturing parts and products.

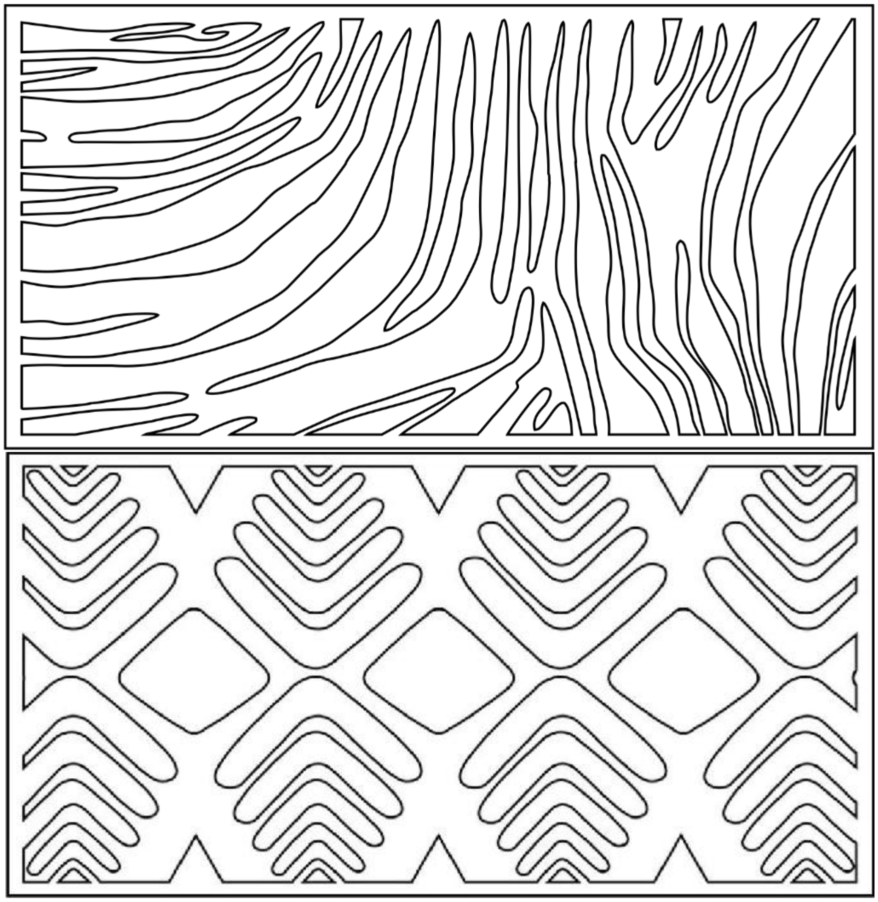

Figure 2: A 2-D Pattern Design using a Vector Graphics Software

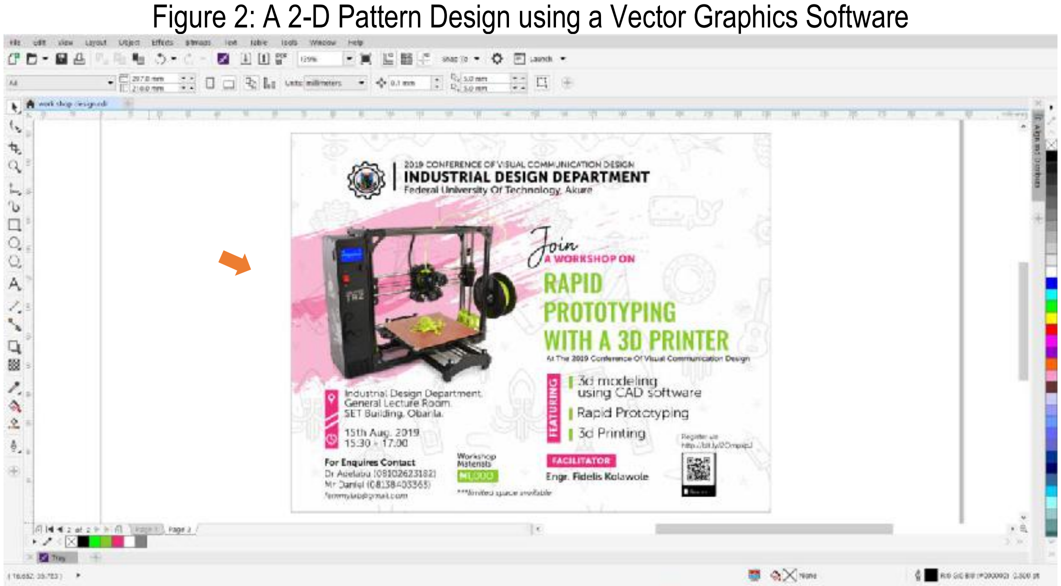

Figure 3: A promotional flier design with 2.5 illustration image using 2-D Vector Design Software (CorelDRAW)

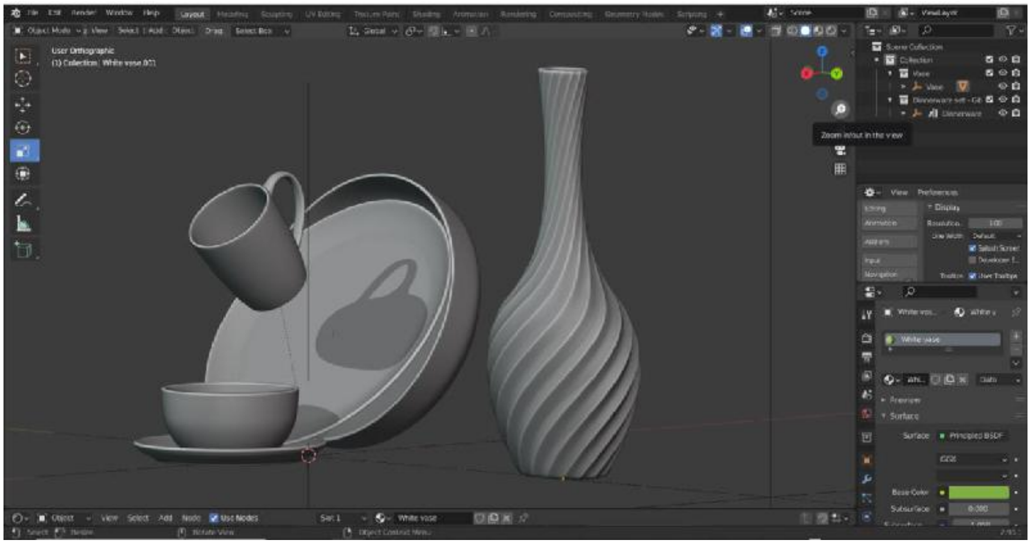

Figure 4: A 3-D model design of ceramic wares in a 3-D CAD Software environment (Blender)

Non-Uniform Rational B-Splines (NURBS) and polygonal models, as illustrated in figures 5 and 6, are two different methods used to represent 3-D geometry in 3-D modelling and computer graphics. NURBS surfaces use mathematical equations to represent smooth curves and surfaces while polygonal models use a mesh of flat polygons to represent the shape of an object. NURBS are ideal for modelling smooth, organic shapes with a high degree of accuracy. On the other hand, polygonal models are typically faster to render and can handle complex geometry with high levels of detail. They are commonly used in real-time applications such as video games and virtual reality where performance is critical.

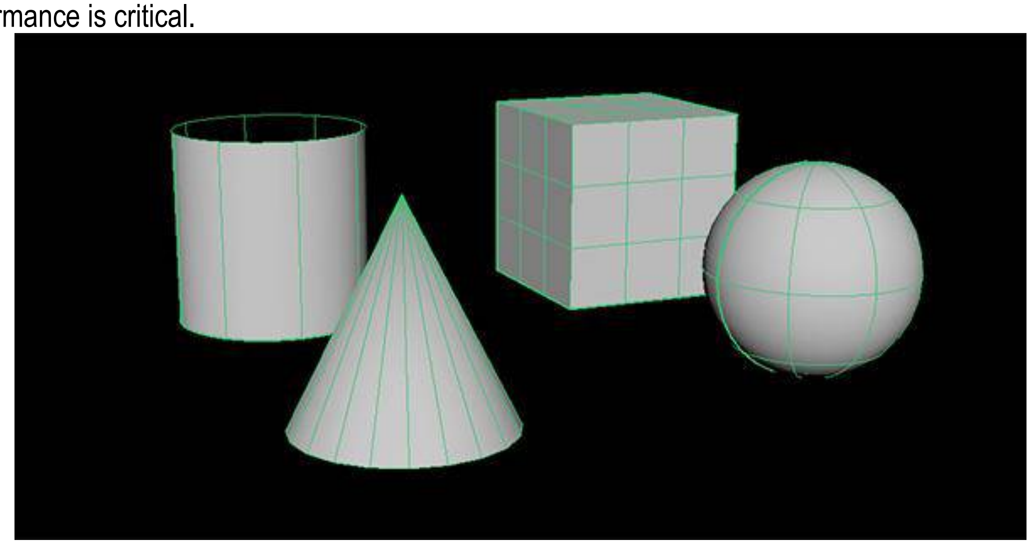

Figure 5: NURBS modelling

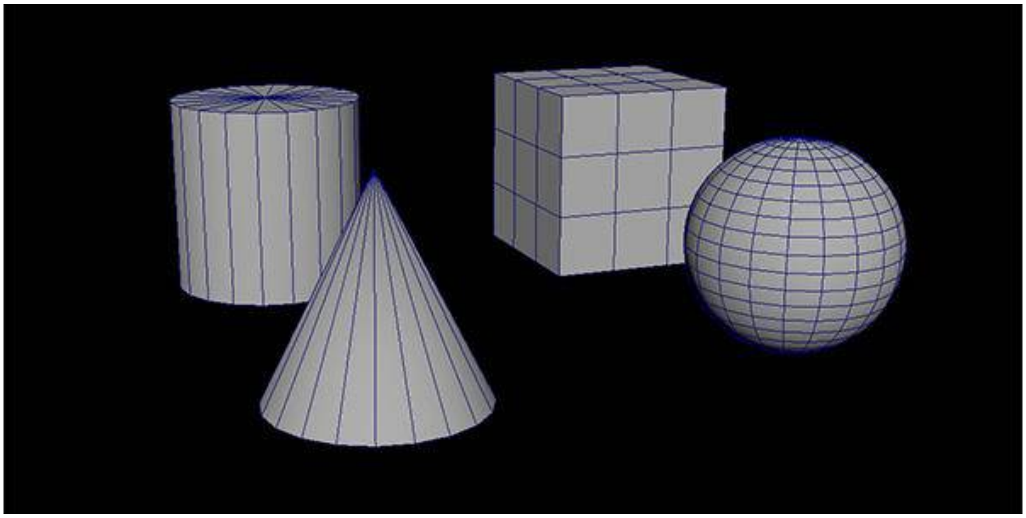

Figure 6: Polygonal modelling

There are three basic types of 3-D models. These are wireframe, surface and solid models.

1. Wireframe models: These are the simplest types of 3-D model, built up with only lines and points that define the edges and vertices of an object. They are often used for conceptual design and can be easily modified.
2. Surface models: They are built by drawing the surfaces of an object. They add a layer of depth to wireframe models by including colour shading and textures to create a more realistic representation of an object. Surface models can be created using NURBS which allows for smooth and accurate curves and surfaces.
3. Solid models: These are the most complex type of 3-D models as they represent an object as a solid and three-dimensional volume. They are built up using simple geometric forms such as cones, cylinders, prisms and cuboids. These can be added or subtracted to produce complex 3-D models. They are typically used in engineering and product design as they allow for precise measurements and analysis. Solid models can be created using various techniques such as constructive solid geometry or boundary representation.

There are some key differences between 2-D and 3-D CAD drawings. 2-D CAD is generally simpler and faster to use as it involves creating flat, two-dimensional drawings. 3-D CAD is more complex as it requires a deeper understanding of geometry and spatial relationships. However, 3-D CAD provides a more realistic representation of the final product and allows designers to test and refine the design more thoroughly. Both 2-D and 3-D CAD have their advantages and disadvantages. The choice of which to use will depend on the specific needs of the project. Some CAD software can be used for both 2-D and 3-D CAD, allowing designers to choose the approach that works best for their projects.

Basic requirements for CAD Software and common features

Before designers can create and develop digital representations of their design concepts, it is important to understand the basic requirements to run any CAD tool or system. Although, the specific requirements to run a CAD tool or system will depend on the software and hardware being used, however, the following general requirements are common to most CAD systems:

1. Computer: A computer is required to run CAD software. The computer should have a fast processor, sufficient Random Access Memory (RAM) and large hard drive to accommodate the CAD files;

2. Operating system: CAD software requires a specific operating system such as Windows or Mac or OS to run properly;
3. Graphics card: A dedicated graphics card is required to run CAD software. The graphics card should have a large amount of memory to handle the complex models in the CAD environment.
4. Monitor: A high-resolution monitor is required to view the detailed drawings and models being developed with CAD software;
5. Input devices: CAD software requires input devices such as a keyboard, mouse or stylus to manipulate the 2-D or 3-D drawings or models;
6. Internet connection: Some CAD software may require an internet connection for updates or to access cloud-based storage;

In addition to these hardware requirements, CAD software may also require specific software dependencies such as Java or .NET framework. It is important to check the specific requirements for each CAD tool or system before installation to ensure that the hardware and software are compatible. Several software programs are available and commonly used in 2-D designs and modelling. Some notable examples are:

1. Adobe Illustrator: This is a vector graphics editor that is commonly used for creating illustrations, logos and other 2D designs. It is popular among graphic designers and artists;
2. CorelDRAW: This is another vector graphics editor that is similar to Adobe Illustrator. It is also used for creating illustrations, logos and other 2-D designs;
3. Inkscape: This is a vector graphics editor similar to Adobe Illustrator and CorelDRAW. It can be used for creating illustrations, logos and other 2-D designs;
4. SketchUp: This is a 3-D modelling software program that can also be used for 2-D design. It is popular among architects, interior designers and product designers;
5. AutoCAD LT: AutoCAD LT is a 2-D CAD software program that is commonly used for technical drawing, drafting and architectural design;
6. Affinity Designer: Affinity Designer is a vector graphics software program that is similar to Adobe Illustrator and is commonly used for 2-D design and graphic design; and
7. Figma: This is a vector graphics editor and collaborative design tool used for creating user interface designs and web designs.

In general, there are two primary formats for creating 2-D digital designs using specialized software. These are:

1. Vector graphics use mathematical equations and geometric shapes to create images that can be infinitely resized without losing quality. Vector graphics are typically saved in file formats such as Adobe Illustrator (AI), Encapsulated PostScript (EPS) and Scalable Vector Graphics (SVG). Popular vector graphics software includes Adobe Illustrator and CorelDRAW. Vector graphics are commonly used for creating logos, typography and illustrations.
2. Raster graphics, also known as bitmap images, are made up of a grid of individual pixels, each with its colour value. Raster graphics are typically saved in file formats such as JPEG, PNG and TIFF. Raster graphics software such as Adobe Photoshop is used for editing and manipulating photographs and other complex images. Raster graphics are typically used in print and web design applications.

Moreover, several software packages are commonly used in 3-D design and modelling. Here are some of the most popular ones:

1. AutoDesk AutoCAD: This is a popular software program for creating technical drawings and designs such as architectural plans or engineering schematics. Also, it has 3-D modelling capability which is commonly used in the fields of architecture, engineering and construction.
2. SolidWorks: This is a 3-D CAD software program that is widely used in mechanical engineering and product design. It allows designers to create complex 3-D models and assemblies.
3. CATIA: This is another 3-D CAD software program that is widely used in the automotive, aerospace and industrial design industries. It allows designers to create 3-D models and simulate the behaviour of the product under different conditions.
4. Blender: This is a free and open-source 3-D modelling software program that is popular among animators, game developers and product designers. It allows designers to create 3-D models, animations and visual effects.
5. Maya: This is a 3-D modelling, animation and rendering software program that is commonly used in the film and video game industries. It allows designers to create complex 3-D models and animations.
6. SketchUp: This is a 3-D modelling software program that is popular among architects, interior designers and product designers. It allows designers to create 3-D models of buildings, interiors and products.
7. Rhino: Rhino, also known as Rhino3-D, is a 3-D CAD software developed by Robert McNeel and Associates. Rhino is a software tool. It is based on NURBS modelling which is a mathematical representation of 3-D geometry that allows for precise and flexible modelling of complex shapes. It is popular among industrial designers, architects and engineers for creating complex 3-D models.
8. Fusion 360: This is a 3-D CAD/CAM software developed by Autodesk. It is a cloud-based software that is used for designing, engineering and manufacturing products. It combines industrial and mechanical design, simulation, collaboration and machining in a single package. It is used by product designers, mechanical engineers and machinists to create 3-D models, simulate their behaviour and create tool paths for CNC machining.

Some key features of 3-D CAD software

1. 3-D Modelling: This allows designers to create 3-D models of objects using a variety of modelling tools and techniques including direct modelling, freeform modelling and parametric modelling. The traditional 3-D modelling techniques are usually based on geometric primitives such as cubes, spheres and cylinders where you add and remove the shapes to form complex objects.
2. Freeform Modelling: This allows for more organic and fluid shapes that can be created by manipulating points, curves and surfaces. With this, designers can create complex shapes and surfaces using a range of intuitive tools and techniques.
3. Parametric Design: This allows designers to create designs using measurements, calculations, drawings etc. to build an object that is easy to repeat. This is applicable for modelling accurate and dimensioned objects, tools and products.
4. Assembly Design: This allows designers to create complex assemblies of multiple parts and components. They can test and optimize the fit and function of each component before final assembly.
5. Simulation and Analysis: This includes tools that allow designers to test the behaviour of their designs under different conditions such as stress, vibration, and thermal effects. This allows for the optimization of their design for strength, durability, and performance.

6. Drafting and Documentation: This allows detailed engineering drawings and documentation to be generated for use in product development and manufacturing processes. This includes dimensions, annotations, and Bill of Materials (BoM).
7. Collaboration and Data Management: This allows designers to work collaboratively with others on the same project, in real-time, regardless of their location.
8. CAM: This includes integrated CAM tools that allow designers to create tool paths for 3-D printing and CNC machining.
9. Rendering and Visualization: This includes rendering tools that allow designers to create photo-realistic images and animations of their designs.
10. Add-ins: This can be used to add new features or automate repetitive tasks.

In order to use any of these programs, a user will need to have basic knowledge of their user interfaces and tools. A person can learn how to use them through online tutorials, user manuals or taking a course. With practice and experience, one can improve skills and create more complex designs.
CAD software are provided to end-users as open-source, freeware, shareware and proprietary software.

1. Open-Source Software (OSS) is a type of computer software in which source code is released under a license in which the copyright holder grants users the rights to study, change and distribute the software to anyone and for any purpose (St. Laurent, 2004).
2. Freeware software includes software that is available for users at no cost. They can be downloaded from the internet and installed directly by the users without a subscription fee. Unlike open-source software, users are not permitted to modify or study the program.
3. Shareware software is software that is freely distributed to users but for a limited timeframe or trial period. For instance, the software can be made free to use for 30 days after which the program will be deactivated and require some payment for full access. Shareware is of different types such as Adware, Freemium, Demoware, Nagware and Donationware.
4. Proprietary software is commercial with restrictions on its distribution and use. Their advantage is that they are more stable, reliable, robust and compatible across many operating systems although their use often requires a subscription. Many industry-standard CAD software are released under proprietary conditions. Their powerful modelling tools and flexibility make it a popular choice among designers who need to create complex 3-D models.

Most of these software categories contain information on the terms and conditions of their use and the minimum system requirement for their installation. Particularly for 3-D CAD software, higher system specifications are often recommended to improve software performance. Many of them are more suited for operation as desktop applications on Windows PC and Mac OS environments. In general, the following criteria are beneficial to consider in selecting CAD software for training:

1. Acceptability in the industry: Training with industry-standard software makes it easier for designers to adapt easily to the real work environment.
2. Compatibility: using software that can read and write a wide range of file formats, including STL, DWG, and STEP is advantageous. This makes it easy to import and export designs from other software tools. Different 3-D design applications support different file formats, and it's essential to choose the right format to ensure compatibility between software programs and facilitate the 3-D design workflow.
3. Versatility: using CAD software that is versatile support the use of a wide range of modelling tools, which can help to create complex shapes, surfaces, and solids.

4. User-friendly interface: software with a user-friendly interface enhances ease of use, increased efficiency, improved engagement, productivity, and good user experience while reducing errors and time to achieve a task.
5. Built-in rendering: In the case of 3-D CAD modelling, software with built-in rendering tools allows designers to create photo-realistic images and animations of their designs.

For creating 3-D designs, many file formats are being used by various 3-D modelling software. The following are common examples:

1. STL (Stereolithography): This is a file format used for 3-D printing and is supported by most 3-D printing software.
2. OBJ (Object): This is a popular file format for 3-D modelling and is supported by most 3-D modelling software.
3. FBX (Filmbox): This is a file format developed by Autodesk for 3-D models used in animation and game development.
4. STEP (Standard for the Exchange of Product Data): This is a file format used for exchanging CAD files between different software applications.
5. IGES (Initial Graphics Exchange Specification): This is another file format used for exchanging CAD files between different software applications.
6. PLY (Polygon File Format): This is a file format used for storing 3-D models with polygonal geometry.
7. 3DS (3D Studio): This is a file format used for 3-D modeling and is supported by most 3D modeling software.
8. DXF (Drawing Exchange Format): This is a file format used for exchanging CAD files between different software applications, particularly for 2-D designs.

CAD/CAM applications for ceramics and glass designs

Increasingly, computers are playing an important role in design operations throughout ceramic industry whether in the advanced or traditional segments. Through the applications of various CAD tools, designers can take innovative approaches to ceramic product conceptualization, product prototyping, manufacturing and marketing. While ceramic product development and manufacturing could be complex, labour-intensive and time-consuming processes, computer applications can be used with the benefits of speeding up the design process or improving the productivity of manufacturing processes (Adelabu and Kashim, 2010).

Computer software can be used to model ceramic forms, simulate ceramic processes, characterize particle packing and perform statistical design experiments. Both software and hardware can be incorporated for automating manufacturing plants. The adoption of CAD tools can be profound, especially in the areas of digital modelling and rapid prototyping of ceramic products, glaze formulation, ceramic decoration, kiln design, firing technology, industrial ceramics, product presentations and visualizations. An example is the 3-D model of a throwing wheel machine concept shown in figure 7.

Prototyping is a product development process peculiar to almost all design fields including ceramics. It is a fundamental design initiation which involves the construction of working models (mock-ups) of conceived products for mass production. The development of ceramic prototypes has been formerly carried out through manual and time-consuming process which relies largely on the skills of an experienced craftsman who employ the use of hand tools only. The introduction of CAD technology to ceramic prototyping has provided a wide range of solutions to some problems related to manual production methods in ceramics.

The development and management of designs with 3-D CAD software which enabled the ability to present products faster than before have become an important enterprising factor in the ceramic industry towards the delivery of quality products. Design templates generated with computer design software are now being used creatively to generate clay product prototypes that exhibit precision and geometric regularity in the ceramic studio. The significance and the benefits of the use of CAD can be seen from the art to part (i.e., design to production) stages. Besides, the application of CAD has also improved presentation and communication in the marketing of ceramic products. Table 1 shows an example list of CAD software for ceramics and glass design applications.

Table 1: Examples of CAD Software Applications for Ceramics and Glass Design

S/N	Software	Software Type/ Proprietary	Relevant Features	Developed by	Initial Release Date	Official Website
1.	AutoCAD	Commercial	Provides a range of tools for 2D and 3D design. Used for creating detailed technical drawings and plans.	Autodesk	December 1982	https://www.autodesk.com/products/autocad/overview.
2.	Blender	Open source/ freeware	3D animation, hard-surface modelling, sculpting and rendering software	Ton Roosendaal /Blender Foundation	January 1, 1998	https://www.blender.org
3.	Cinema 4D	Commercial	3D modelling, rendering, and product visualizations	Maxon	1990	https://www.maxon.net/en/products/cinema-4d/overview
4.	Fusion 360	Freeware and commercial	Cloud-based software which provides a range of tools for 3D modelling, prototyping simulation, and manufacturing (toolpath creation and NC code for CNC machining)	Autodesk	June 2013	https://www.autodesk.com/products/fusion-360/overview.
5.	Mastercam	Commercial	CAD/CAM software solution which provides a range of features for 2D and 3D design, as	CNC Software, Inc.	1983	https://www.mastercam.com/.

			well as toolpath creation, simulation, and verification			
6.	Onshape	Commercial with a free plan	A cloud-based 3D modelling software which runs on a web browser or mobile app and allows for collaboration	A team of former SolidWorks executives and software developers	March 9, 2015	https://www.onshape.com
7.	Rhino	Commercial	A 3D modelling software with flexibility and versatility in creating complex 3D models	Robert McNeel & Associates	1998	https://www.rhino3d.com/.
8.	RhinoCAM	Commercial	A CAD/CAM software solution designed as a plugin for Rhino. It has features for 2D and 3D design, as well as toolpath creation, simulation, and verification	MecSoft Corporation	2003	https://mecsoft.com/rhinocam/.
9.	SculptGL	Open source/ Freeware	A web-based 3D sculpting software for both beginners and professionals	Stéphane Ginier	2013	https://stephaneginier.com/sculptgl/
10.	SketchUp	Commercial	Creating 3D models and photorealistic visualizations	Trimble Inc.	August 2000	https://www.sketchup.com
11.	SolidWorks	Commercial	Creating complex 3D models and detailed technical drawings	Dassault Systèmes	1995	https://www.solidworks.com/
12.	SolidCAM	Commercial	A CAD/CAM software solution that is designed for use with	SolidCAM GmbH	1995	https://www.solidcam.com/

			SolidWorks with features for 2D and 3D design, as well as toolpath creation, simulation, and verification			
13.	TinkerCAD	Freeware	A web-based 3D modelling application for beginners and educators	Autodesk	2011	https://www.tinkercad.com/
14.	ZBrush	Commercial	Creating highly detailed and complex 3D models and textures with a range of sculpting tools and brushes	Pixologic Inc	1999	www.pixologic.com

Figure 7: A 3D model of a ceramic throwing wheel concept using a 3-D CAD software

CAD/CAM applications for textiles and fashion designs

The textile and fashion industries are being transformed through the applications of computer technology from the design stage through to their manufacturing level. In the past three decades, there have been significant advances and innovative developments in the use of computer technology for various applications including structural and defect analysis, modelling and simulation, and apparel design (Hu, 2011; Sinclair & Burke, 2015).

Today, CAD and CAM have become increasingly relevant in the design and production systems in fashion and textiles including a growing development of online virtual systems. It is also notable that the developments in the release of specialized CAD software or computer graphics applications have enabled designers in the modelling of fabrics. With wide access to standard off-the-shelf software such as Maya and open-source software such as Blender, there is the possibility to simulate apparel for a realistic look, model drapery and fit of a garment on the body and even visualize 2-D patterns into 3-D virtual prototyping. See Table 2 below for an example list of CAD software used in the modelling of apparel and textile products. Figures 8 and 9 are examples of pattern and apparel designs created with 2-D and 3-D CAD software respectively.

In the manufacturing process, there is much development in using digital fabrication methods in reinventing traditional design methods. An example is the use of CNC routers in making print blocks or the use of a laser cutter for cutting fabric instead of the traditional hand-cutting methods.

Consumers' experiences are constantly being improved with the integration of 3D garment simulation and scanning technology in the development of an Artificial Intelligence (AI) driven smart mirror that enables consumers to virtually try on their desired apparel without getting undressed. An example of this is the introduction of an AR Smart Mirror by CLO Virtual Fashion, the developer of Marvelous Designer. AR Smart Mirror harnesses 3-D avatars and virtual fitting Application Programming Interface (API) with LG's touchscreen signage and automatic body scanning technology using a 3-D camera. This enables customers to virtually wear and fit a piece of apparel before the actual production.

The benefits of applying CAD and CAM technologies include but are not limited to the following:

1. The customization in the design process in meeting individual needs (mass customization to personalization).
2. Improves precision and greater productivity for textile design.
3. Reduced time in the textile design and production processes.
4. Enhances quality and innovation in apparel design.
5. Organization of information workflow and data management for apparel and textile design to manufacturing.
6. Realistic virtual simulation of fabric textures and physical properties.
7. Aiding the analysis of textile technical properties.

Table 2: Examples of CAD Software for Textile and Fashion Design Applications

S/N	Software	Software Type/ Proprietary	Relevant Features	Developed by	Initial Release Date	Official Website
1.	AccuMark	Commercial	3D simulation for fit-of-garment and fabric drapery based on a virtual avatar; fashion design and production management	Gerber Technology	1988	www.gerbertechnology.com/products/accumark
2.	Adobe Illustrator	Commercial	Digital pattern making	Adobe Inc.	March 19, 1987	www.adobe.com
3.	C-DESIGN Fashion	Commercial	Clothing design and fashion product lifecycle management (PLM)	C-DESIGN	1998	www.cdesignfashion.com
4.	Blender	Open source/ freeware	Cloth simulation	Ton Roosendaal /Blender Foundation	January 1, 1998	www.blender.org

5.	Browzwear VStitcher and Lotta	Commercial	3D clothing design, virtual garment simulation and style showcasing	Browzwear	2000	www.browzwear.com
6.	CLO	Commercial	Digital pattern making and realistic 3D virtual garment simulation	CLO Virtual Fashion	2009	www.clovirtualfashion.com
7.	CREATE	Commercial	Apparel pattern making	Crea Solution	N/A	www.creasolution.com
8.	CorelDraw	Commercial	Digital pattern making	Corel	January 16, 1989	www.corel.com
9.	Efi Optitex	Commercial	3D simulation for fit-of-garment, fabric drapery and virtual catwalks; end-to-end solutions for fashion business	EFI Optitex	1988	https://optitex.com
10.	Lectra Modaris	Commercial	Pattern design systems (PDS), virtual try-on and virtual catwalks, Product data management (PDM)	Lectra	1984	www.lectra.com
11.	Maya	Commercial	Cloth modelling for animation and game characters	Alias Systems Corporation/ Autodesk	February 1998	www.aurodesk.com
12.	Photoshop	Commercial	Digital pattern-making and cloth simulation	Thomas and John Knoll/ Adobe Inc.	February 19, 1990	www.adobe.com
13.	Poser	Commercial	Cloth modelling for animation and game characters	Smith Micro Software	1995	https://www.posersoftware.com
14.	Silhouette Studio	Commercial	Creating designs for Silhouette cutting machine	Silhouette America, Inc	2010	https://www.silhouetteamerica.com/software
15.	Zbrush	Commercial	Fabric sculpting	Pixologic Inc	1999	www.pixologic.com
16.	Marvelous Designer	Commercial	Digital pattern making, virtual try-on and virtual catwalks, cloth and fabric design for	CLO Virtual Fashion	2009	www.marvelousdesigner.com

			animated films and game characters design			

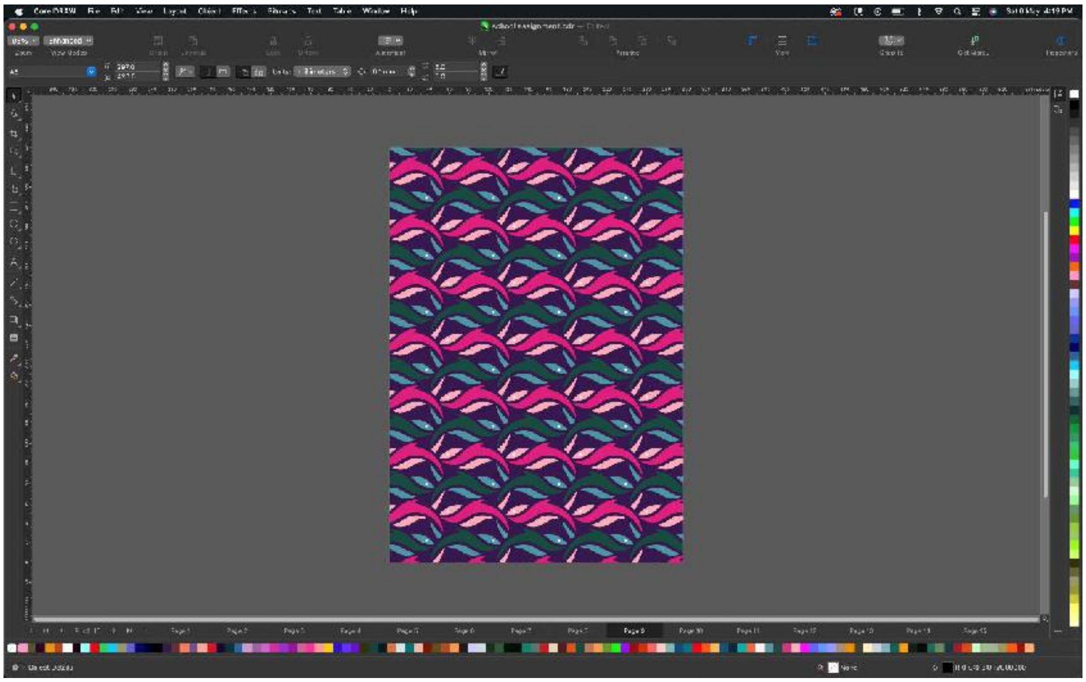

Figure 8: A 3-D apparel design by Olumide Oluwapelumi using CorelDraw software

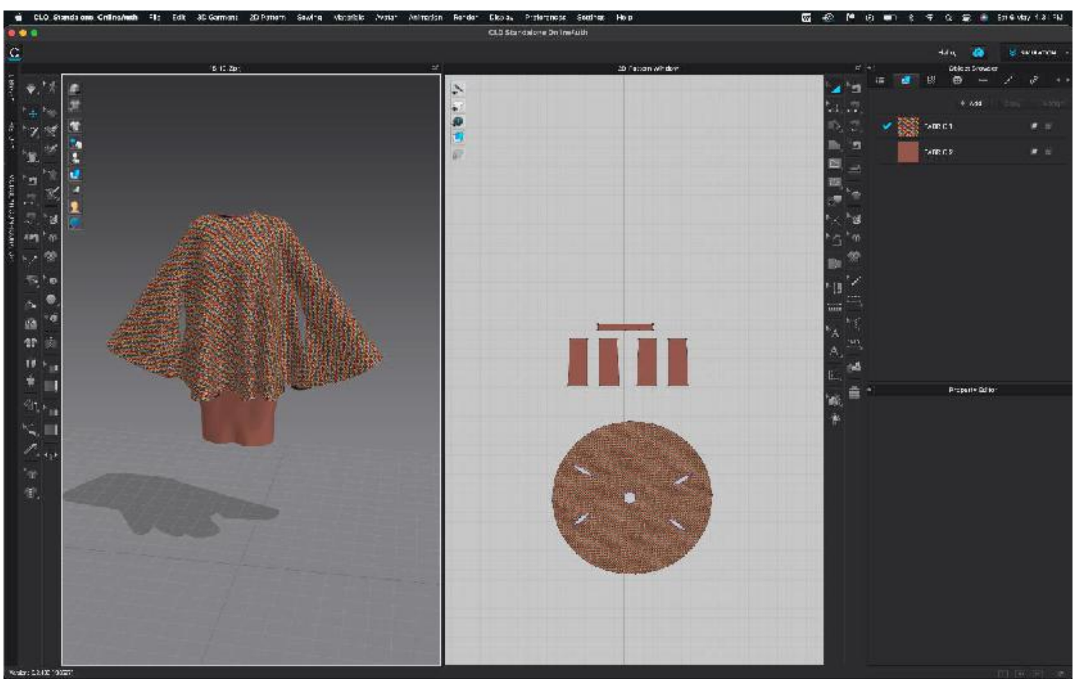

Figure 9: A 3-D apparel design by Olumide Oluwapelumi using CLO CAD software

CAD/ CAM applications for graphic design and visual communication

In graphic design and visual communication, computers play a critical role by providing designers with the tools and technology needed to create, manipulate, and deliver digital graphics and images. Graphic design software programs, such as CorelDraw, Adobe Creative Suite etc., allow designers to create and edit images, illustrations, and layouts using digital tools such as brushes, layers, and filters. These programs also provide a range of typographic tools, allowing designers to create custom fonts, manipulate text, and apply special effects as illustrated figure 10.

In addition to creating designs with various CAD software, designers can share their work with clients and colleagues through digital file sharing and collaboration tools. This facilitates the design review process and enables real-time feedback, leading to more efficient and effective design workflows. Furthermore, computers allow designers to create interactive and multimedia designs, including web and mobile applications, video and animation, and virtual reality experiences. These new mediums require specialized tools and techniques, such as 3D modelling and animation software, which are made possible by modern computing technology. With 3D modelling capabilities, designers can create photorealistic renderings of products, allowing clients to see how their product will look in real life before it is produced. CAD/CAM applications can also be used to design and create prototypes for products, helping designers and clients to visualize and test the product before it is manufactured.

The effect of the applications of CAD tools in the field of graphic design and visual communication is far-reaching, allowing designers to create more accurate and realistic designs and prototypes, and saving time and money in the design process. Examples of CAD software for graphic design applications are listed in Table 3.

Table 3: Examples of CAD Software Applications for Graphics Design and Visual Communication

S/N	Software	Software Type/ Proprietary	Relevant Features	Developed by	Initial Release Date	Official Website
1.	Adobe Creative Suite	Commercial	A collection of design software including Photoshop, Illustrator, and InDesign that are commonly used for graphic design, photography, and web design	Adobe Inc.	September 1, 2003	www.adobe.com
2.	Affinity Designer	Commercial	A vector graphics editor and design tool used for creating logos, illustrations, user interface designs, and other vector-based graphics	Serif	October 2014	https://affinity.serif.com/en-gb/designer/
3.	3d Studio Max (3ds Max)	Commercial	3D modelling and animation software used for creating visual effects in films, TV shows, and video games	Autodesk	1999	www.autodesk.com/products/3ds-max
4.	Blender	Open source/ freeware	3D modelling, animation, simulation and rendering software	Ton Roosendaal /Blender Foundation	January 1, 1998	www.blender.org
5.	Canva	Freeware and commercial	Cloud-based platform with pre-designed and customisable templates for graphic design	Melanie Perkins, Cliff Obrecht, and Cameron Adams	2013	https://www.canva.com/
6.	Cinema 4D	Commercial	3D modelling, animation, and rendering software for creating visual effects, motion graphics, and product visualizations	Maxon	1990	www.maxon.net/en/products/cinema-4d/overview
7.	CorelDraw Graphics Suite	Commercial	Vector illustration, layout, photo editing, and typography tools	Corel	January 16, 1989	www.corel.com
8.	Figma	Freeware	A vector graphics editor and collaborative design tool with a range of features well-suited for graphic design	Figma, Inc	2016	www.figma.com.
9.	Inkscape	Open source/ freeware	Vector graphics editor used for creating illustrations, logos, and other 2D designs	Inkscape community	November 4, 2003	https://inkscape.org
10.	Maya	Commercial	3D animation, modelling, and rendering software used for creating visual effects in films, TV shows, and video games	Alias Systems Corporation/ Autodesk	February 1998	www.aurodesk.com

11.	SketchUp	Commercial	3D modelling software for architectural and interior design, landscape architecture, and game design	Trimble Inc.	August 2000	www.sketchup.com
12.	SolidWorks Visualize	Commercial	Rendering software used for product design visualizations and animations	Dassault Systèmes	2016	SolidWorks Visualize
13.	ZBrush	Commercial	3D modelling and textures for character design and illustration to product design	Pixologic Inc	1999	www.pixologic.com

Figure 10: Examples of a poster (left) and book cover (right) designed by Sanusi Omobolaji using Vector and Raster editing software

Rapid prototyping

Rapid prototyping is a process used to quickly create physical prototypes of a product or part using 3-D CAD data as shown in figure 11. The goal of rapid prototyping is to speed up the design and development process by allowing designers to quickly create and test different iterations of a design. This is often achieved through the use of 3D printing technologies or other manufacturing techniques.

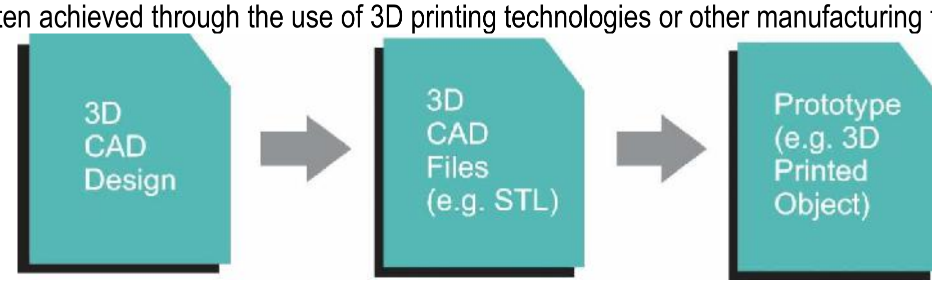

Figure 11: A rapid prototyping process

The process of rapid prototyping typically involves the following steps:

1. Design: The first step is to create a 3-D model of the product or part using CAD (computer-aided design) software or other modelling tools.

2. Preparation: The 3-D model is then prepared for printing, which may involve adjusting the size and orientation of the object to optimize printing.
3. Production: The 3-D printer is a typical example of a rapid prototyping machine which creates a physical model of an object by building up layers of material (such as plastic, clay, metal, or resin) according to the specifications of the 3-D model as shown in figures 12 and 13. Other examples of rapid prototyping machines include CNC routers and laser cutting machines.
4. Testing and refinement: Once a prototype is created, it is tested and evaluated to identify any design flaws or areas for improvement. Based on the results of the testing, the design may be refined and the process repeated until a satisfactory prototype is produced.

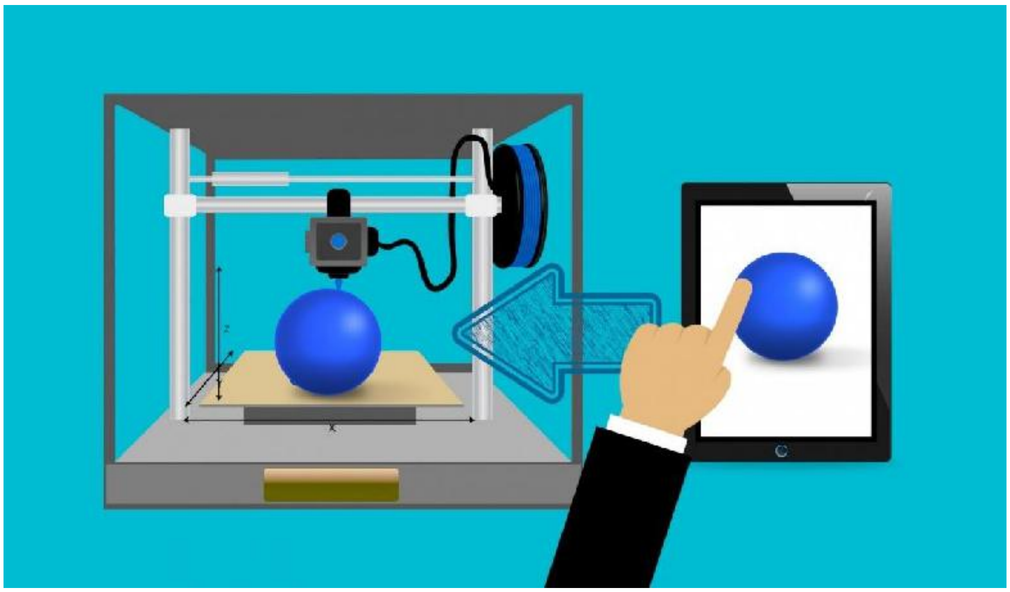

Figure 12: The 3-D printing process
Source: Public Domain Pictures

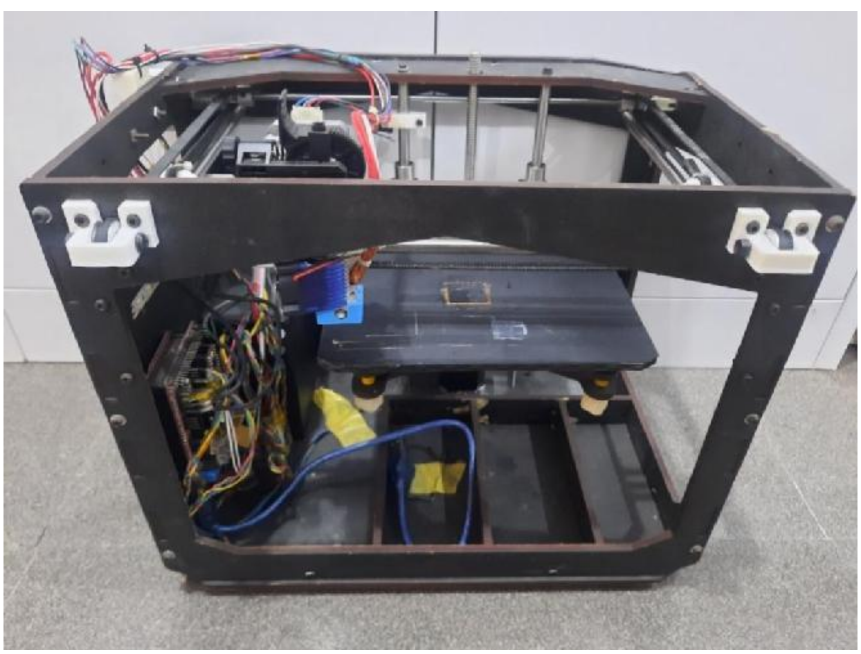

Figure 13: A desktop 3-D printer

Summary

Industrial design is a trans-disciplinary field that is evolving in response to changing times and technological progress and therefore demands the adaptation and assimilation of new skills and sophisticated design tools. With the fading of the traditional approach to industrial design, a new frontier is emerging in an era of digital transformation which requires that design training adjusts to this new reality. CAID plays an important role in modern manufacturing by facilitating the creation of efficient, functional and aesthetically pleasing products. CAD and CAM have become important tools in industrial design fields that can be applied from the conception of ideas to realization processes in the development of concepts and production of prototypes that employ drawing speed, quality production, quick modifications, production innovations, cost and time effectiveness. Various CAD/CAM applications have been developed to enhance the design processes and management in the different specialized areas of industrial design. Each software has its unique features and capabilities and the user needs to choose the one that is available and best fits the needs of a specific design workflow. Furthermore, digital and rapid prototyping has revolutionized the way products are designed and developed, allowing for greater creativity and faster innovation, as designers can easily experiment with different ideas and concepts.

Future directions for CAID portend a growing trend in the integration of more sophisticated CAD/CAM tools and systems in the whole design and production processes. Recent advances in CAD technology which includes Virtual Reality (VR), Computational and Generative Design, AI-assisted applications, and others could yield further possibilities for more responsive and powerful tools for the design and development of complex and intelligent industrial design products.

Exercise

1. What is Computer-Aided Industrial Design?
2. Define CAD and CAM.
3. List four significances of CAD for the industrial design processes.
4. What are the three basic types of computer-aided drawing and give a brief description of each of them.
5. List three types of 3-D models.
6. Mention five basic features of 3-D CAD modelling software.
7. Give three examples of CAD software which can be used in different areas of specialization in industrial design.
8. Using any 2-D or 3-D CAD software of your choice, attempt a visual model design of a product concept related to your area of industrial design specialization. For example, a piece of pottery ware, a textile pattern or a company logo.
9. What is rapid prototyping?
10. What are the basic steps involved in rapid prototyping?

References

Adelabu, O. S. and Kashim, I. B. (2010). Developing computer aided tools for ceramic prototyping in Nigeria. In J. B. Olujimi, M. O. Bello, E. B. Ojo, A. O. Olotuah, M. A. Adebayo, and F. K. Omole (Eds.), *Man, Technological Advancement and Sustainable Environment: 1st International Conference of the School of Environmental Technology, Federal University of Technology, Akure, Nigeria* (pp. 448–454). School of Environmental Technology, Federal University of

Technology Akure.
Bi, Z. and Wang, X. (2020a). Computer Aided Manufacturing (CAM). In *Computer Aided Design and Manufacturing* (pp. 367–411). https://doi.org/https://doi.org/10.1002/9781119667889.ch9
Bi, Z. and Wang, X. (2020b). Computers in Manufacturing. In *Computer Aided Design and Manufacturing* (pp. 1–33). https://doi.org/https://doi.org/10.1002/9781119667889.ch1
Chua, C. K. and Leong, K. F. (2003). *Rapid prototyping: Principles and applications* (2nd editio). World Scientific Publishing Co. Plc. Ltd.
Elanchezhian, C., Selwyn, S. T. and Sundar, S. G. (2007). *Computer Aided Manufacturing*. Laxmi Publications Pvt. Ltd.
Ennis-Cole, D. (2023). Computer-Aided Design. In *Encyclopedia.com*. https://www.encyclopedia.com/education/news-wires-white-papers-and-books/computer-aided-design
Groover, M. P. (2023). Automation. In *Encyclopedia Britannica*. https://www.britannica.com/technology/automation
Hu, J. (2011). *Computer Technology for Textiles and Apparel* (J. Hu (ed.)). Woodhead Publishing.
Mourtzis, D., Makris, S. and Chryssolouris, G. (2018). *Computer-Aided Manufacturing BT - CIRP Encyclopedia of Production Engineering* (pp. 1–13). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-35950-7_6550-4
Narayan, K. L. (2008). *Computer Aided Design and Manufacturing*. Prentice Hall of India.
Roth, R. E. (2012). *CAD/CAM: Principles and Applications*. Cengage Learning.
Sinclair, R. and Burke, S. (2015). Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) of Apparel and other Textile Products. In R. Sinclair (Ed.), *Textiles and Fashion: Materials, Design and Technology*. Woodhead Publishing.
SURFACEID. (2017). *Understanding CAID (computer-aided industrial design)*. https://surfaceid.com/blog/understanding-caid-computer-aided-industrial-design/?nowprocket=1
Ulrich, K., Eppinger, S. and Yang, M. C. (2020). *Product Design and Development* (7th Edition). Mcgraw-Hill.
Zeid, I. (2014). *Mastering CAD/CAM* (2nd Editio). McGraw Hill Education.

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CHAPTER 26
Basic Design
by
PETERS Edem Etim

Overview

This chapter aims to provide students with a critical understanding of the basic design practices in the context of industrial design and technology. Students will explore the concept of design as it relates to the different areas of design namely ceramic, fashion design, graphics, textiles, glass design and technology and metal design. It examines two- and three-dimensional designs, the elements and principles of design in art production. It explores the engagement of basic tools, materials and techniques for design making in different artistic contexts. Students will explore the roles of design and the implication in industry, economic growth and sustainable development in Nigeria.

Objectives

At the end of this chapter, students should be able to:

1. define industrial design;
2. describe the concepts of basic design;
3. outline the role of different design areas;
4. demonstrate an understanding of the application of visual elements and principles of design;
5. create a simple design for any visual art area;
6. mention some elements and principles of design; and
7. identify simple basic design tools in design areas.

Introduction

Basic design is the application of necessary inputs in an arrangement or composition engaging desired materials and techniques. It is a creative expression with specific approach, which communicates an intention. According to the Oxford Advanced Learner's Dictionary, design is "the general arrangement of the different parts of something that is made, such as a building, book, machine, and others, and the art or process of deciding how something will look, work, and others; by drawing plans, making models and others as well as design as pattern-arrangement of lines and shapes such as floral /abstracts /geometric designs as decoration". Egunlae (1989) observes that "design is an arrangement scheme or composition. It is a plan for arranging separate materials into a unified pattern". It is necessary to note that basic design is engaging the necessary aspects of composition that are most relevant and from which other things could emanate. According to Ogunwole (1997), design is a drawing or outline from which something may be made. It is through design that probably man's vital problems are solved. This could be expressed in the basic needs of mankind such as food, clothing, shelter and others, which are very crucial to man's present living standard. According to Wong (1993) "Design is practical. The designer is a practical person. But before he is ready to tackle practical problems, he has to master a visual language (visual elements). This visual language is the basis of design creation. Thorough understanding of this would definitely enhance his capacity in visual organization". Even though, the present standard of living accommodates an enormous number of items, which design constantly generates, the focus here is on the various industrial design disciplines. The two-dimensional designs and three-dimensional designs approaches are engaged in executing the necessary aspects in the various industrial design areas. Among the areas of industrial design include ceramics, textiles, graphics, fashion design, glares, metal work and jewellery.

Concept of design

The starting point of any design is its conception before the actual implementation. Udosen (2000) submits that essentially, designing involves planning and implementation. It means the use of skill to manipulate materials to fulfil objectives. To design, one must be conscious of the need to do so, and be aware of the opportunity and the content as well as identify the available resources. This also implies that designing activity results in learning about the environment, about one's capability and the way in which one may relate to others". The various factors or considerations, discussed by Udosen, agree with the fact that creating a design must be intentional for the outcome to meet the desired purpose. Udosen further confirms an Ibibio proverb, which says that, "the earth-worm swore that, if it is attacked by an over powering enemy, before it dies it must make marks on the ground as a sign that it had put up a hard struggle". The mark made on the ground by an earth worm, even if it forms a complex pattern, is not a design because clearly, such a pattern has no purpose and has no potential of satisfying anyone. This analogy by Udosen may be controversial, since the design on the ground made by the earth worm could still be utilized by man for some desired purposes. Design is an intentional expression by man for a purpose. According to Cyril-Egware (2021), "Design is conceived and the motifs are put together in an orderly manner to actualize a set goal. The conception for the complete form of an object often is a sketch, model or a set of instructions that is a preliminary stage in the process that leads to a finished product". Design is an all-important area for human development. Design dynamics boost the economic growth of nations. Peters (2013) states that "design entails the application of the visual elements and principles in various combinations to produce some desired expressive qualities. All works of design have desirable form. Each culture seems to develop its own characteristic style of living and its own way of achieving visual order". Saymour (2002) in Peters (2013) asserts that "the Design Council declares design as an activity that translates an idea into a blueprint for something useful, whether a car, a building, a graphic, a service or a process". This implies that the focus of design is to improve the quality of lives of people. Seymour further states that "design is making things better for people" The idea is that design brings about improvement in the lives of people either in products or services. The development of a society or any nation's economy relies on industrial production of goods to shape its economy. In order to meet the demands of contemporary life, design creation is crucial and it is the way forward to redouble the powers of creative ingenuity, resource, innovation and invention.

Ideation

Ideation is the process of generating and development ideas, often used in the design process in order to achieve creative solutions to challenges or problems. This includes exploring, brainstorming, sketching, and refining ideas to generate concepts that can be further developed or created into designs. Ideation, in the context of design using digital graphic tools, can involve creating sketches or wireframes, digital mood boards, visual prototypes to explore and develop ideas for a project. These tools allow designers in all design areas to quickly iterate ideas in a tangible and desirous way before finalizing or putting finishing touches to the designs. This process is the basic approach to design implementation and production, and is applicable to all visual arts areas namely; ceramics, fashion design, graphic design, textile design, glass design and technology and metal design. Wong (1993) sees design as a process of purposeful visual creations. Unlike painting and sculpture, which are the realization of artists, personal visions and dreams, design fills practical needs. A piece of graphic design has to be placed before the eyes of the public and to convey a predetermined message. He further asserts that an industrial product has to meet consumers' requirements.

Two- and Three-Dimensional design

Design has processes it should follow to achieve the aim of its fulfilment as a design. According to Wong (1993), "a good design, in short, is the best possible visual expression of the essence of 'something', whether a message or product. To do this faithfully and effectively, the designer should look for the best possible way this 'something' can be shaped, made, distributed, used and related to the environment. His creation should not only be just aesthetic but also functional." It is important to note that concepts and principles are necessary in design making. Wong further claims that a designer's "taste and sensitivity to visual relationships are much more important, but a thorough understanding of them would definitely enhance his capability in visual organizations". Any form of visual design that exists in two dimensions such as length and width is referred to as 2-D design; while any form design that exist in three dimensions such as length, width and depth is referred to as 3-D design. Two-dimensional design comprises of graphic and textile designs among others. The implication of these areas of design being referred to as "two–dimensional" is the characteristics of having the length and width, but no depth and they are flat. The three-dimensional design comprises of length, width and depth. It is also referred to as 3-D and has the quality of having or appearing to have the dimensions of length, width and depth. Such areas of design include ceramics, sculpture, product design, jewellery and architecture, among others.

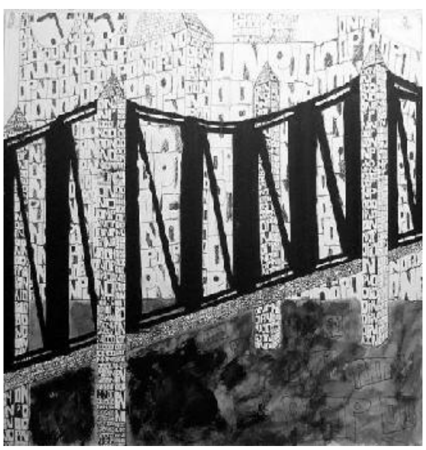


Figure 1:
Courtesy: Suny Ulster: Two- Dimensional Design

Figure 2:
Courtesy: Cnc Cutting Design - Laser Cutting Design (2D)

Figure 3:

Figure 4:
Courtesy: *shutterstock.com (3 Dimentional*

Elements and principles of design

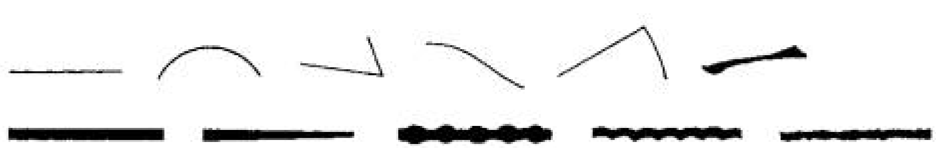
The combination of elements and principles of design creates a good and successful design. Cyril-Egware (2021) observed that "creating beautiful designs is more than mere inspiration or a great idea". It is about understanding the fundamentals of the elements and principles of design to be able to create beautiful and functional arts and crafts. This is applicable to the use of elements and principles of design to create a unique design.

Elements of design

The elements of design comprise line, shape, texture, space, form and colour. These visual elements are the tools the designers, craftsmen and artists engage in the skilful creation of their works.

Line: Line is seen as a continuation of a dot. It is the basic element of design and one cannot conceive of any illustration, writing or any work of design or art without the use of a line. There are different types of lines, which include dotted lines, straight lines, zigzag lines, curved lines, wavy lines among others as shown in figure 5.

Figure 5



Shape: Shape is created when a line, which starts at a point moves back to join the beginning point to form either two- or three-dimensional objects. The various lines at different directions can meet to create shape, form or patterns, and this can be organic or geometric as shown in figure 6.

Figure 6

Form: It can mean mass or shape depending on how it is arranged. It can also be the whole work of design as shown in figure 7.

Figure 7

Texture: It is the feeling or the surface quality of an object, such as rough or smooth, fine or coarse. It is experienced by sight or when one touches the surface quality of an object as shown in figure 8.

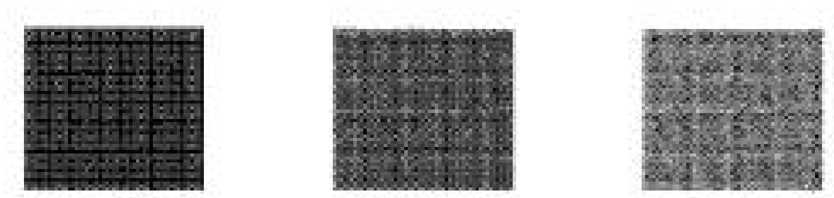


Figure 8

Space: This is a visual element in design, which interacts with lines, colours and shape. Space is three-dimensional volume comprising of height, length and width and can also be expressed as an illusion of depth in two-dimensional design. In design, space can be "negative" where it is empty and not utilized, as well as "positive" where it is utilized as shown in figure 9.

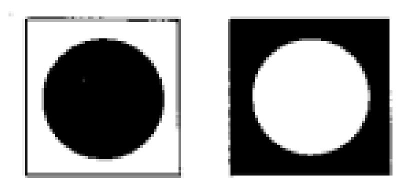


Figure 9

Colour: Colour is very important in design making. It is also considered as being dependent on light and value. Light makes colour visible and value is the level or measure of lightness or brightness or darkness in a design. Both 2-D and 3-D designs engage colour or light and value in design making. Colour is referred to as the decomposition of white light with seven colours in the visible spectrum namely: red, orange, yellow, green, blue, indigo and violet. According to Cyril–Egware "the colour of an object is determined by the way in which it either absorbs or reflects the rays of these colours. Thus, an object that reflects all the colours of the spectrum will appear white, whereas one that absorbs all the colours will appear black". It is necessary to note that the actual light, either natural or artificial falls on 3-D form, but an illusion of light is created on 2-D works or design as shown in figure 10.

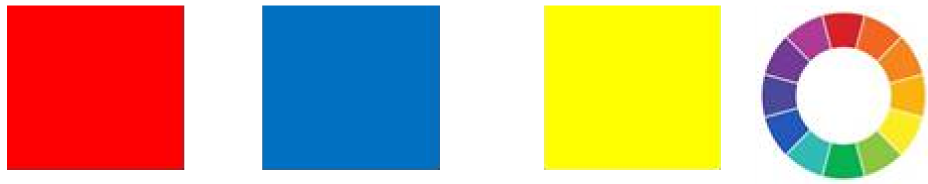


Figure 10

Red Blue Yellow RYB

Colour Model

According to Wong (1993), design is practical and the designer is a practical person. But before the designer is ready to tackle practical problems, he/she has to master a visual language (visual elements). Visual language is the basis of design creation. A thorough understanding of this would definitely enhance the designer's capacity in visual organization.

Principles of design

This is the arrangement of elements of design into a unit in an organized way to make a design. A good organization or arrangement of the elements of design makes a successful design. Among the principles of design includes: proportion, balance, harmony, dominance, movement, contrast, graduation, emphasis, perspective, rhythm, repetition, variety, unity and discordance. Some of them appear to be similar and have close relationship with one another. Principles of design or organization are simply used as guidelines by the designer or an artist to help in making decision on the selection of visual elements. The choice of the elements of design such as line, shapes, texture or colour among others, and their engagement to achieve a good design or work of art gives rise to the aesthetic and utilization functions in design and art.

Proportion: It is the comparison of one thing to another in size in a design. It could be the amount or size or location in a design as shown in figure 11.

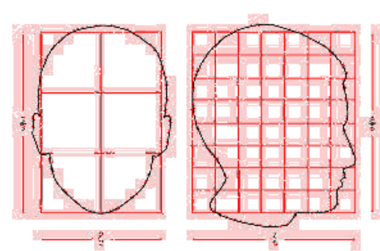


Figure 11

The Proportions of the Head

Balance: It is the equilibrium achieved in a design as a result of the application of the visual elements such as line, colour, shape, among others in a particular design as shown in figure 12.

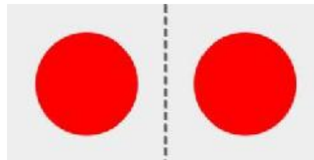


Figure 12

Balance In Design

Emphasis: This is the area of interest in a design. It is a focal point, which shows the degree or extent of importance of the most salient part in design. This centre of attraction or interest in a design shows the content conspicuously. Dominance and contrast have close relationship with emphasis in design as shown in figure 13.

Figure 13

Variety: The design or the work of art becomes appealing and interesting when varieties of the various visual elements are put into a design to avoid being monotonous as shown in figure 14.

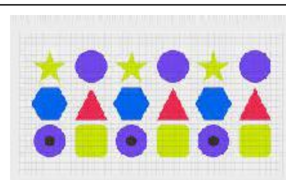


Figure 14

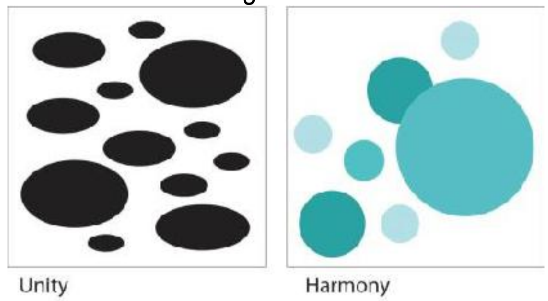
Courtesy: Fabrik Brands

The Variety Principle Of Design

Repetition and unity: They create the feeling of oneness when joined as a whole and is expressed in a design, and a repetition of the same visual element at specific parts of design as shown in figures 15 and 16.

Figure 15
courtesy: Widewalls – Repetition

Figure 16



Movement and rhythm: Rhythm is the continuous flow of the visual elements in a design. Movement is the sense of the consistent flow of the visual elements that express aesthetic sensibilities in the design as shown in figure 17.

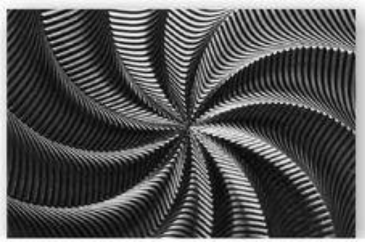


Figure 17
Courtesy: Pinterest - Rhythm and Movement

Contrast: It involves the placement of elements of design in opposing manner to give interest and strength to the design. Contrast, dominance and emphasis have close relationship as shown in figure 18.

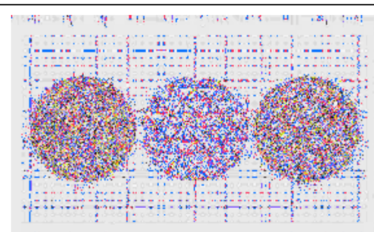


Figure 18
Courtesy: Fabrik Brands - Contrast In Graphic Design

Gradation: In a desi ress value by showing light and dar

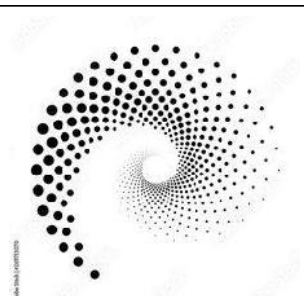


Figure 19

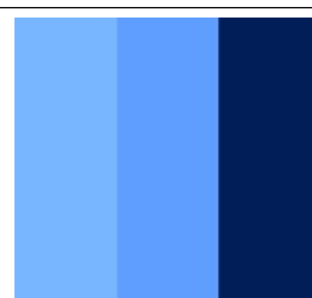


Figure 20

Some basic tools, materials and techniques for design making

The nature of design to be accomplished determines the type of basic tools, materials and techniques necessary. Among the areas of design considered include ceramics, fashion, graphics, textiles, glass, and metal. In artistic productions, the medium of expression and techniques of design execution also influence the type of tools and materials one requires.

Ceramics

Classified under three-dimensional design ceramics involves the production of wares, and engaging heat treatment of non-metallic and inorganic materials such as clay. Among the various products of ceramics include table-ware such as plates, cups, saucers, tiles, bricks, electrical insulators, sanitary wares, gift items and containers for special use. Peters (2001) states that "Ceramics involve wares made partly or wholly from clay. It is shaped in ordinary temperature and unless forcibly deformed it keeps this shape and after heating (firing) to a sufficient maturing temperature, the shape is permanently retained". The products of ceramics are made from natural clays and clay 'bodies' (combination of clay with feldspar and others) which could be sourced in abundance in different parts of Nigeria and other parts of the world. Products of ceramics design require the preliminary aspect of generating ideas or concept about the intended product. The process starts by making two-dimensional design on paper, then transforming it in the next stage into the three-dimensional aspect of design. The structure of ceramic ware gives rise to its function. Structural design in ceramics involves a work that has volume, mass and occupies space as a result of its height, length and width. Design in ceramics requires taking care of thickness, weight, height, stability, spout, rim, foot, handle where necessary, and any other thing that concerns structures and functioning. The design requires documentation of concepts, ideas or thought in a 2-D approach on paper or sketchbook, and afterward engage in different stages of design with specifications and due consideration to elements and principles of design. Among the basic tools in ceramics include modelling tools, callipers, throwing ribs, turning tools, needles, fettling/potters knife, rolling pin and guides, brushes, coilers, harps, throwing stick with hook and others. The ceramics equipment are kiln, clay mixer, dryers, ball mill, throwing wheel, spring balance, ware rack, spray booth, standard pyrometer, spray gun, bowls, buckets, mortar and pestle and brass sieve among others. Ceramics require the following basic materials for its production, clay, feldspar, quartz, flint, kaolin, Borax, Barium grog, glaze, alumina, oxides, and others. Techniques used in ceramics production are manual/hand modelling, throwing, jigger/jolley, extension, casting and others. It is necessary to note that every ceramic work must pass through the heat process or fired to become ceramic ware or a finished work. The firing of ware in the kiln or a firing chamber makes the clay work rendered dense, hard, durable, rock-like and permanent as shown in figures 21 and 22.

Figure 21
Ladi Kwali: Nigeria's Famous Female Potter
Courtesy: The Guardian Nigeria News

Figure 22:
Courtesy: UMass Amherst (Google)-Ceramic Wares

Fashion design

The visual elements and principles of design are necessary for all aspects of fashion design. Steele (2009) states that fashion design refers to "the kinds of clothing that are in a desirable style at a particular time". Basic tools and equipment in fashion design include measurement notebook, flexible tape, scissors, French curves, brown paper, tracing wheel, set square, long ruler, tailor's chalk, push pins, cutting boards, tracing paper, straight pins, pins, needles, tailor's square, pinking shears, pen/pencils, thimbles, stiletto, knitting pins, iron, ironing board, mannequins, mirror, straight sewing machine and storage facility. Materials for fashion design include; fabric, under fabrics, accessories such as thread, hooks and eyes, piers fasteners, buttons, ribbons, and others. Techniques in fashion design are laying and cutting out, hand stitching, machine stitching, machine sewing and others. According to Cyril-Egware (2011), Fashion is a continuing process of change in dress styles accepted by a large group of people at a given time and place. It could also be described as a dynamic trend in clothing and textiles as accepted by a particular people. She further affirms that people use textiles and clothing in one way or the other in the forms of underwear, inner wears, outer garments and accessories, to compliment some selected outfits. The global demand for fashion is very high due to population increase and rises in people's tastes. Bell-Gam (2008) in Cyril -Egware (2021) states that man created, utilized and designed dresses with leaves and animal skins, necessitated by the environment, climate and the need to cover the body. The high level of growth and development in fashion design today has brought about various modern clothing styles and fashion accessories such as bags, shoes, bangles, earing, hats and others. The numerous design concepts in fashion attracts people from different cultures and backgrounds to boost patronage, economic development and sustainability as shown in figures 23 and 24.

Figure 23: A Fashion Designer in Nigeria
Courtesy: Google

Figure 24: Nigerian Native Styles You Should Rock.
Courtesy: Amplifying the AAUA stories (Google)

Graphics design
Graphics is the use of line, colours, typography, images, symbols and application of elements and principles of design with the aim of conveying a message or advertising products. It is a means of communication, and the design should possess the following characteristics, namely, legibility, brevity, clarity, centres of interest and suitability, among others. It is a universal medium for communicating ideas and documentation. Graphics engages in products advertisement, poster designs, different methods of printing and photography, greeting cards among others. Basic tools and equipment in graphics include mathematical set, drawing set, poster colours, 2B pencils, paper and cleaner, metric rules, cutting tools, masking tape, contact gum, cellotape, drawing board screening board, light table among others. Techniques in graphic production include the following: illustration, printmaking, poster design, book jacket, sign writing, typesetting, layout, bill-board design, animation, photography, cartooning, crest, logo and badges design, among others as shown in figure 25.

Figure 25: Courtesy: Google (Graphic Design)

Digital graphics
Digital graphics refers to the creation, manipulation, rendering and exhibition of visual designs using digital tools and software applications. In digital graphics, images, videos, animations and various visual assets are created, edited and circulated for use in different channels such as mobile apps, social media, print media and web pages as being demonstrated in figure 26.


Figure 26: Courtesy: Google (Graphic Digital Design)

Textile design
Textile design is the process of planning and producing a fabric's appearance and structure. Cyril-

Egware (2019) explained textiles as being as important as food and shelter to man. It is used for clothing, furnishing and toys. She indicated that textiles are simply the art of using fibre to make finished fabric or cloth, while fashion is a form of self-expression and autonomy at a particular period and place and in a specific context, of clothing, footwear, lifestyle, accessories, makeup, hairstyle, and body posture. The basic tools and equipment in textiles design are dye bath, squeegee, buckets, sketchbooks, pencils/pen, rope, knife, bushes, lino, basins, printing tables, light box, mesh, stencils, carbon paper, foam stamps, pebbles, scissors, tracing paper, baton/flat wood, stoves, rubber hand gloves, bowl or cup, razor blade, sticks, lino cutting tools, rags, squeegee paper, cello tape, wooden frame, ruler, a sheet of glass or Formica table, set of loom, textile printing machine and others. Textiles materials are vat dyes, chemicals, cotton fabric, raffia, cord twine, sets of yarns or threads and others. Textile design techniques are batik, tie-dye, weaving, printing, appliqué among others. The protection from harsh conditions of weather brought about the inventions of clothing to cover nakedness. And, since then, clothing has been undergoing series of innovations and further inventions. As shown in figures 27 and 28.

Figure 27:
Courtesy: Google (Textile design - Nigeria)

Figure 28: The Kofar Mata dye pits in Kano, northern Nigeria. Established since 1498 by Wale Dan Mama. Photograph by: Myloupe/UIG via. Courtesy: Google

Glass design and technology

It involves making of transparent and hard product such as bottles and others using silicate materials. Peters (2001) states that a glaze is different from glass in that “glass is a supper cool liquid without alumina, while glaze must have alumina”. According to Garkida (2023), glazes and silicate technology is about the study and conversion of solicitous materials to glaze products for sculpture, tableware, laboratory ware, packaging and smart glass. Others include glass- ceramics for bone repair and bearings, refractories for furnaces as well as glasscrete for buildings and glassphalt for roads. The manual approach in glass technology involves the activity of a glass-blower in blowing hot glass into shapes with the help of a special tube. According to Alemaka (2015) in Alemaka (2017), modern day glass making is a complex industrial endeavour consisting of diverse operations comprising of raw materials processing, glass forming and annealing, tempering, laminating, labelling, packing and many more. The products of glass industries impact on almost on every aspect of modern living. Such products include laboratory glassware for scientific experiments, mirrors for astronomical telescopes for studying distant objects in space, sheet glasses for architectural application, light bulbs for lighting in living and working spaces as well as tableware used for serving food and drinks and a host of other technical apparatuses. Basic tools and equipment for glass designer blowing tube, calliper, tung, knife needle, furnace, containers, French curves, furnace bench, stools, tables, bellows, long ruler, set square, fettling tools, storage facility, among others. Techniques of glass design involve the use of a furnace to heat the glass, and blowing tubes for gathering molten glass and blowing wares. Alemaka (2017) asserts that the complex processes involved in industrial glass manufacture are also carried out by complex machinery, usually highly computerized and requiring high level skills. The processes of batch formulation, mixing, conveying, and charging are carried out by automatic or semi-automated machines. Glass designing could also be achieved during the process of production. The popular method of designing glass is the glass-blowing. Glass blowing is a method of shaping glass, and it is either done by mouth or by a machine. A blow pipe, which is a long piece of iron is dipped into molten glass to allow the desired quantity to stick on the blow pipe. The glass is then rolled on an iron table to distribute it evenly around the pipe. The pipe is blown into to make a bubble in the glass. This is then shaped by squeezing and stretching, adding or cutting a little more appropriately until the desired shape or design is achieved. Further design could be obtained by adding desired colours and textures. The glass with attractive colours or stained glass is made by the addition of certain chemicals during the process of manufacturing.

Tools that are used for glass blowing

1. Diamond glass cutter or sharp stone or file with sharp edge or saw.
2. Poker
3. Carbon plates
4. Flanges e.g. rectangular, triangular, flat flanges and others. The purpose of the flange is for design making.
5. Asbestos sheet for flatting
6. Glass marking pencil
7. Rubber
8. Rimmer
9. Protective goggles
10. Duodenum goggles.

Types of glassware

1. Pyrex. It has a heavy weight. Pyrex is used for heat experiment. Another name of Pyrex is Borosilicate.
2. Soda line glass. It has a light weight.
3. Lead glass. It has a light weight. Soda and lead glasses are used for cold experiment.

Methods of glass blowing

1. Cut the glass
2. Brush the glass with wire gauge.
3. Grind with sand paper
4. Fire polish

Methods of glass cutting

1. Hand parting using saw and other tools.
2. Hot spot method through the application of heat.

Things to consider when cutting glass

1. It is important to note that glass has to be warmed before actually heating to avoid cracking.
2. Use asbestos sheet or carbon board to drop melted drops of glass.
3. When cutting the glass, the rough edge must be brushed with wire, and must be warmed

before actual heating to avoid cracking.
4. Use asbestos sheet or carbon board to drop melted drops of glass.
5. When cutting the glass, the rough edge must be brushed with wire brush and grinded with sand paper and the fire polish.

It is interesting to design and produce glassware. The important factor in glass making is the viscosity of the molten oxides. The major ingredients in glass are sand, lime and soda ash. Other raw materials such as colourants could be considered minor ingredients, although they produce attractive and important effects as shown in figures 29 and 30.

Figure 29
Courtesy: Google (Hand glass blowing Nigeria)

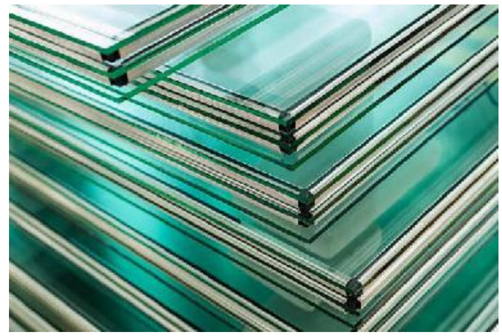


Figure 30:
Courtesy: Google (Sheet Glass in Nigeria)

Metal design

It involves engaging that usually hard and shining type of solid mineral substance, which allows electricity and heat to pass through it, such as iron, gold, aluminium, silver and tin among others. Metal design involves the fabrication and forming, electroplating and finishing of metals and their alloys into jewellery, craft and functional objects. Smithing is an aspect of metal design that has solved various economic problems such as provision of farm tools, domestic wares and others. Other products of metal design include various types of plaques, seals and logos. The basic tools for metal design are hammers, angle grinder, flange and punch tools, calliper, ruler, drill bits, hole punch, level, hardware, clamp, vice, hose, pipe fitting, writing instrument, pliers, utility magnet, furnace, bellows, knives, saws, files, chisels, vices and woodworking table, notches chews, tube benders, welding machine, drill presses, metal folders, drive axle and others. Materials required are metal sheets, metal rods and others from different types of metals. Techniques in metal design include cutting, bending, assembling, casting, forging, forming, parching, machining and extrusion among others as shown in figures 31, 32, 33 and 34.

Figure 31:
Metal Fabrication in Nigeria
Courtesy: Black Ornament Forge (Google)

Figure 32:
Metal Craft
Courtesy: Google

Figure 33:
Metal Fabrication in Nigeria
Courtesy: Google

Figure 34:
Metal Fabrication in Nigeria
Courtesy: Wrought Iron Gate Design from Nigeria
Courtesy: Google

The role of design

The development of any nation depends on the intentional planning and shaping of the economic destiny that will guarantee the provision of amenities and services to sustain life and better environments citizens. This is realizable with a deliberate and strategic decision making to make things better for the people, and this is what design is all about. The development of any nation's economy relies on industrial production of goods to shape its industries. Design takes into consideration the broad parameters of aesthetics, functionality and ergonomics. These vital parameters of design are dynamic, whereby the aesthetics, ergonomics and usability of products may be improved for better utility, marketability and production. The industrial designers look towards how society uses products and services, while the tools developed in the industries extend to techniques and ergonomics which optimizes how people interact with designed products for overall performance and human well-being.

Summary

Design in the aspects of perception of form, technical application, materials and production methods considered in the different design areas will boost the intended knowledge in design application. Indeed, design is the one common thing that cuts across most fields of profession such as ceramics, graphics, fashion design, glass design and technology, textiles, metal and jewellery design, software, architecture, art, engineering, science and information technology. Design is a vehicle that brought about industrialization as a result of felt needs to improve the people's way of life as well as methods of manufacturing. Design dynamics boost the economic growth and sustainability of nations. Design is a means of driving change in the world today. The nations of the world that have developed socially and economically have done so in the context of continuous developments in design.

Exercise

1. Choose any visual art area and create a three-dimensional design suitable for use in your home, using the elements and principles of design.
2. Design suitable pictorial poster for advertising a new fruit juice product.

3. Make a design for textiles production using any aquatic motif.

4. Using the indigenous motif of your community, design a souvenir gift item for your paramount ruler commemorating his coronation.
5. Design a ceramic gift item to be given to your Vice-Chancellor on the occasion of a special anniversary of the university.
6. Considering the trends in fashion today, create a suitable design for ear ring and bangle.
7. Design a poster to encourage students to work hard and be of good behaviour.
8. Design a souvenir plaque to be given to the best graduating student in your university.
9. Identify the basic tools in an area of design and improvise two of such simple tools using locally source materials.
10. Consider an area of three-dimensionality, use a suitable medium to produce a design of a gift item showing the working drawings and model.

References

Alemaka, E. M. (2017). A Review of Computer Application in Decision Making and Decision Support System in the Glass Industry. *Journal of Ceramics and Environmental Design*. Port Harcort: University of Port Harcourt Press. Vol. 4, No.1.

Cyril- Egware, P. I. (2021). *Basic Entrepreneurial Skills in Textiles and Fashion Design*: A Practical Guide. Port Harcourt: Onyoma Research Publication

Cyril-Egware, P. I. (2019). Textiles Design as a Tool for Cultural Identity in Nigeria. Design in the Nigerian Concept: Evolving Indigenous Design Approaches, Concepts, Practice and Education. Papers from the Conference of Visual Communication Designs. Industrial Design Department, Federal University of Technology, Akure, Nigeria.

Egunlae, S. A. (1985). *The Essential Groundwork in Art and Design*. Ado-Ekiti, Omulayo Standard Press and Bookshops Co. (Nig.) Ltd.

Garkida, Adele (2023). *Glass and Silicate Technology, Information on Glass Silicate Tech. in Art & Design*. Professors-Whatsapp. Zaria: Amhadu Bello University.

Hornby, A. S. Oxford Advanced Learner's Dictionary: *International Student's*", Edition (7th edition). Oxford: Oxford University Press.

Ogunwole, S. (1997). "Graphic Design Analysis. The cover Design of Environ in Environ". *Journal of Environmental Studies*, Faculty of Environmental Design, Ahmad Bello University, Zaria, Nigeria, vol. No. 1 Nov.

Peters, Edem E. (2001). *An Approach to Ceramics: Theory and Practice of Ceramics*. Uyo: Liberty Communication Publishers.

Peters, Edem E. (2013). Design Dynamics as Panacea for Sustainable Development in the third world Nations. *International Journal of Arts, Culture and Sustainable Development.* Cameroon; Centre for Advancement Training and Research. Vol. 3, No.1.

Steele, V. (2009). *The Corset: A Cultural History*. Yule University Press New Haven & London.

Udosen, N. (2000). *Design Education for the Nigerian Child*. Art Today for Tomorrow: Book of Readings- Millennium Conference, Uyo. 2000, Vol. No. March,

Wong, Wucius (1993*). Principles of Form and Design*, John Wiley & Sons, Inc.

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CHAPTER 27

Introduction to Graphic Design

By
AZI Joseph Izang

Overview

Design has taken on diverse meanings in the society today. While some refer to the process of piecing and mending fabric together to produce apparel as design, others consider a poster advertising a product as a design. Yet, when a builder lays bricks to form a beautiful house, it may also be referred to as design, just like an educationist may allude to designing an educational curriculum. Does design therefore mean planning and organizing things or producing objects with tangible physical outcomes? Does design refer to producing a blueprint or does it require fabricating a product like a hoe, cutlass or grinding machine? What process is required by an engineer to manufacture an aircraft? Is design a creative process that employs spontaneous and intuitive non-technical craftsmanship or systematic mathematical precision skills or is it something in-between? Is design a craft, an art or a science? Some argue that design must be guided by standard rules and mathematical meticulousness; does that mean that there is no room for accidental outcomes or human factor or personal feelings and expressions of the designer? This chapter takes basic design level undergraduate students through the process of conceiving and understanding design processes, from the definition, to the application of elements and principles, to the impact of design on society, as well as some relevant theories and philosophies. The chapter would also take students through understanding design from the point of view of practice, by learning about the professional materials, the methods and ethics of using them and the theories that guide their application. Students are encouraged to apply the basic skills learnt in this course towards creating design solutions that bear the personal styles of the designer and showcase their creative aptitude. As our professional vision and philosophy is to allow students to evolve their design styles and personal expressions towards problem-solving, even while being guided by standard design techniques, principles and methods. Hence, students are being equipped to be creative, innovative and globally competitive design thinkers and problem-solvers, through theoretical and practical skills training. The chapter concludes with some test items prepared to assess students' creative and innovative skills, as well as stimulate their understanding of the process of design by combining both the spontaneous and systematical processes in their practice.

Objectives

At the end of this chapter, students should be able to:

1. describe what design means;
2. explain the principles and elements of design;
3. define graphic design;
4. review the application of some principles and elements of design on a poster;
5. discuss some notable graphic designers;
6. review billboard design process from thumbnail to finish; and
7. assess the role of creativity, innovation and design thinking in the design process.

Understanding design

Design is the process of creating a visual composition, from conceptualization to drawing and to the production of a finished output. Sengstack and Boicey (2015) in their book *Mastering Informatics…*quoted Alina Wheeler as saying: "design is intelligence made visible." A product of design must be aesthetically pleasing to the eyes and mind and must fulfil a utilitarian function. Its development process must be guided by specific elements and principles. Suffice to say that design has become one of those words having such a wide range of reference that represent such varied situations that the underlying processes appear to share little in common. Lawson (1980) contemplates, how is it that an engineer may be said to design a new gearbox for a car, while a fashion designer may be said to design a new dress? The process which gives rise to a new gearbox, he maintains, is surely precise, predetermined, systematic and mathematical in its nature. Which are hardly the qualities associated with fashion design which, by contrast, seems rather nebulous, spontaneous, chaotic and imaginative. However, many kinds of design call for a process that combines both extremes in varying proportions like Town Planning, Urban Design, Architecture, Interior Design and Industrial Design. They all involve elements, which may seem precise and nebulous, systematic and chaotic, mathematical and imaginative. Interestingly, these design fields all have to do with the creations of objects (or places), which have practical purposes – aesthetic and utilitarian. In other words, design is a conscious activity, guided by aims and objectives. Garner (2005) asserts that it refers to planned and organized actions intended to bring about some predetermined outcome, although there may also be accidental or unexpected results. It is an activity that usually displays expertise, knowledge, creativity and thoroughness, having a close relationship with technology, human needs and aesthetics. Design is used for two primary purposes: personal expression associated with art (abstract or realistic) and also in product development, categorized into aesthetic (industrial design) concerned with looks and feel of product and function (engineering design) concerned with the utility of a product as shown in figure 1.

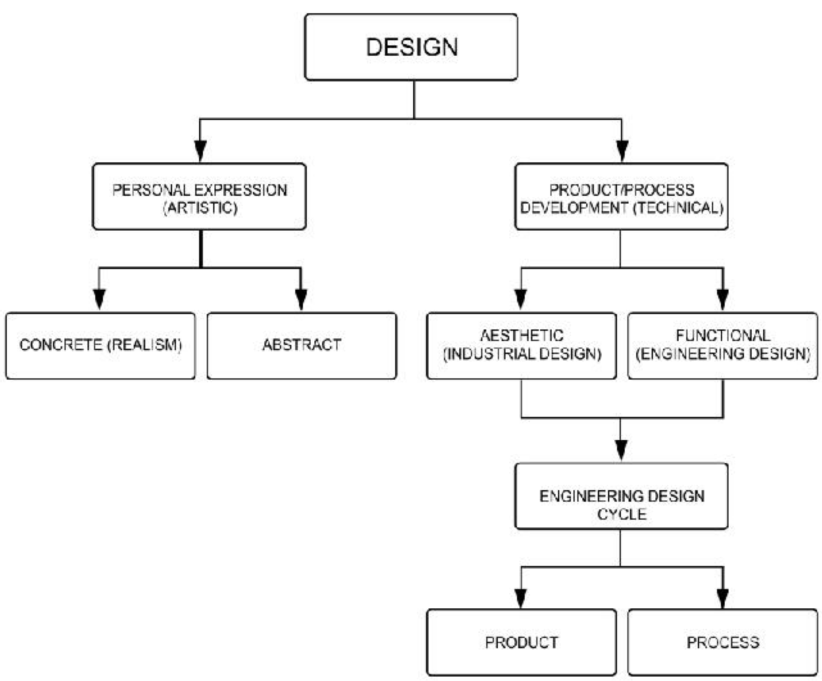

Figure. 1: Design is Grouped as Artistic and Technical
Source: Bertoline and Wiebe (2002)

Atkinson (2017), in the editorial commentary of the *Design Journal* (an International Journal for All Aspects of Design, Published by Tailor and Francis Group, UK), affirms that: 'design' means: the disciplines covering products, places and communication design (i.e. graphic design, information design, product and industrial design, fashion and textiles, interior design and design issues); design management (design strategy, design policy, marketing and design, design and manufacturing, innovation); design theory (design methods, psychology and design, creativity and design); eco and environmental design, gender issues in design. He argues that these forms of design may be addressed from an educational, historical, technological or practical perspective. Overbeeke and Hummels (2002) assert that design is a very old profession it simply refers to the way in which craftsmen have been designing and creating objects for millenia. In spite of the seemingly different nature of all these design disciplines, one area of commonality across them is the fact that they employ guided elements such as line, colour and texture, as well as principles like emphasis, balance and repetition.

Elements and principles of design

According to Sanchez (2019) and Malvik (2020), the elements and principles of design are the structural components that assist a designer to better understand the meaning of design, towards creating a compelling and appealing composition as briefly discussed below.

Elements of design: The elements of design are the building blocks that form the structure of a design, and are used in conjunction or opposition with each other to create visually striking and impactful designs. These elements are:

1. **Point** - A point is the smallest and most basic element of design and it can be used alone or as a unit in a group (forming a line or a shape).
2. **Line** - If many points are placed one next to the other a line is obtained, which can have length and direction, but no depth. Line is used to create a shape and also perspective.
3. **Shape** - Shape is a design element that contains two-dimensional height and width, it can be geometric (triangle, square, circle, etc.), realistic (animal, human, etc.) or abstract (icons, stylizations, etc.).
4. **Form** - Form is derived from the combination of point, line and shape and has volume, it is 3D in nature and can be viewed from any angle (a cube, a sphere, etc.). A form has width, height and depth.
5. **Colour** - Colour is the response of the eye to differing wavelengths of light within the visible spectrum. In design, colour can be used to generate emotions and create interest. Colour properties are: hue, value and saturation.

- Hue is the colour name.
- Value refers to the lightness or darkness of the colour.
- Saturation refers to the intensity of a hue.

6. **Value** - Is defined as the relative lightness or darkness of a colour, it suggests the depth or volume of a particular object or area. Value is the degree of lightness and darkness in a design and the contrast between black and white.
7. **Texture** - Texture is the surface quality (simulated and/or actual) that can be seen and felt, which can be rough or smooth, soft or hard, etc. It exists as a surface we can feel, see or imagine.

8. **Space** - While space is the area between and around objects (negative space), it also refers to variations in the perspective and proportions of objects, lines or shapes.

Principles of design - The principles of design combine the elements to create a composition, they are the guidelines used to arrange the structural elements of a design. They are composed by:

1. **Emphasis** - Emphasis is a principle of design that refers to a focal point among other elements within the entire design composition. For instance, for a concert poster, should the focus be on the band, the message, the concert venue or even the cost?
2. **Alignment and balance** - Every element in a design composition has weight, like colour, size and texture. Equally weighted pieces located on either side of a centreline generate balance in symmetrical designs like the Mercedes Benz logo (see Plate 1). An asymmetrical design shows opposing weights and uneven balance.

Plate 1: Mercedes Benz Logo Showing Symmetrical Balance
Source: https://logohistory.net/mercedes-benz-logo/

3. **Contrast** - The contrast principle of design generates space and distinction between elements and to operate effectively together and be viewable a background should be different from the colour of the main object. For instance, if every font is bold, how will readers determine what is most important?
4. **Repetition** - Repetition is a principle of design that is vital for achieving beautiful graphic design patterns. Like in starting a business, one of the first things a company needs is a great logo on its website, business cards, social media and other marketing materials. And logos often have repitetive elements.
5. **Proportion** - The visual size and weight of motifs in a composition and their correlation with other parts of the design is referred to as proportion. It is only if all aspects of a design are well-sized and intelligently arranged that proportion would emerge to show good alignment, balance and contrast.
6. **Movement** - Movement as a principle entails controlling the elements in a composition such that the eye is led from one to the next, and the information is transmitted chronologically to the audience. The narrative of a poster design for a show would present the location, time and how to acquire tickets.

White space: The empty space around the parts in a design composition is known as white space.

Although, white space is not merely empty, it helps organize and create hierarchy and aesthetics informing the viewers' eye that objects in one area are separated from objects in other areas.

Industrial design and mass-production

According to Zukowsky (2021) industrial design, the design of mass-produced consumer products, is primarily responsible for the production of manufactured items that not only work well but please the eye and have a competitive advantage over similar products. Also, that the work of an industrial designer often includes graphic design, such as advertising and packaging, corporate imagery and branding and interior design (also called interior architecture or environmental design) the arrangement of man-made spaces. Overbeeke and Hummels (2002) claim that industrial design (ID) as a profession derives from the more general discipline of design, specifically seen as a product of the first Industrial Revolution when a single craftsman could no longer be responsible for 'every stage' of the development of a product. Of course, with the monopoly that existed within the art guild, the Industrial Revolution broke the practice where individual artists were responsible for the entire process of production from conception to finish and sale. Although, the concept of 'division of labour' had already been established within the manufacturing industry at the beginning of the sixteenth century, as craftsmen specialized in one aspect of the production leading to a great trade expansion. This gave birth to mass-production and greater standardization of production and consequently 'industrial design'. Zukowsky (2021) claims that the first industrial designer is considered to be the German architect Peter Behrens, who was influenced by the 19th-century English designer and poet, William Morris, and by the Arts and Crafts Movement, which advocated creating designs for public rather than middle-class or royal patrons. Behrens taught Walter Gropius, who later founded the German School of Design, Bauhaus in 1919. Though now antique, its distinct vision of modern life is not a thing of the past (Chiasson, 2023). In Nigerian universities, industrial design as a course was pioneered by the Ahmadu Bello University (ABU) Zaria, after breaking away from the Department of Fine Arts in the late 1970s. It operated for about 3 decades as a Department with 4 sections namely: Ceramics, Glass, Graphics and Textiles, until the Department of Glass Technology (now Glass and Silicate Technology) was curved out. Today, the programme operates in 6 other Nigerian Universities either called by the same nomenclature or structured as Fine and Applied Arts or Visual and Creative Arts and domiciled in the Faculty of Environmental Design, Environmental Sciences or Environmental Studies.

What is graphic design?

Graphic design is one of the forms of design that deals with visual communication; how the eye sees and interprets visual images. According to Clark (2023), graphic design is the art of combining text and pictures in advertisements, magazines, billboards, books or digital contents. Cann (2023) posits that graphic design is the creation of visual compositions to solve problems and communicate ideas through typography, imagery, colour and form. According to Tomboc (2020), Cann (2023) and Palombi (2023), there are several types of graphic designs.

Types of graphic designs

1. Visual Identity Design
2. Advertising Design
3. User Interface (UI) Design
4. Publication Design as shown in plate 2
5. Packaging Design
6. Motion Graphic Design
7. Information Design

8. Environmental Graphic Design
9. Art and Illustration for Graphic Design
10. Game Design
11. Web Design
12. Infographic Design
13. Textile and Surface Design

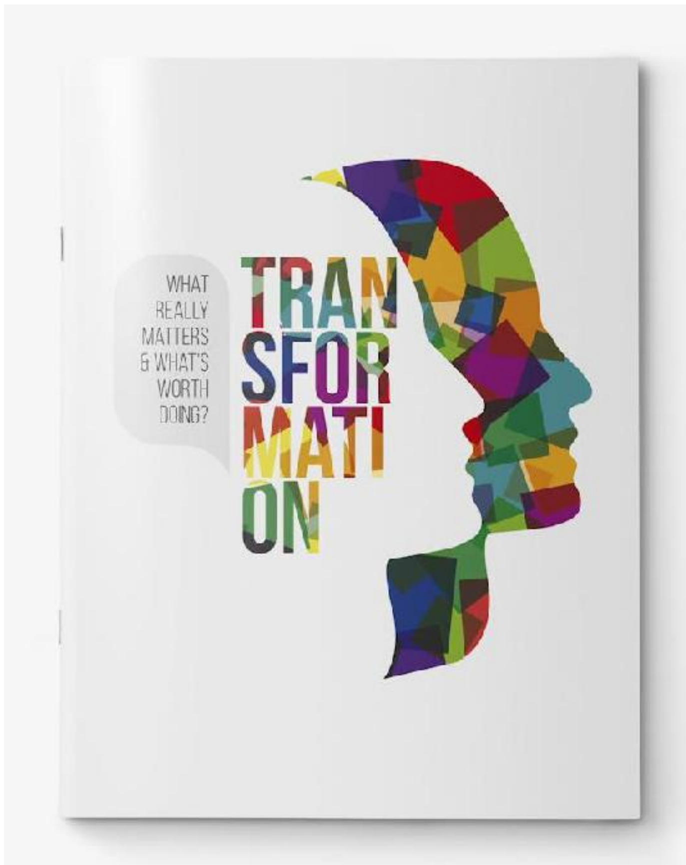

Plate 2: Publication Design
Source: Cann (2023)

There are dozens of graphic design tools, key among which includes pencil, pen, paper, poster colour, ruler, eraser, as well as computer software like CorelDraw®, Adobe Illustrator®, InDesign®, Photoshop®, Inkscape®, LaTeX®, PosterGenius®, to name a few. Kennedy (2023) argues that when using these tools, graphic designers must ensure their designs are creative and original. Graphic design focuses on expressing an idea or communicating a message through visual storytelling to a target audience with a desired result, to either provide information, invoke thought, change mindset, stimulate meaningful conversation or sell a product (Stubblefield, 2023). Graphic designers create visual content that apply visual hierarchy and page layout techniques, using typography and pictures to meet users' specific needs and focus on the logic of displaying elements in interactive designs to optimize the user experience (International Design Foundation, 2002).
According to the American Institute of Graphic Arts (AIGA), graphic design is defined as “the art and practice of planning and projecting ideas and experiences with visual and textual content.” In other

words, graphic design communicates certain ideas or messages in a visual way that can be as simple as a business logo, or as complex as page layouts on a website (Malvik, 2020). Commercialization induces competition, and competition creates infinite choices. Choice is one human instinct that induces the feeling of satisfaction in human existence, as everyone existing in the consumer-inclined commercialized world of today would be pleased when allowed to express their freedoms of choice. Hence, companies look for graphic design contents that can attract consumers using images, colour and typography, as ways to connect emotionally and create sustainable lifelong relationships. Although the term, "graphic design" has only been around since the 1920s, the art form itself has been an important part of visual communication for thousands of years (Palombi, 2023). Communication was necessary when early man was able to convey the expressions of his emotions first through gestures (non-verbal communication) and later words. According to International Design Foundation (2002) graphic design is an ancient craft, dating back from the past Egyptian hieroglyphs to at least 17,000-year-old prehistoric cave paintings, with early examples seen in ancient manuscripts. Adding that the term originated with the print industry and it continues to cover a range of activities that concern aesthetic appeal and marketing. The graphic design industry today spans many different traditional disciplines as well as perpetually evolving new ones like medicine, architecture, business, entertainment, tourism. These are seen through traditional and digital contents that are presented via electronic media like TV, mobile phone or tablet devices. It is evident, in today's advertisement practices, that graphic design is used towards persuading audiences to buy a product or service or accept a concept or idea. Exposing students to the tasks, challenges and potentials of the graphic design medium at the formative stages of their professional training in environmental design is significant. This is essential towards reinforcing and broadening their capacities in creative thinking, problem solving, critical thinking and innovation, as prerequisite skills in growing their design skills. Stubblefield (2023) attests to the fact that acquiring aptitudes in communication, attentiveness, patience and most importantly a good grasp of the project's goal are additional competencies in developing competence. Graphic design is the craft of planning and creating visual content to communicate ideas and messages to a target audience, which products can be seen everywhere from billboards, cereal boxes, product manuals to mobile apps. Also, designing the layout of a magazine, creating a poster for a theatre performance and packaging for a product are all examples of graphic design (Palombi, 2023). There is no doubt that the different forms of graphic design encountered daily, whether at home, in offices, or on the streets, influence our perception, emotions, everyday choices, purchase decisions and lifestyle generally. Graphic design is one way that companies connect with consumers, as it combines artistic, cultural, psychological and business attributes in providing contents that must first make meaning to the target audience, then attract their attention, convey a message, develop a brand identity and promote and sell a product (Brain Station, 2023).

Graphic design theories

According to Spacey (2020) design theory is any first principle, concept or technique that is useful for solving problems aided by design thinking. Design theories are often aligned to a style or philosophy such as minimalism, modernism, postmodernism or new complexities. Theory is all about the question "why". The process of becoming a designer entails understanding "how"; like how to apply the elements and principles of design in creating an exquisite design work, how to use design materials, how to organize and visualize information, how to attract the consumer, how to manage projects and meet clients' specifications, how to salvage critical challenges when they emerged along the project lifecycles and so on. Fiore (2023) posits that the concept of graphic design theory consists of identifying the various elements in an image and explaining the significance of each element, and it can be used to comprehend aesthetic principles that influence the interpretation of a design by the viewer.

Prominent graphic designers

Some well-known graphic designers, with some of their most notable designs, include: (1) Paul Rand - considered the father of graphic design, and was the first to separate fine art from graphic design by emphasizing accessibility alongside aesthetics. He designed the IBM and UPS logos; (2) Saul Bass - notable for the design of several iconic logos, such as the logos of Quaker Oats, Kleenex, Minolta and AT&T; (3) Milton Glasser - who designed the poster for Bob Dylan's Greatest Hits in 1967; (4) Susan Kare - who designed the first Mac icons; (5) Massimo Vignelli - who incorporated modernist traditions into his designs for different industries like Bloomingdale’s, American Airlines, Ford and the New York City subway map and signage designed in 1972; (6) Ivan Chermayeff - who with his design firm are responsible for dozens of memorable and iconic logos, including those for National Geographic, the Smithsonian, PBS and NBC; (7) Lindon Leader - whose FedEx, Hawaiian Airlines, DoubleTree Hotels and CIGNA logo designs solidified him as a leader in graphic design as shown in plate 3.

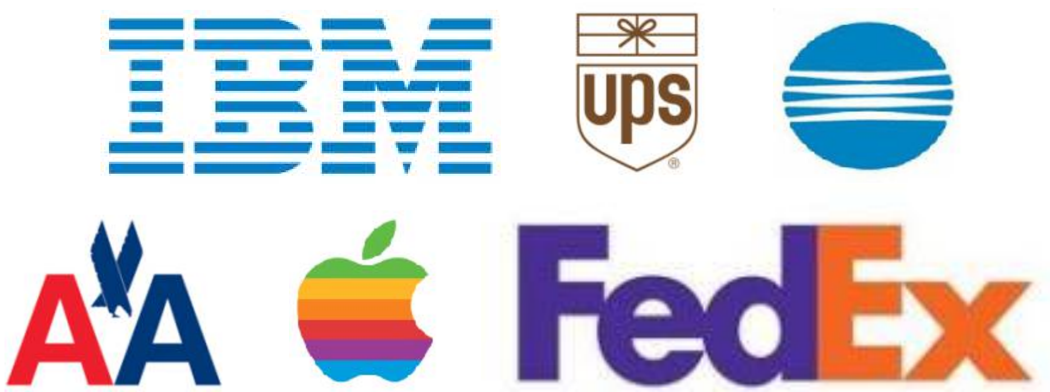

Plate 3: Cross Section of Logos Designed by Notable Designers.
Sources: Prezlab (2022); Erikkowalski (2013); Carney (n.d.)

(8) Rob Janoff - who designed the Apple logo, possibly the most famous mark in the world today. Janoff said the idea of an apple with a bite taken out of it was “really a no-brainer” and that “If you have a computer named after a piece of fruit, maybe the image should look like the fruit? He added “bite is also a computer term, wow, that was a happy accident”; (9) Chipp Kidd – who designed the Jurassic Park logo and (10) Michael Bierut - who created Hilary Clinton's 2016 campaign logo have both high net worths of $16 million and $1.4 million, respectively. However, it is not clear who the richest graphic designer is since designs may vary in price depending on the commissioner (PrezLab, 2022; *Erikkowalski, 2013; Carney, n.d.*).

Types of graphic design styles

According to Team Superside (2023) the roles of the designer and client in the success of a design project are very essential, while the client requests a project and details what he or she wants, the designer’s responsibility is to ensure that standard project specifications are adhered to, reflecting the client’s requests. But what happens when a client’s idea of a certain design style does not align with the designer’s idea or professional ethics? Like what the client thought was a minimalist design is more corporate than he/she wanted it to be or what a designer deems as playful design style falls more under what the client views as illustrated. Of course, a good client-designer relationship is needed to achieve a successful design output. However, the best way is for both the client and designer to have a firm understanding of what design styles are. Below are some examples of types of graphic design styles:

1. Minimalist Design
2. Contemporary/Modern Design
3. Corporate Design
4. Elegant Design
5. Playful Design
6. Organic and Natural Design
7. Illustrated Graphic Design
8. Geometric Design
9. One-Shoe-Fit-All Design
10. Sustainable/Green Design

Graphic design process

The digital world of today has made graphics to be part of our everyday language. Prpic (2023) suggests this graphic design process:

1. **Design brief** – setting out the goals and strategy of your design
2. **Research phase** – learning about the market or users you're designing for
3. **Concepts** – brainstorming ideas for your designs
4. **Concept development** – polishing and refining your ideas
5. **Design review** – getting feedback on your design ideas
6. **Iterate** – improving your designs and collecting more feedback
7. **Approve** – getting sign-off from your stakeholders
8. **User testing** – collecting feedback from real users or customers

Process of developing a design concept

A good design passes through a rigorous process of development. According to Lambert (2019), loose thumbnail sketches can evolve into a finished piece of key art for use in a global advertising campaign. The development stages are:

1. Thumbnail Sketches - The first stage of a design process is to do as much research as possible for the subject and theme of the design to assist with this process. With all of the information acquired, like the background of the company, product or service to be advertised, relevant photographs, benefits product or service offers, a designer would quickly create a series of small thumbnail sketches to explore the initial ideas about the composition. The sketches can go in a number of different directions exploring varied placements, sizes and directions of the image and textual elements, in search of the ideas that work best.

2. Developed Ideas - Once an initial direction to the design is formed, a designer can share the complete drawing concept with the design team and possibly the client for feedback. Often there are new ideas that would emerge at this stage to improve the initial concept, which would require revising the design based on that feedback. This process usually continues until all stakeholders are happy with the design.

3. Detailed Drawing - Once approval is secured a detailed drawing is developed. Based on the approved design concept one can start with a very quick outline of the improved design. At this stage more realistic, proportions and clear depiction is required. On securing the basic layout sketched, one then spends time adding more details and expression to the illustration.

4. Colouring - With a finished drawing complete, a designer can exploreg the basic colour schemes from the colour wheel. When done in Photoshop®, the colouring is done on a layer underneath the main drawing, with the drawing set to 75% opacity, after which the design can be exported to Procreate® to add final colour details using a pencil brush. The process can be followed through gradually until the overall colouring of the design composition is attained.

5. Effects - For the final stage of the design, one can add highlights, textures and other special effects to serve as the icing on the cake. These are needed to give the design a traditional and realistic look. After which the design is sent for review and any final notes. Often there are new ideas that come up at the very end or small adjustments required to the colour and lighting or positions and sizes or any relevant areas or even typographic errors detected.

6. Adaptations - Once the design is approved by the studio and client, the designer can create variations adaptable for various advertising campaigns. such as creating vertical design layouts for posters, horizontal for billboards (static and electronic), tall horizontal and vertical versions, for used on tall or wide walls and a square design that be used on CD/DVD covers.

Advertising design tips

Advertising design is the intersection of marketing and design, referring to the visual artwork created specifically for advertisements. The purpose of advertising is to sell products and services; this can be done through a handbill, poster, billboard, internet and TV commercials. Levinton (2023) offers the following as among key advertising design tips:

- **Composition should tell a story:** A designer must have a great visual storytelling capability as a valuable component of design.
- **Keep it simple:** Always keep a design composition simple, with a complicated design concept, chances are that one is likely to confuse the audience.
- **Short and punchy copy:** A good advertising design focuses on the product and ensures a standard visual presentation; a designer should use engaging visuals and copy to support his/her visual storytelling efforts.

Types of posters

While product promotion can be placed on billboard, poster, cinema, and the internet, posters are among the most common medium for product promotion. Korenkova, Maros, Levicky, and Fila (2020) identify the two major forms of advertising to be traditional advertising (e.g. television, radio, leaflets, poster etc.) and modern advertising (e.g. advertising on social networks, webpages, via e-mail, etc.). Producing advertising posters often takes much time and design efforts, given that designers are confronted with abundant choices of design elements and layouts (Guo, Jin, Sun, Li, Li, Shi and Cao (2021). There are different types of posters that are used to disseminate information. Printbritannia Team (2021), Geuens (2023) and Krzysztofik (2023) explain some types of posters as:

1. **Advertisement posters:** Advertisement posters have produced many of modern history's iconic pop-culture images since the turn of the 20th century, through brands like Coca-Cola®, Camel®, Apple®, and Nike®. They are designed as prints distributed through magazines, newspapers, billboards and posters around cities and targeted at diverse audiences.
2. **Event Posters:** Event posters are the primary media for promoting any upcoming events such as concerts, plays and musicals, fairs, sporting events, conferences and trade shows, which are advertised and leave lasting impressions on the target audiences.
3. **Political Posters:** Some of the most famous posters are associated with major moments and conflicts in human history, like the World War I poster of the U.S. Army "I Want You" depicting

Uncle Sam, also the World War II “We Can Do It” poster released by Westinghouse Electric and the 2008 iconic Barack Obama “Hope” poster designed by artist Shepard Fairey.

4. **Movie Posters:** Movie posters are perhaps the most popular and sought-after print materials. This is especially true for posters of classics like The Godfather, Jaws, Star Wars, Pulp Fiction, and Terminator, among many other hit films and franchises.

Tips to design an advertisement *p*oster

Posters are one of the oldest, most tried-and-true types of marketing collateral, they offer an effective way to draw attention to a product. Conway (2022) and McGuire (2023) proffer the following points to note in designing a standard advertisement poster:_

1. Identify the essential parts of a poster: headline, body and signature.
2. Arrange the 4 P’s of your promotion strategy: your product, price, promotion and place.
3. Choose a design that will mark your audience and look good in your selected place.
4. Make your campaign details the focus of the poster.
5. Add high-quality images of your product or service.
6. Include a relevant call to action.
7. Start with a simple background colour or texture.
8. Show where or what store the sale is taking place.
9. List exactly what products are available.
10. Add some contact information or a website.
11. Include your branding or logo.
12. Select an appropriate computer design application to use.

Elements of a standard poster

A good poster attracts audiences with a clear, uncluttered design that has a pop of colour, with information presented in logical order such that audiences can navigate through the composition easily. In addition, a good poster is not overloaded with text; it contains only the most essential bits of text and relevant graphics needed to tell the story (Argonne National Library, n.d.). Examples of standard poster designs can be seen in: (i) ‘Visit Africa’ (Plate 4) by Joseph Izang Azi asserting that the use of culturally relevant imagery has the capacity to enhance comprehension (Azi, 1999); (ii) The ‘African Wildlife’ poster (Plate 5) designed in 2023 by 200 Level INBD 203 Concepts in 2D Design students of the Department of Industrial Design, Ahmadu Bello University, Zaria. At its core, a poster is made up of four key features: a title, graphic(s), text and white space. However, elements such as layout, flow and colour affect the order and style of these four key features which are discussed herewith (Argonne National Library, n.d.).

1. **Title:** The title is a descriptive indicator of the contents of the poster and it should not exceed two lines of text.
2. **Text:** Posters typically employ around 800 words (and no more than 1000 words) of text.
3. **Graphics:** Graphics must appear *in context* with the main text and the goal of the advertisement.
4. **White space:** Also called blank space, it exists as a key feature of a poster because it is necessary for creating the breathing room and defining the borders of your presentation.
5. **Layout:** There are many design options for the layout of a poster. Some popular options include vertical columns, contrasting fields and graphic-centred designs.
6. **Flow:** Flow coordinates with how the readers’ eyes move around the different sections of a poster, the flow should be logical and readers are never confused about how to find information on the poster.

7. **Colour:** Adding colour to a presentation is an excellent way to draw a reader's gaze and define the different sections of a poster. But colour should always be used sparingly and with considerable thought.

Tips to design an advertisement billboard (as shown in plates 4 and 5)

1. **Identify the target audience:** It begins by identifying the primary target audience. Although a large number of people from different walks of life will see your billboard advertisement, not all of them will resonate with your message. Identifying the ideal audience will help a designer to structure his/her message in a way that his/her target audiences immediately feel connected to the product brand.
2. **Get the story right:** If the billboard is on the side of a highway where people will be speeding through, have a story that leaves a good impression. To get a strong hold of a story, think about the one thing you want people to remember if they looked at it for 5 seconds or less. The billboard should tell people how the product will solve their problem or fulfil a need. So, do you want them to remember the product image when next they visit the store?
3. **Keep it short, sweet and safe:** The average viewer of a billboard only has 5 to 10 seconds to view, read the text and understand the message. So, the message has to be kept short. Incredibly short! It is recommended that one sets for a maximum of seven words which include the logo, tagline and contact information. Ensure the prioritizing of the most crucial information so that the billboard serves its purpose without coming off as illegible or overwhelming.

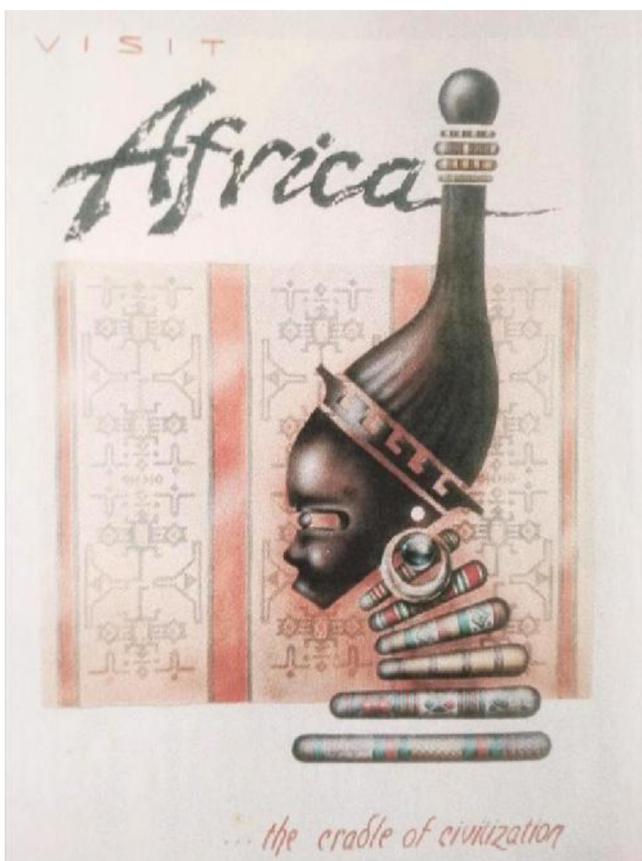

Plate 4: Visit Africa Poster by Joseph Izang Azi in 1992 (Azi, 1999) and Plate 5: African Wildlife Poster Designed by 200 Level Students of Industrial Design, Ahmadu Bello University, Zaria (in 2023).

Source: Joseph Azi's Design Collection and DID Design Collection

4. **Simplicity:** The key purpose of a billboard advertisement is functionality. As such, legibility and simplicity are important. Simplicity means keeping the design legible, minimizing the design elements, and avoiding elements that are complex to comprehend. It is only when people easily understand a message on a billboard would the design be considered effective.
5. **Be loud:** A billboard design has to have a resounding design. For such a big-sized layout, a designer must make sure everything in the design screams for attention, the louder the design the higher the chance that it would grab audience's attention.
6. **Be colourful:** Use bright colours and aim for high contrast to increase readability. Contrasting colours help to improve the retention of a message. To make the most of the design, a designer should use a simple background that does not interfere with the copy or image. For digital displays, a designer should use only RGB colour files as he/she would for a website, TV or computer monitor.
7. **Use high-quality images:** Whether working with print or digital billboard designs, one wants to prevent the impact of the design images from being affected by pixilation. So, be sure that the images and photographs used in the billboard designs are in high resolution. Stick to one large image or photo. Keep the visual elements to a maximum of three – the logo, headline and focal image.

8. **Include a call to action:** The purpose of any advertisement is to drive potential customers to take an action. Hence, this call to action must be obvious in the advertisement design, like to follow a web address.
9. **Make it interactive or dramatic:** While traditional advertisements offer the designer the chance to intrigue an audience with creativity, digital advertisements offer the opportunity to engage an audience. For instance, a designer can play with billboard dimensions to create a more striking design, by making it dramatic with animation. Not only does this captivate the audience, it also appeals to multisensory organs. However, while traditional billboards are mostly placed on the highway, digital billboards are more flexible and can be placed in malls, airports and street lamps, allowing customers to engage with the brand on the go. This is a great way to enhance the memorability of the advertisement as well as increase brand awareness.
10. **Test your idea:** After designing a billboard, a designer needs to ascertain its effectiveness. An excellent test is to show the design to someone from a distance for only 5 seconds; if they feel puzzled then you need to go back to the drawing board. Finding the right location to place a billboard is also very significant as location plays a critical role in determining the success or failure of billboard advertisement. To succeed, a billboard must be positioned in the right location. According to Airdoor, 74% of drivers consciously notice billboards and 48% of them take time to read. Good locations can be: near schools, near office buildings, near bus stops and train stations, near hotels and other commercial establishments, just off the highway/freeway to name a few.

The rules of billboard designs

All content in a billboard design is reviewed by a billboard advertising service provider [like Advertising Practitioners Council of Nigeria (APCON)] before it is eligible to appear before the public. A design will only be approved if it satisfies the following criteria:

- No nudity, profanity, intimations, graphic violence, personal attacks or hate speech.
- Does not advertise illegal goods or services.
- Has legitimate and functioning website domains.
- No false claims or inflammatory statements.
- No footnotes, disclaimers or ambiguities of any kind.
- Includes a logo, brand name and/or URL
- Does not contain negative ads targeted at a person, event or business.
- No text codes that can distracting drivers.
- Clearly states if it is a political advertisement and avoid potentially controversial designs.
- If you’re advertising music, add an “explicit content” tag to the ad.

The process of developing a billboard design

Plates 6-11 bellow are products of a design composition that answer to the task of creating a billboard design composition for the product (Adidas shoe company and Apple Technology).

Department: Industrial Design
Course: Graphic Design: Advertising Design Production
Course Code: INDE 431 (400L)
Project: Billboard Design
Designer: Jimoh Faruq Boluwatife
Admission No: U17ID1014

Stages of the Design

Rough thumbnail sketch expressing the initial ideation in developing the advertisement design concept of an Adidas sports shoe.

Detailed design with realistic, proportions, realistic colours and clear visual depictions for review by design team to elicit final feedback.

More refinement with almost final modifications with realistic shapes, proportions, colours, positions and visual effects incorporated into the design composition and presented to the design team and client for final feedback and modifications.

Plates 6, 7 and 8: Showing the Different Developmental Stages of Adidas Sports Shoe Billboard Advert Design by Jimoh Faruq Boluwatife, 400 Level Graphics, DID, ABU, Zaria (Designed in 2023)

Plate 9: Showing the Final Design Composition Requiring Only Finishing Touches and **Plate 10:** Showing the Completed Design Concept of the Adidas Sports Shoe Billboard Advertisement by Jimoh Faruq Boluwatife, 400 Level Graphics, DID, ABU Zaria (Designed in 2023)

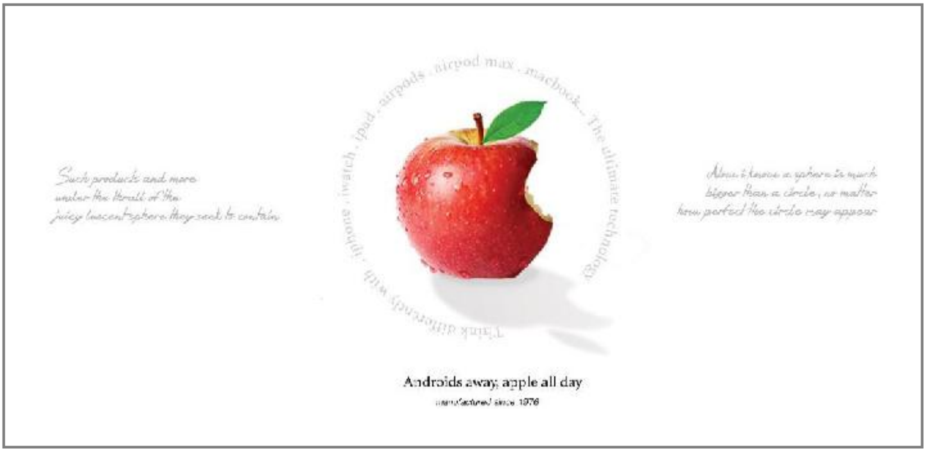

Plate 11: Showing the Completed Minimalist and Poetic Design Concept of the Apple Technology Billboard Advertisement. by Donatella Eleojo Abu (2023)

All the billboards in Plates 6-11 followed all the stages of design from thumbnail to finish. Here, students' aptitude in aesthetics, communication, attentiveness, patience and a deep understanding of the project tasks were put to practise. Also, no good design can be carried out successfully except adequate dosage of creative, innovative and design thinking skills are ingested.

Creativity, innovation and design thinking

Innovation does not happen without creativity, thinking outside the box and going against the established norms (Peek, 2023). Only with creative ideas can one truly innovate and implement solutions that work and solve problems. Creativity is the ability to think in new ways and apply fresh perspectives to old problems. Shawn Hunter, author of Out Think: How Innovative Leaders Drive Exceptional Outcomes defines creativity as "the act of conceiving something original or unusual" (Wiley, 2013). Stone (2023) opines that in today's fast-paced and ever-evolving world, the terms creativity and innovation are often used interchangeably, however they are significantly different. While creativity involves generating original and unique ideas, innovation is about implementing the ideas to create products of value. Innovation is defined as a product, process, service or business model featuring two critical characteristics: novel and useful. Of course, there would be no use creating something new or novel if no one would put it to any use. According to Han (2022) in an age when creativity and innovation are key to business success and growth, one is likely to come across the term "design thinking." When design thinking is carried out with utmost modesty, it brings about innovation and innovation in turn inspires meaningful and impactful solutions. Han (2022) argues that innovation is anchored around human-centred problem-solving design and the need to understand how the solution would impact the user. Creativity is one of those traits that people seem to have an intrinsic understanding of, but if asked to define, they get tripped up. It is easy to come up with a list of creative people like Frida Kahlo, Steve Jobs and Steve Wozniak, Einstein; and the outcomes of creativity like a novel, an invention, a new way of looking at the world, but it is difficult to fathom the actual concept of creativity. Creativity is the ability to transcend traditional ways of thinking or acting and to develop new and original ideas, methods or objects are.

- **It is an ability:** It is an ability to run a mile, or to do calculus or recite a Shakespearean sonnet (Shall I compare thee to a summer's day?). So, creativity is a skill that is specific to an individual. For some people, it might seem to come naturally, but it is something that anyone can improve at if given the time and effort.
- **It transcends traditional ways of thinking:** Transcending means going above and beyond, hence it is recognizing the limitations of what already exists and trying to improve upon it.
- **It develops new and original things:** The key word here is to "develop", as creativity goes beyond imagining: it is about developing. If it is an idea, one goes out and does the research to prove it and if it is a new process, one tries and tests it to see if it works. If it is an object, one would make efforts to build it.

Types of creativity

Arne Dietrich, Associate Professor of Psychology and Chair of the Department of Social and Behavioral Sciences at the American University of Beirut, Lebanon, conducted research into creativity that segments it into four types: (i) deliberate and emotional (ii) deliberate and cognitive (iii) spontaneous and emotional and (iv) spontaneous and cognitive. People can experience each of the four types of creativity, especially for knowledge workers like researchers, lawyers and doctors, deliberate and cognitive creativity may manifest while on the job. Spontaneous and emotional creativity may show itself during an artistic pursuit. Deliberate and cognitive creativities use focused attention and formed connections between information stored in the brain and rely on the prefrontal cortex, while emotional and spontaneous creativities stem from the amygdala and tend to be more instinctive. People who are good at taking insights derived from each type of creativity excel at thinking outside the box and applying new approaches to their work.

Design processes in creativity

Phase 1: Ideation - is all about creativity and coming up with unexpected solutions that address the customers' real needs and wants.

Phase 2: Prototype - is about making the ideas and solutions tangible and experienceable. From storytelling, role plays, paper mock-ups to building the idea with Lego - everything that allows you to interact with your target group is allowed.

Phase 3: **Test** - the objective is to test your prototypes with users and customers to receive feedback and learn in order to understand if the solution properly addresses their needs. It's about validating assumptions and the desirability of the solution before investing more budget in the development.

Impact of graphic design on society

A good graphic design composition combines image and textual elements creatively to capture audience's attention towards communicating information or advocating an ideology. A well-executed graphic design work can also elicit an emotional response from the viewer or even motivate him/her to take action (Palombi, 2023). According to Normoyle (2019) graphic designers, also known as visual communication designers, user-experience designers and interaction designers, are concerned with attempting to resolve complex problems within and around the social, technological, economic, environmental and/or political landscapes of societies. Prakash (2010) affirms that graphic design is an essential medium for social change through its ability to enlighten, educate and inform audiences, using contents that are driven by social, political and commercial concerns. The world would be full of chaos without graphic design, considering the significance of product labels, traffic lights, way-finding directional signs, operational manuals of electronic appliances to name but a few. Through the power of creativity and innovation in visual communication, graphic designers bring social change using the different graphic media at their disposal. The centre for social innovation at the Stanford Graduate School of Business defines 'social innovation' as the process of inventing, securing support for and implementing novel solutions to social needs and problems (Zu, 2021).

Summary

Imagine a world without graphic design, talk about product labels, traffic lights, way-finding directional signs, operational manuals of electronic appliances, there would be confusion in a lot of ways. Like not having product descriptions and differentiation labels, consumers' power of choice would be hampered. Hence, a consumer would not know which brand of product to buy. Consider how significant the traffic lights are to commuters, safety and orderliness for both pedestrians and motorists? To the graphic designer, the knowledge of the principles and elements of design serve as guide towards making a standard design, which can serve the purpose of visual communication. Graphic designers must understand visual communication techniques and applications, to enable them resolve complex problems within and around the social, technological, economic, environmental and/or political landscapes of the society. Positive social change can also be induced through the use of graphic design as a medium for enlightenment, education and information in the society, applying carefully guided contents that can drive social, political and commercial interests and national development.

Exercises

1. What do you understand by design?
2. Define industrial design, highlighting the aesthetic and utilitarian functions.

3. Discuss the role of the Bauhaus movement in the evolution of industrial design.
4. Discuss the elements and principles of design and their relevance in guiding design production.
5. Explain the key roles of graphic design in the society.
6. Create a billboard concept advocating peaceful coexistence to commemorate the global peace day.
7. Discuss the visual and textual elements of your poster and how they would relay the message of peace.

References

All Time Design (2023). How to Design a Billboard – A Comprehensive Guide. https://alltimedesign.com/how-to-design-a-billboard/Anonymous (n.d.). The Design Thinking Methodology. https://www.impactweek.net/how-we-work/method/?gclid=CjwKCAjwjYKjBhB5EiwAiFdSfgcQpQg0nnyRc982q8DZqlFXc90foKnj55YorTKHK L9iMDnjtDiBexoCMtIQAvD_BwE. Retrieved March, 2023

Argonne National Library (n.d.). Educational Programme and Outreach Guide to Effective Poster Design. https://www.anl.gov/education/guide-to-effective-poster-design#:~:text=At%20its%20core%2C%20a%20poster,of%20these%20four%20key%20features. Retrieved June, 2023

Atkinson, P. (2017). The Design Journal and the Meaning of Design, The Design Journal, 20:1, Pp 1- 4, DOI: 10.1080/14606925.2017.1253247.

Azi, J. I. (1999). An Evaluation of the Effectiveness of the Use of Colour in Contemporary Nigerian Advertisement Design. An Unpublished M.A, Thesis in the Department of Industrial Design, Ahmadu Bello University, Zaria.

Brain Station (2023). What is Graphic Design? https://brainstation.io/career-guides/what-is-graphic-design.

Cann, M. J. (2018). The 8 types of graphic design you need to know. https://99designs.com/blog/tips/types-of- graphic-design/

Carney, R. (2023). 33 famous graphic designers that everyone should know. Future publishing ltd. https://www.creativebloq.com/graphic-design/names-designers-should-know-6133211

Chiasson, D. (2023). The Man Who Built the Bauhaus. Condé Nest. https://www.newyorker.com/magazine/2019/04/29/the-man-who-built-the-bauhaus

Clark, D. (2023). What is graphic design? https://slideplayer.com/slide/6650944/

Conway, R. (2022). How to Make Your Own Advertising Posters. https://www.wikihow.com/Make-Your- Own-Advertising-Poster

Cunff, A. L. (2022). Combinational creativity: the myth of originality. Ness Labs. https://nesslabs.com/combinational-creativity#:~:text=A%20common%20misconception%20is%20that,%2C%20transformational%2C%20a nd%20combinational%20creativity.

Erikkowalski (2013). American Airlines Drops a New Logo & Ditches Helvetica: Massimo Vignelli is Not Impressed. https://gd3branding.wordpress.com/2013/01/29/american-airlines-drops-new-logo- massimo-vignelli-is-not-impressed/
Fiore, K. (2023). What is Design Theory? https://study.com/academy/lesson/what-is-design-theory.html
Geuens, R. (2023). 7 Types of Posters and What Makes them Stand Out. https://piktochart.com/blog/types- of- posters/#:~:text=Posters.,ll%20cover%20them%20all!).
Guo, S., Jin, Z., Sun, F., Li, J., Li, Z., Shi, Y. and Cao, N. (2021). Vinci: An Intelligent Graphic Design System for Generating Advertising Posters. ACM Digital Library. https://dl.acm.org/doi/abs/10.1145/3411764.3445117
Han, E. (2022). What is Design Thinking & Why is it Important? Harvard Business School Online. https://online.hbs.edu/blog/post/what-is-design-thinking#:~:text=Design%20thinking%20is%20an%20extension,mastered%20through%20practice%20 with%20peers.
International Design Foundation (2002). Graphic Design. https://www.interaction-design.org/literature/topics/ graphic-design#:~:text=Graphic%20design%20is%20a%20craft,to%20optimize%20the%20user%20 experience.
Kennedy, S. (2023). What is Graphic Design? - Definition & Explanation. https://study.com/academy/lesson/what-is-graphic-design-definition-explanation.html
Korenkova, M., Maros, M., Levicky, M. and Fila, M. (2020). Consumer Perception of Modern and Traditional Forms of Advertising. Volume 12; Issue 23. https://www.mdpi.com/2071-1050/12/23/9996.
Krzysztofik, A. (2023). How to Make a Poster in 6 Easy Steps [2023 Guide With Templates]. https://piktochart.com/blog/how-to-make-a-poster/
Lambert, K. (2019). Poster Illustration (Process). https://www.behance.net/gallery/82892035/Poster- Illustration-(Process)
Lawson, B. (1980). How Designers Think. The Architectural Press Ltd, London.
Levinton, A. (2023). 8 Types of Advertising Design with Tips and Examples. https://www.superside.com/blog/advertising-design
Malvik, C. (2020). What Is Graphic Design? A Beginner's Guide to This Creative Career. https://www.rasmussen.edu/degrees/design/blog/what-is-graphic-design/#:~:text=First%2C%20what%20is%20graphic%20design,messages%20in%20a%20visual %20way.
McGuire, S. (2023). How to Make a Poster in 10 Steps (2023 Poster Design Guide + Templates). https://venngage.com/blog/poster-design/
Morr, K. (n.d.). What is creativity? The ultimate guide to understanding today's most important ability. Vista. https://99designs.com/blog/creative-thinking/what-is-creativity/. Retrieved June,

2023
Normoyle, C. (2019). A Blended Perspective: Social Impact Assessment in Graphic Design. East Carolina University, School of Art & Design, Greenville, NC, USA. Dialectic: Volume 2, Issue 2, Summer 2019. A scholarly journal of thought leadership, education and practice in the discipline of visual communication design. https://quod.lib.umich.edu/d/dialectic/14932326.0002.205/-- blended-perspective-social-impact-assessment-in-graphic?rgn=main;view=fulltext.
DOI: https://doi.org/10.3998/dialectic.14932326.0002.205.
Overbeeke, K. and Hummels, C. (2002). Industrial Design. In The Encyclopedia of Human-Computer Interaction, 2nd Ed. (2002). https://www.interaction-design.org/literature/book/the-encyclopedia-of-human- computer-interaction-2nd-ed.
Palombi, N. (2023). What is graphic design? With examples for beginners. https://webflow.com/blog/what-is- graphic-design.
Peek, S. (2023). Creativity is Not Innovation (But You Need Both). BND. https://www.businessnewsdaily.com/6848-creativity-vs-innovation.html
Prakash, A. (2010). Graphic Design for Social Change: Incorporating Service-Learning into Design Curricula. In Bryant, J. A., Schonemann, N. and Karpa, D. (2011). Integration Service-Learning into the University Classroom. Published by Jones & Bartlett. Massachusetts. https://books.google.com.ng/books?hl=en&lr=&id=82S93ER_1U4C&oi=fnd&pg=PA155&dq=graphi c+design+for+social+change:+incorporating+service-learning&ots=y52bJdnI_j&sig=AMHfNQu40gh4kQniYmxvVnbJKEQ&redir_esc=y#v=onepage&q=gr aphic%20design%20for%20social%20change%3A%20incorporating%20service-learning&f=false.
PrezLab (2022). 54 Most Famous Graphic Designers of All Time. https://prezlab.com/54-most-famous-graphic-designers-of-all-time/#:~:text=Saul%20Bass%20is%20thought%20to,Psycho%20and%20West%20Side%20Story.
Price, P. C., Jhangiani, R. S., Chiang, I. A., Leighton, D. C. and Cuttler, C. (2017, 3rd American Ed.). Research Methods in Psychology. Pressbooks. https://opentext.wsu.edu/carriecuttler/chapter/methods-of-knowing/
Printbritannia Team (2021). Different Types of Posters. https://www.printbritannia.com/blogs/article/108/different-types-of-posters.
Prpic, N. (2023). The 8-Step Graphic Design Process (from Briefing to User Testing). https://filestage.io/blog/graphic-design-process/
Sanchez, D. (2019). The Elements and Principles of Design. https://medialoot.com/blog/the-elements-and- principles-of-design
Sengstack, P. and Boicey, C. (2015). Mastering Informatics: A Heatlhcare Handbook for Success. Sigma Theta Tau International, IN, USA. ISBN: 978-1-938835-66-7
Spacey, J. (2020). 68 Useful Design Theories.

Stone, S. (2023). What's the Real Difference between Creativity and Innovation? https://ideascale.com/blog/whats-the-real-difference-between-creativity-and-innovation/#:~:text=Creativity%20is%20the%20act%20of,innovation%20is%20building%20the%20rock et

Stubblefield, E. (2023). An Introduction To Graphic Design: What Is Graphic Design. https://www.freepik.com/blog/introduction-graphic-design-part-1/

Supermind (2023). Types of Media. https://www.mentalhelp.net/internet/types-of-media/#:~:text=Modern%20media%20comes%20in%20many,of%20software%2C%20and%20the%20I nternet.

Team Superside (2023). The Ultimate Guide to Graphic Design Styles. https://www.superside.com/blog/guide-to-design-style

Tomboc, K. (2020). 9 Types of Graphic Design Your Team Needs to Know About. https://learn.g2.com/types-of-graphic-design.

Zu, L. (2021). Social Innovation. In: Idowu, S.O., Capaldi, N., Zu, L., Gupta, A.D. (eds) Encyclopedia of Corporate Social Responsibility. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642- 28036-8_252

Zukowsky, J. (2021). Industrial Design. *Encyclopedia Britannica*, https://www.britannica.com/topic/industrial-design/Design-in-the-21st-century-technology-and- democracy. Retrieved 9 May, 2023.

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CHAPTER 28
Introduction to Metal Design
By
EMERIEWEN Kingsley Osevwiyo

Overview

Metal design basically is aesthetic creation which stems from man's conception of ideas for production in metals. Items conceived to be fabricated in metal should have a purpose and the metal designer should understand the purpose (Omatseye & Emeriewen, 2013: 62). Look around you, the metal jewelleries, kitchen utensils, cutleries, trophies, farm implements, medals amongst other metal products are produced by metal designers. In other words, art expressed through metal design has always been in existence. A metal designer is one who practices the art of metal items production using a variety of metals such as gold, copper silver, steel etc (Emeriewen, 2021). Oftentimes, metal design products are beautiful, complimenting their functions, as well as having commercial value. The metal products from metal design evolve not merely out of the designer's artistic prowess, but his use of working techniques and equipment. Metal design has found its way into higher Institutions as an undergraduate degree programme. The basic courses offered in metal design are; metal smithing, jewellery and foundry practice. Metal design as an area of specialisation provides an opportunity for a metal designer to create functional items employing fabrication skills. The expectation is that the metal designer will graduate, armed with theoretical and practical metal fabrication skills not only for self reliance but also to build the manpower base of Nigeria.

Objectives

At the end of this chapter, students should:

1. Understand the term Metal design.

2. Be able to define the following terms; metal design, metal smithing, jewellery, foundry practice, metal designing/modelling and styling.
3. Know the types of metals used in metal design.
4. Know the names as well as functions of some basic tools and machines used in metal design.
5. Understand some basic metal working processes.
6. Carry out simple metal design projects.

What is metal design?

Metal design refers to the use of metals in the fabrication of aesthetically functional objects. In other words, metal design stems from man's conception of ideas for design and production in metals. The terms 'jewellery and silver smithing', 'metal work', and 'metal craft' are some very popular words commonly used in describing the term metal design (Emeriewen, 2021). However, aside the creation of metal objects of beauty, metal design products also satisfy utilitarian needs. The origin of metal design is tied to man's first knowledge of metals (Untracht, 1975: 3). For thousands of years, metal has retained its importance as the oldest material known to man, and has had a decisive influence on man's civilization too (Heinz and Dieter, 1971). In the opinion of Shirley (1973: 140), metals in art have been there for over five thousand years, when the earliest craftsmen in Stone Age discovered and first used metal. This singular act saw a great step forward in civilization. It moved local technology from stonework to metal. Metals could be shaped by the basic working processes of bending, beating, melting and by pouring in a molten state, into a mould.

In Nigeria, some notable cultures like those of Ife, Benin, Tsoede and Igbo Ukwu have a long history of metal working; predominantly in bronze and brass. The metal works from these cultures say a lot about the skills of the craftsmen who produced them. Lately, traditional metal workers in Nigeria produce functional metal works that also have aesthetic values. For example, some metal designers produce musical instruments and tools (Emeriewen and Kalilu, 2015: 70). The tools fabricated by some Nigerian metal designers is filling the gap brought about by reduced importation as well as high cost of importation of these products from developed nations. For instance, Akwa, a town in Eastern Nigeria is popular for its blacksmithing industry. Shotguns, farming implements and tools are some items Akwa metal workers produce. Modern technology and urbanization has not stopped the metal designers in Nigeria from practicing their art.

While acknowledging the importance of metal design products in their aesthetics and utilitarian functions, especially in local context, the academic significance of metal design is equally important (Emeriewen, 2017: 51). One of the many specific objectives of fine and applied arts programme according to the Nigerian Universities Commission's White paper (2022: 220) is to promote adequate general knowledge and specific skills and techniques to enhance the effective performance of graduates in the special areas to use materials with technological methods for the benefit of human resources and economic and social needs. In other words, no art form including metal design is valid if it does not serve some needs of society.

Metal design is a specialised course in the applied arts discipline. The course is taught and practiced on the thresholds of creativity, functionalism, and localization of products (Emeriewen, 2016). For a well grounded practice of metal design, the metal designer must take and also be competent in the following practical courses; jewellery, metal smithing, foundry practice, metal designing/modelling and styling.

Jewellery

Jewelleries are decorative ornaments used to adorn the body. Some examples of jewelleries are; necklaces, rings, and bracelets. The aim of this course in metal design is to introduce students to the basic workshop processes in the production of jewellery with focus on;

1. equipping the students on how to use tools for jewellery production, as well as the basic forming techniques.

2. teaching students how to work with precious metals, the processes of jewellery making and fitting.
3. the various designs and decorative options like enamelling, filigree, etching etc.
4. other processes involved in the production of fine decorative works such as chasing and repousse, jewellery casting as well as other mass-production techniques of jewellery production.

Metal smithing

Metal smithing dwells on the production of useful decorative items from metals. The fabrication of the items is commonly done by shaping of the metals. Metal candle sticks, trophies, plates are some examples of products crafted through metal smithing. This course is generally aimed at equipping a metal designer with the under listed;

5. the techniques and practices involved in the construction, fabrication and finishing of steel,
   aluminium, copper, bronze and brass.
6. provides them with knowledge in the pressing, spinning or beaten sheet metal to shape, as in hollowing, raising, planishing etc.
7. exposing the students to basic knowledge in core construction.
8. display an understanding of construction or fabrication in forging, giving particular attention too, to the tools and processes used in forging.
9. acquire basic knowledge in tools making, and be familiar with the names of tools in metal smithing, and their respective uses.
10. appreciate the need to understand the processes involved in metal construction as well as assemblage.
11. be conversant with the construction in forging as decorative smithing in scroll works.

12. get a good measure of exposure and experiences in machine work, particularly in lathe operations such as turning, facing, drilling, boring, parting, knurling, and sometimes screw-cutting.

Foundry practice

Foundry practice is a course in metal design that refers to a production process in which molten metal is poured into a mould that contains a hollow space of a desired shape. Foundry practice is the same as metal casting. The process of metal casting allows for the production as well as mass-production of metal items (Agbontaen, 2016). Brass, bronze, silver, gold, copper, aluminium, etc are some metals used in metal casting. The aim of foundry practice in metal design is;

13. to equip the students with the general principles of metal casting.
14. help students to appreciate the various processes involved in foundry practice and techniques.
15. teach students to evaluate the equipments and tools for casting the different metal types.
16. introduce students to industrial metal casting processes with emphasis on shell mould, investment mould casting and mass-production through metal casting.

Metal designing/modelling and styling

Metal designing/modelling and styling is a course in two and three-dimensional constructions. It affords the students an opportunity to put their creative ideas on paper. It is also aimed at helping students to;

17. understand the representation of two and three dimensional forms on paper.
18. have a general knowledge of the principles of arts like balance and symmetry, especially as it pertains to designing in metals.
19. acquire knowledge of measurements in designing.
20. produce models in cardboard, plastacine clay, P.O.P etc.

21. correct errors from models, with a view to achieving a good finished product.
22. make computer generated models out of the manually made ones.
23. acquire a good knowledge of modelling products to be made in metals.

Aside the major courses in metal design, there are other ancillary courses like computer aided design (CAD) which is taken by metal design students. Knowledge and proficiency in CAD leads the metal design students to express their design concepts using modern gadgets land technology. In other words, the CAD tends to eliminate the traditional designing methods, where pencils, pens, water colours etc are used in expressing design ideas on paper (Obasuyi, 2023). Some of the gadgets students use in CAD are phones, tablets and laptops. In CAD, the metal designer expresses his design concepts through a wide range of design applications and softwares like Corel draw, Instant artist in a computer or tablet. Exposure to CAD gives the metal design students an idea of what the outcome of his project would look like.

Some metals used in metal design

In metal design, some ferrous and non-ferrous metals are used in articles fabrication. Ferrous metals are the metals that rust easily while non-ferrous metals do not rust. Iron and steel are examples of ferrous metals while brass, bronze, copper, gold, aluminium are some examples of non-ferrous metals. Table 1 highlights some metals used in metal design.

Name of metal	Form	Area(s) used
Copper	Sheet, strip, wire, pipe scraps	Metal smithing, jewellery and foundry practice
Brass	Sheet, strip, wire, pipe, scraps	Metal smithing, jewellery and foundry practice.
Bronze	Sheet, strip, wire, pipe, scraps.	Metal smithing, jewellery and foundry practice.

Carbon steel	Sheet, textured sheet, square rod, round rod, corrugated rod, wire, strip, round pipe, square pipe, rectangle pipe, angle bar, beams and channels.	Metal smithing.
Stainless steel	Sheet, textured sheet, rectangle pipe, round pipe, square pipe, strip, angle bar. Stainless steel fittings.	Metal smithing.
Aluminium	Sheet, scraps.	Metal smithing and foundry practice.
Lead	Scraps.	Foundry practice.

Table 1: Some metals used in metal design.

Some machines and tools used in metal design

In metal design, a range of manually operated and electrically powered tools and machines are used in articles' fabrication. In table 2 below, are some basic tools and machines used in the courses taken under metal design.

Metal smithing	Jewellery	Foundry practice
Hand held power drill	Hand held power drill	Modelling tools
Angle grinder	Piercing saw	Furnace
Files	Jewellers needle files	Files
Bench grinder	Bench grinder	Tongs
Chasing and repousse tools	Rolling mill	Electric blower
Wooden and iron stakes	Assorted pliers	Hammer
Snips or hand held shears	Tweezers	Crucible
Doming blocks	Doming die	Angle grinder
Bench vice	Pin vice	Bench grinder
Firing hearth and blow torch	Firing hearth and blow torch	Skimming pole

Table 2: Some tools and machines used in metal design.

Working techniques used in metal design

Basic working or production techniques in metal design vary in the metal design courses. However some working processes cuts across two or more of the courses in metal design. For instance metal casting is used in the production of some items of jewellery as well as in some portions of smithed works. Similarly, all the end products of metal design undergo some form of finishing. For metal smithing, the summary of working techniques is; design/planning, cutting, forming, joining, finishing. In the case of jewellery, the general working techniques are; design/planning, wire preparation, building with wires/assemblage, cutting, forming, casting and finishing. For foundry practice, the general working techniques are; planning/modelling, casting and finishing. Details of some metal design working processes are explained below.

Design/Planning: In metal smithing, any article to be fabricated most times determines its design and subsequent planning. For some metal designers, design and planning starts with rough sketches of the article to be produced. Sometimes too, it may be important to produce a paper mock-up or dummy of the item to be produced as seen in figure 1.

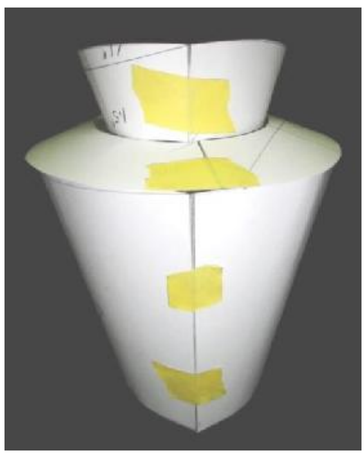

Figure 1: Cardboard dummy of a vase. Source: Emeriewen, 2014.

The design and planning is the followed by cutting out the articles' part from a sheet metal of choice. Cutting tools and machines used for cutting operations includes hack saw, hand held shear, table shearer, electric jig saw and piercing saw.

Forming: Involves a variety of processes aimed at giving shape to a metal form. Some of the processes are chasing and repousse (figures 2 & 3), doming and sinking (figures 4 & 5), swaging (figure 6), metal carving (figure 7), bending, folding, scrolling and twisting.

Figure 2: Aluminium foil relief panel done with chasing and repousee. Source: Emeriewen, 2014.

Figure 3: Aluminium foil relief panel done with chasing and repousee. Source: Emeriewen,

2014.

Figure 4: Copper gongs produced by sinking process. Source: Emeriewen, 2014

Figure 5: Sinking block used to produce the gongs in figure 4. Source: Emeriewen, 2014.

Figure 6: Swaged portion on a brass traditional sword. Source: Emeriewen, 2014.

Figure 7: Linear patterns on copper curtain holders carved in with a cutting disc. Source: Emeriewen, 2014.

Finishing: Once a metal article's fabrication is completed in metal smithing, casting and jewellery, the next stage is finishing. For a smithed or cast item, grinding of excess solder from joints with grinding disc accessory is the first finishing process. This is then followed by sandpapering, polishing, buffing and lacquering (figures 8 – 11). However, finishing of some non-ferrous metal castings may not necessarily follow the procedure described above. For such items, they are sandpapered and wire brushed to give a matt finish. Generally, finishing operations are quite important not just for aesthetics purposes, but in the preservation of metal items (Kalilu and Emeriewen, 2012: 157).

Figure 8: Grinding a brazed brass joint with a grinding disc accessory in an angle grinder. Source: Emeriewen, 2014.

Figure 9: Sandpaper glued to a disc made out of linoleum (attached to an electric motor). Source: Emeriewen, 2014.

Polishing and Buffing: Upon the completion of grinding and sandpapering finishing processes, the item is now ready for polishing and buffing. Polishing and buffing are mechanical means of giving sheen to a metal item. Technically, polishing abrades a metal's surface while buffing smoothens it. For polishing, a polishing mop on a rotating electric motor is charged with a polishing compound and used to polish metal items as seen in figure 10. This is followed by buffing. For buffing a buffing mop on a rotating electric motor is charged with a buffing compound and used for buffing. In both operations, the metal article is held and slightly pressed against the charged mop. In some cases, polishing and buffing may leave a residue of greasy film on the metal item. In this situation, the film may be cleaned with a clean soft cloth or facial tissue paper soaked lightly in thinner. Polishing and buffing is followed by lacquering.

Figure 10: Polishing a mace with a charged polishing mop attached to an electric motor. Source: Emeriewen, 2014.

Figure 11: Polished and lacquered brass and copper medallions. Source: Emeriewen, 2014.

Building with wires/assemblage in jewellery

For wire working using gold or silver wires, the metal designer prepares the precious metal into wire form. The formed wires are then used in creating articles especially jewellery. The wire work is also called filigree. The stages in the preparation of the wire as well as the use of the wire in article production are shown in figures 12 - 24.

Figure 12: Melting pieces of silver scraps with a blow torch. Source: Emeriewen, 2014.

Figure 13: The melted silver in ingot form being reduced to thick wire form in a rolling mill. Source: Emeriewen, 2014.

Figure 14: Further reduction of a silver wire in the tinnier grooves of a rolling mill. Source: Emeriewen, 2014.

Figure 15: The reduced silver wire. Source: Emeriewen, 2014.

Figure 16: Filing an end of a silver wire for it to be drawn.
Source: Emeriewen, 2014.

Figure 17: Drawing the silver wire through the different sizes of holes in a round draw plate.
Source: Emeriewen, 2014.

Figure 18: Drawn silver wires ready for use. Source: Emeriewen, 2014.

Figure 19: Twisting two strands of drawn wires together using a 2' X 4' wood with a flat piece of wood. Source: Emeriewen, 2014.

Figure 20: Using plain (untwisted) silver wire to form the outer frame of an earring. Source: Emeriewen, 2014.

Figure 21: Formed outer frame for an earring. Source: Emeriewen, 2014.

Figure 22: Using a Carborundum stone to file excess solder on the formed earring frame.
Source: Emeriewen, 2014.

Figure 23: Using twisted silver wire to fill the inside of an earring form.
Source: Emeriewen, 2014.

Figure 24: A portion of an earring's frame densely filled with twisted silver wire and all parts assembled. Source: Emeriewen, 2014.

Foundry practice: The processes involved in investment casting also called 'cire-perdue' in foundry practice are depicted in figures 25 - 42.

Figure 25: Making a core for a King's bust from well kneaded laterite soil.
Source: Emeriewen, 2014.

Figure 26: Covering up a core with beeswax Building-up (sculpting and ornamenting with strips and sheet of beeswax). Source: Emeriewen, 2014.

Figure 27: Sculpted beeswax forms used as dressing paraphernalia and ornamentation in a bust of a king. Source: Emeriewen, 2014.

Figure 28: Wax model over a core. Source: Emeriewen, 2014.

Figure 29: Covering the wax model with kneaded laterite soil. Source: Emeriewen, 2014.

Figure 30: The wax model completely covered with a thick layer of laterite soil.

Source: Emeriewen, 2014.

Figure 31: Addition of a sprue to the underside of the wax model. Source: Emeriewen, 2014.

Figure 32: Carbon wire bound laterite soil casing (mould) of beeswax model. Source: Emeriewen, 2014.

Figure 33: Covering the carbon wire bound laterite soil covering of beeswax model with slurry soil. Source: Emeriewen, 2014.

Figure 34: Melting copper alloy scraps in a furnace. Source: Emeriewen, 2014.

Figure 35: An open fireplace where moulds to be cast are de-waxed and warmed. Source: Emeriewen, 2014.

Figure 36: Placing a de-waxed mould (casing) in a dug hole. Source: Emeriewen, 2014.

Figure 37: The iridescent mould buried halfway in the ground with the sprue positioned upward to receive the molten metal. Source: Emeriewen, 2014.

Figure 38: Using a tong to carry a laterite soil crucible containing molten copper alloy. Source: Emeriewen, 2014.

Figure 39: Pouring molten copper alloy into the mould to assume the shape of the expended beeswax. Source: Emeriewen, 2014.

Figure 40: Destroying the laterite mould (casing) housing the metal cast. Source: Emeriewen, 2014.

Figure 41: Parts of a copper alloy cast partially revealed. Source: Emeriewen, 2014.

Figure 42: A king's bust cast in copper alloy. Source: Emeriewen, 2014.

Summary

Metal design as a course under applied arts, centres on the production of decorative and functional items using metals. To practice as a metal designer, there are some courses one must take. They are; metal smithing, jewellery and foundry practice. In each of the basic course, is a variety of working process a metal designer is expected to understand. The goals of each course as highlighted above are to provide the metal design student practical experience needed for successful practice. Similarly, there is a variety of machines and tools used in metal design. The metal designer should know and understand the functions of each machine and tool for different metal design tasks. An understanding of metal design working processes as well as tools and machines will lead to successful practice of metal design.

Exercise

1. What do you understand by the term metal design?
2. Write short technical notes on metal smithing, jewellery, foundry practice, metal designing/modelling and styling.
3. List some metals used in
    a. metal smithing
    b. jewellery
    c. foundry practice
4. Write out five machines or tools used in
    a. metal smithing
    b. jewellery
    c. foundry practice
5. List and explain three working processes used in
    a. metal smithing
    b. jewellery

c. foundry practice

6. Following the photographs in jewellery wire work, produce a pair of simple wire earrings using silver wire.

7. Using the photographs shown in foundry practice as a working guide, model and cast using aluminium, a candle holder.

References

Agbontaen, U. (2016). "Unpublished Lecture Notes". APM 314, Metal casting and production methods.

Dieter, K & Heinz, U. (1971). *Creative Metal Craft.* London. Batsford Ltd.

Emeriewen, K. O. & Kalilu, R. O. R. (2015). "Emerging Trends in Blacksmithing in Benin City, Nigeria". *CITAR Journal of Science and Technology of the Arts.* Vol. 7 (2). Pp. 70-76.

Emeriewen, K. O. (2014). "An Analysis of Materials and Technology of Benin Metal Arts; 2000 – 2010", Ph.D thesis, Department of Fine and Applied Arts, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Emeriewen, K. O. (2007). "A paradigm for metal design: The University of Benin Art School experience". *Global Journal of Humanities*. Vol. 6, (1 & 2). Pp 51-57.

Emeriewen, K. O. (2016). "Unpublished Lecture Notes". APM 214, Introduction to metal design.

Emeriewen, K. O. (2019). "Unpublished Lecture Notes". APM 310, Jewellery 1.

Emeriewen, K. O. (2021). "Unpublished Lecture Notes". APM 214, Introduction to metal design.

Kalilu, R. O. R. & Emeriewen, K. O. (2012). "Porcelain waste as material for the servicing of metal art objects and artefacts". *Journal of the Australian Ceramic Society, Vol.* 48 [2]. Pp 156-165.

Nigeria University Commission. (2002). Core Curriculum and Minimum academic standards for the Nigerian University system (CCMAS) for Environmental sciences. https://nuc-ccmas.ng/download/ccmas- environmental-sciences (Accessed on 16 March 2023).

Obasuyi, F. O. E. (2023). "Unpublished Lecture Notes". APM 313, Metal designing/modelling and styling.

Omatseye, B. O. J. & Emeriewen, K. O. (2010). "Classroom Metal Design Experience: Creating Opportunities for Young Entrepreneurs". *Awka Journal of Fine and Applied Arts* . Vol. 1. Pp. 62 - 79.

Shirley, F. A. (1973). *Metal; Design and Construction*. Amersham: Houlton Educational PublicationsLtd.

Untracht, O. (1975). *Metal Techniques for Craftsmen.* U.S.A: Double Day & Co. Inc.

Untracht, O. (1985). *Jewellery Concepts and Technology.* U.S.A: Double Day & Co. Inc.

Biodata of Author

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CHAPTER 29
Introduction to Glass and Ceramics Technology
By
KASHIM Isah Bolaji

Overview
For centuries, traditional ceramics and glass production underwent the processes that developed from rudimentary pottery and glass melting through early men's activities to the modern-day finest white-ware and glass products as identified in markets all over the world. They have been confirmed to be produced as modern industries bring to bear technical ceramic products and glass with an ever-growing range of today's modern applications. Examples are glass made from oxides which expand and can contract like rubber without fracturing easily. Technical ceramics are consumed in nations associated with electronic products because of their superior properties over metals and alloys.

Objectives
At the end of this chapter, students should be able to:
1. identify the characteristic features of glass and ceramics;
2. examine the major components that characterize the recipe/batch formulation for glass and ceramics;
3. identify the working process of the different kilns/furnaces used for the production of glass and ceramic products;
4. discuss the basic role of refractories in heat generation for glass and ceramic production;
5. assess the role of pyrometric instruments in temperature regulation in the kilns/furnace; and
6. examine the role of ceramic and glass products in modern development.

History of Ceramics

Historically, ceramics had a developmental trend with its root from pottery handcraft dating back to 400B.C. From legendary information, materials are carried by the early men in woven baskets lined with river clay. After water was poured out of the container, the layer of clay dried. The loss of moisture caused the shape to shrink and separate from the sides of the basket. It was discovered that they could harden the moulded pottery in hot ashes and make it into containers to transport and store foodstuff. The pottery activities could be witnessed as far back as the period

of Egyptian to Greek civilizations.
Ceramics by definition are clay products that are materially hardened through the application of heat such that it cannot physically revert to its original state again. In a more applied scientific term ceramics is defined as an inorganic, non-metallic solid made of either metal or non-metallic compounds that have been formed into a product and then hardened by heating to high temperatures above 1100^0C. Owing to this heat treatment, they are hard, corrosion resistant and brittle. Therefore, ceramics is an art and technology of making objects of clay by a firing medium.
Glass is a hard brittle substance typically transparent or translucent made by firing silicate with soda ash and lime to produce products like windows and drinking containers.

Some key terminologies in ceramics
Clay: A natural material extracted from the earth crust.
Ceramic categorization: Earthenware, stoneware and porcelain.
Forming techniques: Coiling, pinching, slabbing, slip-casting and throwing.
Stages of product development: Slip, plasticity by ageing, leather hard, bone dry, greenware and bisque once fired.
Firing stages: Application of heat using wood, gas, kerosene and electrical elements to get the temperature at which a clay becomes mature or a glaremelts.
Basic tools: Bat, banding wheel, callipers, pyrometric or optical pyrometer, cut-off ware, fettling knives, Plaster of Paris mould, needle, rubber ribs, scrappers, wooden modelling tools.
Other essential pottery terms: Centering, extension foot ring, glaze, grog, stacking, vitrification and wedging.

Some key terminologies in glass:
Annealing: Control processing of glass cooling to prevent residual stress in the glass
Cullets: Broken glass, excess glass from a previous melt or edges trimmed off when cutting glass to size.
Double glazing: Use of two tiles of glass, separated by an air space within an opening to improve insulation against heat transfer and sound transmission.
Durometer: The gauge used to measure the hardness of an elastomeric material.
Edging: Grinding the edge of flat glass to a desired shape or furnished.
Frosted furnish: Surface treatment for glass consisting of acids etching of one or both surfaces that diffuse transmitted light and reduces glare.
Laminated glass: Two or more tiles of glass permanently bonded together with one or two interlayers.
Lehr: Long funnel-shaped oven for annealing glass in a continuous process.
Lite: Term used for a plane glass which could also be spelt as light.
Permanent set: The amount by which a material fails to return to its original dimension after being deformed by an applied force or load.
Primer: A coating specifically designed to enhance the adhesion of sealant systems to certain

surfaces to form a barrier to prevent migration of components or to seal a porous substrate.

Types of ceramics

Ceramics are classified into two main categories. These are traditional and advanced ceramics as shown in figure 1. The traditional comprises those that have a long history of common usage such as concrete refractory and porcelain while the advanced ceramics are those with modern applications in the areas of porcelain, engineering and technology that use pure oxide products (e.g., Al_2O_3, SiO_2, ZnO_2, ZnO, MgO, $MgAl_2O_3$). The earthenware and stoneware ceramics are categorized based on their material content and final maturational temperature. While earthenware are low fired with a range of temperatures between 750^0C to 1080^0C, stoneware are fairly higher and rock-like in nature; such that they are impervious to liquid, unlike earthenware which is still fairly porous.

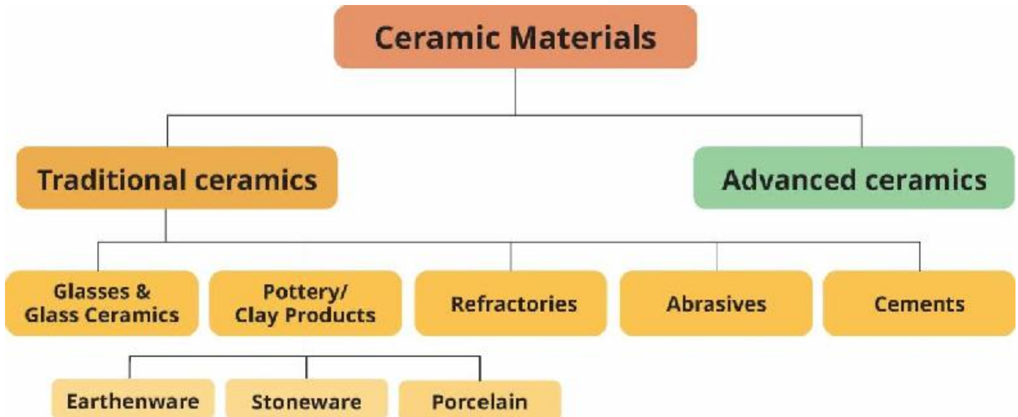

Figure 1: Classifications of ceramic materials

The high-tech ceramic products are an advanced fine ceramic technique that took a departure from the traditional world of ceramics in the 1980s. They are made using very precise calculations that considered everything from material to final processing techniques. Fine ceramics products have become an essential part of today's lifestyle. Examples of earthenware are flower pots, terra-cotta tiles, fire bricks and pots for cooking and storage. Stoneware comprises flower vases, dinnerware, and artificial ceramics such as glazed tiles. The process that happens to fall within the range of technical ceramics comprises automotive engine parts, artificial bone and teeth, kitchenware such as knives that are rust-proof and anti-bacteria deodorants.

Different types of pottery

Earthenware: it is a form of pottery used as ovenware for thousands of years before the development of kiln that can be used for heat treatment to very high temperature lower than 1000^0C. A popular choice for beginner ceramists, because they have materials that are easier to work with.

Stoneware: stoneware takes a longer time and temperature to mature compared to earthenware with an operational temperature above 1200^{0}C. They are more durable and non-porous and can withstand temperature from microwaves.
Porcelain: the last type of pottery to make its way in Europe and North America around the 1700s. It was highly treasured in China with a maturation temperature of 1300^{0}C and above. They are distinct from others because of their whiteness, translucency and body gasification.

Advantages of ceramics
They are employed as abrasives, refractories, thermal insulators, electrical resistance, as lightweight ceramics. They are chemically inert, corrosion resistant and very hygienic for use.

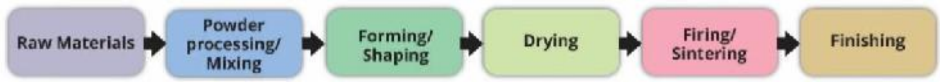

Figure 2: A general flow for ceramic processing and production

Different types of glass
There are four (4) different types of glass. These are annealed glass, heat-strengthened glass, tempered or toughened glass and laminated glass. Annealed glass is a process that allows glass to cool slowly in a controlled manner until it reaches room temperature. Without this process, the glass formed might shatter. Heat-strengthened glass is typically specified when additional strength is needed to resist wind pressure, thermal stress or both, within 650^{0}C -700^{0}C. It has limited strength. Tempered glass is used for balustrades and structural applications. Its cooling process is accelerated and accompanied by uniform and simultaneous blast air on both surfaces, this process makes the glass 4-5 times stronger and safer than annealed glass. Laminated glass offers many advantages in terms of safety and security. It does not shatter on impact but is held together by the interlayer. The engineering properties of this glass are transparency, strength, workability transmittance, U-value and recycling properties.
1. In what way is ceramic a useful material?
2. When are high-strength ceramics useful?
3. Where is advanced ceramics usage applicable?

Properties of glass: Transparency, strength, workability, transmittance, U-value and recycling.
Types of glass: Float, shatterproof, laminated chromatic, tinted, toughened, wool and insulated glasses.
Applications: Shop, public places, skylight, aquarium, aesthetics glass wool, insulating glazed units.
U-Value glass: Represents the amount of heat that can be transferred through the glass. Insulated glass has a lower U-value.
Laminated, Tempered/Toughened glass: Glass with superior weight, thickness UV proof

soundproof, toughened glass.

Batch formulation

In ceramics, it is usually referred to as body formulation, while the glass making for the thin layer of glass coating on ceramic surfaces is referred to as glaze recipe. The combination of glass raw materials and components is referred to as batching. In ceramics, the body composition usually comprises plastic and non-plastic materials. The plastic materials are kaolin (primary clay) and non-plastic materials (silica, limestone, talc and feldspar). The above substances cover a mixture of the major raw materials for making any of the ceramic products (earthenware, stoneware and porcelain) and also the main part of the products, as opposed to the glass. In glaze preparation, three key components are required to make a glass used as a thin layer to cover a ceramic body so as to give the product desired beauty, seal its porosity and make them hygienic for use. The major material components are fluxes (feldspar) which help bring down the melting temperature of the other components. Clay is the major forming material that provides the flesh and silica is the major glass former. The clay is the link between the glass former and the alkaline fluxes. Ceramic glazes protect and seal fresh pottery, making it both functional and beautiful. Once a glaze is applied and the piece is fired, causing a chemical reaction, the outcome could be magical. The silica, which is a glass former is a key ingredient in glass, which are obtainable from quartz, flint and pure silica with a melting point of 1710^{0}C. The alumina is highly refractory and contained in all glazes to act as a stiffening agent. Without clay in any glaze, the melted glass will slide off the surface of the ceramic piece as it is applied. It allows the glass to stick to the ceramic body after the glaze melts. The fluxes play a key role in lowering the melting point of silica. They promote vitrification, that is, transformation into glass. The colouring agent only enhances the beauty of the ceramic product by providing colour. The colours are supplied through the addition of metallic oxides such as cobalt, iron oxide, tin oxide, chromium oxide and manganese oxide. In glaze making, the materials used to create a glass include soda ash, limestone and silica sand. They are mixed and ground together to create a powder solution referred to as a batch. Waste glass known as cullet is also introduced into the batch to help further lower the melting temperature of the raw materials.

The production process follows three (3) critical stages as shown below.

1. Fusion of raw materials.
2. Working with molten mass to create a form.
3. Annealing.

Silica, which is the glass former, liquifies into a viscous melt at 1713^{0}C and its viscosity at this point is too high to work with. A temperature in excess of 2000^{0}C must be attained to work on pure silica glass, which is economically unviable for a majority of glass applications. The production of glass requires the addition of fluxes, which is why sodium carbonate (soda ash) at 25% to silica content is used to reduce the melting point from 1723^{0}C to 850^{0}C. Such glass can be soluble except for the addition of calcium oxide, which is supplied from limestone that renders it insoluble. The most appropriate application of the materials by ratio is silica 75%, lime 10% and soda ash 15%. Figure 3 shown glass manufacturing process.

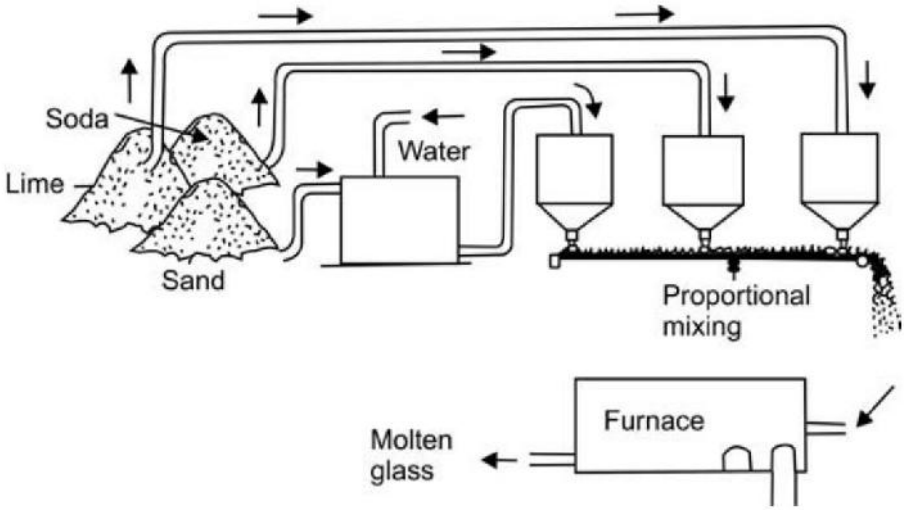

Figure 3: Glass manufacturing process
Source: https://www.pcepurnia.org/wp-content/uploads/2020/03/Glass.pdf

Kilns/Furnaces

According to Jones (2007), fire and change are two of the central tropes of ceramics. Fire has an ambiguous role in ceramics. It fixes the manipulated clay and prevents it from being refashioned into a new form. Fire thus removes clay from the world of mutability and takes it to permanence. Historically, the tradition of ceramic product firing evolved from the Far East to the rest of the world. Kiln, therefore, is a refractory chamber that has proved to be a very essential part of the manufacturing of ceramics and glass products. The two materials require a high temperature so that chemical and physical reactions can occur to permanently alter the unfused body. Subjecting ceramic wares in the kiln allows for gradual drying in preparation for bisque or single firing. The physical and chemically combined water in clay products have to evaporate and then quartz inversion and conversion take place. The first quartz inversion is cristobalite inversion at 226^{0}C, while the second occurs at 570^{0}C. This is formed naturally and slowly during cooling. All bodies containing carbonaceous matter get burnt off. At further higher temperatures the clay body gets sintered at red heatand so it becomes impervious to liquid. With further temperature, it becomes vitrified. The different types of kilns used in ceramics are wood, gas as shown in figure 5, kerosene, electric shown in figure 4 and raku kilns. Only the electric kiln uses electrical elements and it is a complete oxide firing. Raku kiln firing is a specialised firing in which top-loading kilns are used with very low-temperature glazes on wares. When the biscuit wares are glazed and kept in the kiln, they are removed at about 1000^{0}C and kept in a metal container with dry or wet leaves so that the metallic oxide can react to the carbonized atmosphere to produce very fantastic metallic colours. For efficiency, most of the kilns are updraft kilns.

Figure 4: An electric chamber kiln for ceramic firing

Figure 5: A gas-fire kiln

Figure 6: A laboratory chamber furnace
Source: http://www.ceradelindustries.com/industrial-furnaces/

The glass production process begins with the precise definition of the raw materials in various percentage ratios and must be done with the barest minimization of impurities in the final products. These ingredients are thoroughly mixed before undergoing either tank melting (the most common method) or pot melting, which is suitable for small volumes or glass with special optical characteristics. The melting process follows these four phases: batch melting (by heating the material), refining (eliminating gas bubbles), homogenization (to ensure uniformity) and condition.

The various methods of glass production are Down-draw, Up-draw, Rolled, Micro float and Tube drawing.

Down–draw: This is a method of producing thin glass. The thinness of the glass can be controlled by the speed of the process.

Up–draw: This uses the up-draw process, which involves a ribbon of molten glass used to produce a wide range of glasses. It can be used in this process to produce the desired thickness.

Rolled: This is a method used to produce stronger and more durable glass ceramic for flat sheets and trimmed down to required sizes.

Micro float: This is a method used to produce highly homogenous glasses with mirror-like surfaces. It is usually accompanied by exceptional flatness and excellent optical properties.

Tube drawing: This uses borosilicate glass tubing in a variety of diameters.

The role of refractory in Kilns/ Furnaces

Refractory materials have resistance to the effect of heat without deterioration either in the kiln or in the furnace. That is stress resistance or mechanical strength of any material, especially at high temperatures. That is, they are non-metallic materials having physical and chemical qualities that make them perfect for different types of construction or as a crucial component of systems applied to temperatures above 1000^{0}C. The following are the type of satisfactory materials: fireclay, alumina, silica, magnetite, chromite, zirconia, insulating materials and monolithic refractories.

They all possess basic properties that make them physically and chemically stable at high temperatures. They must have resistance to thermal shock and must be chemically inert.

Pyrometry

The ability to subject kilns and furnaces to heat at high temperatures also demands that ceramic and glass materials put in the kiln be monitored for appropriateness, in terms of maturational temperature. The major devices that are used are optical pyrometers or temperature-measuring cones. An optical pyrometer is a device designed to operate within the visible spectrum to measure temperature typically in the range of 700^{0}C to 4000^{0}C by comparing the photometric brightness of the heated object against the brightness of a standard source such as an incandescent tungsten filament. The radiation is emitted by every object with a temperature that goes beyond absolute zero. This radiation is referred to as infrared as a majority of the radiation falls within the region above the visible red light in the electromagnetic spectrum. Radiation energy is used in determining the temperature of the body being measured. This heat energy is received by a detecting device and transformed into electric signals. The pyrometric cones are ceramic materials, which are bent through a narrow temperature range and used to determine not only when firing is completed but are used to calibrate the electronic pyrometric device. It is used to quantify the amount of heat delivered by the kiln. They are composed of the recipe of ceramic materials and designed to melt and bend through a target temperature. The popular cones in ceramic are Orton cones and Herman Sager cones. They both studied the melt dynamics of oxide compounds to invent the first cone.

Figure 7: A digital pyrometer

Figure 8: Seger cones before use

Summary

The application-based classification of ceramics can be summarized as advanced ceramics (structural and functional ceramics) and also traditional ceramics. Traditional ceramics include whiteware, cement, abrasives, refractories, brick tiles and structural clay products. Functional ceramics covers electronic substrate, package ceramics, capacitors, piezo electronic ceramics, magnetic ceramics, optical ceramics and conductive ceramics, and structural ceramics (Bio-ceramics, ceramic used in automobile industries, nuclear ceramics and wear resistance ceramics). For glass, it can be classified into the well-known glass (heat resistance glass dish, temperature glass, glass bath tub). Specialised glass products such as laminated glass are widely used for bulletproof, burglar proof, showcase, counter, aquarium, skylight, and long corridor.

References

Alan, G. K. (2005). Ceramic Technology and Processing. Standard Publishers Distributor Delhi, India.

Cardew, H. A. (1969). Pioneer Pottery. Longman, London.

Coll, M. and Robert, S. (2000). Wood-fired Ceramics: Contemporary Practices. A&C Black, London.

David, J. (2007). Firing: Philosophies with Contemporary Ceramic Practice. The Crowood Press

Ltd Ramsbury.

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CHAPTER 30

Introduction to Digital Art and Design

By

AJIBADE Babson

Overview

Digital art started from the early 1960s when John Whitney, a pioneer computer graphicist, first developed computer-generated art. In 1963 Ivan Sutherland invented the first computer-graphics interface called *Sketchpad*. These two events marked the true beginning of digital arts. But the term “digital arts” was first used in the early 1980s when Harold Cohen made paintings with his software called AARON. Digital art simply means any work of art that is produced using digital tools. Therefore, a digital artist is one that produces art using the computer and software as primary tools. Digital art comprises of 2D and 3D computer graphics, and can be purposed for a video game, a CD-ROM, a projection, a website, or for printed/electronic display. While 2D computer graphics are produced from two-dimensional values like texts and digital images, 3D versions are employed for creating three-dimensional animated works such as characters in video games and animated movies. With contemporary global interactions increasingly being conducted over the Internet, artists can now use digital tools to produce, circulate, exhibit or sell their digital arts virtually. This course describes and explains digital arts, and provides an understanding of the tools used to produce them. Also, it is designed to acquaint students with the emerging opportunities for digital arts and how they can develop the competences to produce, circulate and sell their own digital products.

Objectives

At the end of this chapter, students should be able to:

1. define digital arts;
2. explain the global context for the emergence of digital arts;
3. state the types of digital arts;
4. state the meaning of Non-Fungible Tokens (NFTs);
5. explain how NFTs make money;
6. explain what digital artists do;
7. explain how to make digital art;
8. use software for digital arts;
9. use hardware for digital arts; and
10. explain how to sell digital arts.

Introduction

One of the main legacies of the Covid-19 pandemic is that it compelled a global shift from in-person contacts to the Internet, social media and virtual interactions in all walks of life. This shift to the virtual in business and social life had high impact on the creative industry generally, because it opened-up new markets for creatives to produce and sell various artistic products. With the pandemic over, the main opportunity that has evolved is that the new markets for creative works is easily reached through the internet and social media, eliminating the need to own physical shops or even sell physical art. Using digital tools, artists can now produce digital versions of their arts, and create wealth by selling their digitalised products in virtual shops using the internet and social media. By also being able to produce and sell digital, rather than only physical works, contemporary artists can generate streams of income, maximise profits and extend their client base. Therefore, in order for the contemporary students of art and design to function and be relevant in the industry today, it is most important to learn the techniques for producing and marketing digital arts of all types.

What is digital art?

The fact that we have works of art representing all recorded civilisations shows art is a constant in human societies and it is only the mediums of expression and means of circulation that change with time. While it was not possible for the artists of cave paintings to transmit their creation from one location to the other, virtually all paintings produced from the Medieval times to the present (no matter the style) can be moved physically from one place to another, because of the type of surface they painted on. So, the main differences between the prehistoric and other paintings that followed were the medium used and the type of ground (moveable or none-moveable) they painted on (Clottes, 2022). However, all the art produced during both the prehistoric and historic times are “traditional” in the sense that they all used pigmented materials and binders on actual, tangible surfaces. This is where digital arts differ completely from traditional arts. The main difference between traditional and digital art is that one uses actual tools like brushes, pallet and material pigment with binder on actual surfaces, and the other relies absolutely on technology, manipulated by software and digital versions of traditional painting tools. To put it simply, digital art is any art produced with the help of technology, while traditional art is made without the use of technology (Tate, 2023). Table 1 shows some typical differences between traditional and digital art tools and processes. Looking critically at the lists on both sides of the table, one can notice that digital art uses digital versions of the same traditional art tools and processes.

Table 1: Differences between Tools and Processes of Traditional and Digital Arts

S/N	Traditional Art Tools	Digital Art Tools
1	Actual studio space with hardware	Digital studio in PC or handheld with software
2	Actual painting ground	Digital painting ground in the application
3	Actual brushes	Digital brushes in the application

4	Actual pallets	Digital pallets in the application
5	Material colour pigments	Digital colours in the application
6	Ground size is determined before work	Output size can be changed at any time
7	Ground type is determined before work	Output surface can be changed at any time
8	Circulated physically	Circulated virtually
9	Buyer is collecting a tangible art	Buyer is collecting a digital art
10	Displayed by mounting	Displayed by projection, digital display or printed and mounted
11	Limited production because each copy is produced originally	Unlimited production because each copy is just a digital reproduction

Digital art was first used in the early 1980s when the pioneer digital artist, Harold Cohen, used a paint program called AARON to make paintings. Developed between 1972 and the 2010s, AARON was continually fine-tuned by Cohen as technological developments became more available. AARON was able to draw and make stylized and still life paintings, including portraits of people on its own, without human inputs (Anderson, 2001). From initially enabling a robot to make big paintings on sheets of paper, advancements in technology has made digital art to become computer generated and can be scanned or drawn using a mouse or stylus on any handheld. From the 1990s, advances in digital technology also made it possible for artists to download and manipulate video images from video cameras in computers. With this, artists' creative freedoms expanded, because they are able to edit moving images and create various visual collages. Further developments have made it possible for artists to create interactive digital arts that give audiences some control over the image output they will see (Tate, 2023).

Types of digital arts

Digital arts include creative work produced with digital tools, such as digital painting, matte painting, Computer Generate Images (CGI), and so much more. Works of art are termed "digital" when they are created in the semblance of regular arts, but employing computer software and digitally outputting it. Such digital arts might then be two-dimensional or three-dimensional images. Also, digital art does not have to be printed on a surface because it can also be projected or made for just viewing on the screen of a computer, smartphone, tablet and other handhelds (Waelder, 2015). In whatever style digital arts are produced or displayed, they are not less varied in colour and rich in details than analogue or traditional art (Thomson-Jones and Moser 2022). Whereas digital arts are a recent development, they have already become parts of a massive industry where lots of different types of arts and artists operate (Cant, 2020). While the main types of digital arts are explained below, the list is not exhaustive, because there are specializations and regular instances of combinations in actual productions. Artists, for example, can do a digital painting as background image for a 3d sculpting.

Digital photography is a process that captures images using an electronic device called digital camera. It employs electronic digital sensors rather than film to translate light into visual images. In digital photographs, the image is formed and stored as little bits of data.

Digital painting is an art form in which artists use their stylus like a brush or pencil to produce illustrations, drawings and paintings in a software program using a tablet or computer as a digital canvas. Being generally faster and more cost effective than traditional painting, digital painting is the ideal medium for contemporary entertainment industries such as publishing, advertising, video games and film.

Digital installation is an interactive art form that is often large-scale, using projections and/or real-time video capture to enhance immersive environments for audiences.

2-D computer graphics refers to computer-based generation and manipulation of two-dimensional digital images, texts and geometric models. The 2-D parameter uses only two coordinates, X and Y, making it easier than 3-D.

3-D computer graphics, often called CGI, 3D-CGI or three-dimensional computer graphics, creates digital images using three-dimensional representations of geometric data in the computer. The 3D parameter has an extra coordinate "Z" (3^{rd} dimension), making it more complex than 2D. The application of 3D graphics techniques is fundamental to the entertainment and computer-aided design industries.

Pixel art is a form of digital art created using graphical software that builds images with only pixels. Pixels are like tiny squares, and pixel art has the same look as mosaics. When one enlarges a pixel art, the pixels are also enlarged and sort of distort the clarity of the image.

Photo painting is a form of digital art in which photographs are converted into digital paintings in the semblance of any style, texture or effect the artist chooses. Several free and paid software are available for virtually anyone to create astonishing effects even on handhelds like cell phones.

Digital collage is similar to paper collages, but created by layering virtual texts and images from various sources together into a new piece of art.

Vector graphics are based on design elements made possible by sequences of mathematical instructions that enable creatives to create high-quality artworks that can maintain quality no matter the size they are scaled (CorelDRAW®, 2023). Common vector file types are CDR, PDF, SVG, and AI. While pixel art will reduce in sharpness when enlarged, vector arts will retain sharpness no matter how large they are scaled.

Raster art is composed of millions of small dots of colour called pixels, such as the pictures one takes on a smart phone. Unlike vectors that retain quality with scales, the pixels in raster arts get bigger and more pronounced the bigger one scales the image. Common raster file types are JPG, GIF, TIF and PNG.

Data moshing is the art of creating visual or audio effects in media files by adjusting the data. In so doing, when the file is played-back, the effect is experienced.

Dynamic painting is the art created wholly or partially by using autonomous, non-human systems that can independently produce artistic visualisations.

Cinemograph is a combination of a still image and a video, where most of the scene is stationary, and only a section moves on a continuous loop.

Figure 1: Traditional painting pallet, brushes and colours

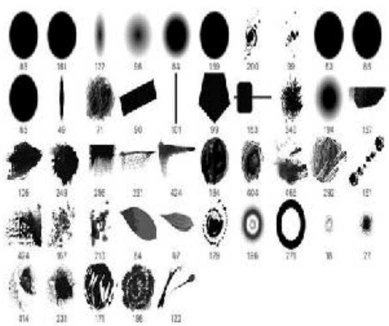


Figure 2: Digital arts brushes used with digital colours.

Software and hardware for digital arts

While traditional artists use various hardware and physical tools, digital artists use software to create their arts in a computer or other handhelds. The main challenge in choosing digital art software is that there are so many brands to choose from, making it overwhelming. Whether for beginners or professional digital artists, the main issue is knowing which is the most versatile and suitable digital software for their intended business (Cass, 2023a). For digital art, the primary considerations are budget,one's style of art and the specs of the computer or graphic tablet. For laptop computers and tablets, some very good choices available in the market are shown in table 2. Also, whether one will be working on paintings, logos and illustrations, there are several applications that will work for any type of digital art. Some of the best and more popularly used digital art software are listed in Table 3. Some, like Krita©, GIMP©, Clip Studio Paint Pro© and MediBang Paint Pro© are free software that can be downloaded on the internet. But most software is paid. Any of the digital art software is good and each digital artist selects what can work for creating digital artworks and graphic designs, using layering tools, various brushes and several paint tools, textures and patterns that make limitless visual aesthetics possible. But some software like Corel Painter 2022© have outstanding accuracy for capturing different media, and is just the right application for experienced traditional artists that want to shift to digital art (Cass, 2023b). To start as a digital artist, it is therefore the best to do a market survey and an online search to find what hardware or software will fit one's budget and still perform the digital artistic output needed.

Table 2: Current Good Laptops and Drawing Tablets for Digital Art and Artists

S/N	Laptop	Attributes
1	Apple MacBook Pro	The best laptop for digital art overall — 16"
2	Microsoft Surface Book 3	The most powerful digital art laptop — 15"
3	Dell XPS 15	The best all-round digital art laptop — 15"
4	ASUS ZenBook Pro Duo UX581	Best laptop with dual screen – 15.6"
5	HP Envy X360	The best digital art laptop for performance — 15.6"
6	Acer Spin	The best laptop with an impressive screen- 11.6"
7	Apple Macbook Air	The best laptop for digital art for battery life — 13.3"
8	Lenovo IdeaPad Duet Chromebook	The best budget-friendly laptop -10.1"
9	Lenovo Flex 5 Touchscreen	The best 2-in-1 convertible digital art laptop — 15.6"
10	Microsoft Surface Go	The most portable digital art laptop — 10"
11	Microsoft Surface Laptop 4	The best big-screen laptop for digital art — 13.5"/15"
	Tablets	**Attributes**
12	Wacom Cintiq 16 Drawing Tablet	The best drawing tablet with screen overall
13	GAOMON PD1161	The best budget drawing tablet with screen
14	Huion KAMVAS GT-191V2	The best value drawing tablet with screen
15	XP-Pen Artist 12	The best portable drawing tablet with screen
16	XP-PEN Artist 15.6 Pro	The best mid-tier drawing tablet with screen
17	Huion Kamvas Pro 13	The best customizable drawing tablet with screen
18	Huion Kamvas Pro 16	The best large drawing tablet with screen
19	XP Pen Artist 13.3 Pro	The best entry-level drawing tablet with screen
20	Wacom Cintiq Pro 24	The best high-quality drawing tablet with screen
21	Huion KAMVAS Pro 12	The best lightweight drawing tablet with screen
22	Apple iPad Air	Best Value Apple tablet

23	iPad Pro 12.9-inch	The best drawing tablet for professionals
24	Microsoft Surface Pro 8	The best tablet with detachable keyboard

Source: Adapted from Cass (2023a and 2023b).

Table 3: Popular Digital Art Software		
S/N	**Software**	**Attributes**
1	Adobe Photoshop©	The best digital art software overall
2	Procreate©	The best digital illustration software for iPads and iPhones
3	Corel Painter 2022©	A great software for capturing different art mediums digitally
4	Adobe Fresco©	A digital art program for iOS and Windows
5	Adobe Illustrator©	The best software for illustrations and vectors
6	Affinity Photo©	One of the best affordable digital art software
7	Rebelle 4©	A great software for replicating painting techniques
8	Krita©	The best free software to use with drawing pads
9	CorelDRAW©	The affordable Photoshop alternative for vectors
10	GIMP©	The best free Photoshop alternative
11	Clip Studio Paint Pro©	the best affordable software for concept art and illustrations
12	MediBang Paint Pro©	A great free software for digital painting and manga
13	Paintstorm Studio©	A multi-platform digital art software
14	IbisPaint©	A free art software for Android and IOS tablets
15	ArtRage©	Best digital art software supporting both mobile and desktop

Source: Adapted from Cass (2023a and 2023b).

Difference between traditional and digital painting

Whereas we have mentioned various types of digital arts above, it is important to note that most of these are highly specialised. Besides, no matter the type of digital art one wishes to do, it is virtually the same tools that are used. For a beginning digital artist, digital painting is the most obvious and easy entrepreneurial entry point. While most other digital arts are produced to more sophisticated order, it is easy to produce and market digital paintings, based entirely on the artist's personal creative directions. From this perspective, our discussion of digital arts in this chapter is narrowed to the example of digital painting. While table 1 shows some simple differences between traditional paintings and digital ones, figures 1 and 2 give an idea of the differences between traditional painting brushes and digital ones. In traditional painting, one gets a physical ground on which to paint, and then makes sketches and do the painting, using the set of brushes and the choice of paint – water colour, gouache, acrylic or oil colour – in the physical palette. In terms of the process, digital painting is quite similar to traditional painting, using brushes and colours. This time, however, there are no physical paints, grounds or brushes to be used, because everything employed to create the art is in digital form, within the application software one is working with in the computer or graphic tablet. A limited set of brushes, for example, is all that a painter needs for traditional painting. In digital painting, the artist has access to a limitless set of specialised and convenient digital brushes that can be used for virtually anything to be drawn or painted. As an example of the amazing range of tools available to the digital artist, Photoshop© has a collection of over 1000 packs of brushes, from which an artist can select for use in creating stunning digital paintings (Photoshop Brushes, 2023). Also, while in traditional painting the artist holds the brushes in the hands, in digital painting the artist picks and applies any particular brush, colour or pattern of choice with a mouse or a stylus. In Figure 3 bellow, the artist is painting a view of Ire-Akari in Ibadan. Notice that it is a stylus being used to do the painting, after selecting the colour from the palette on the right side. In traditional painting a pallet is the flat surface upon which colours are placed and mixed, as can be seen in Figure 1. In digital painting, a colour palette is a harmonious visualisation of colour swatches that are usually employed for paintings that involve the use of colour combinations, such as interior design, graphic design, paintings, etc (Meijers, 2023). In producing the painting in Figure 3, for instance, the artist had to use a palette to achieve the colour mixes, combinations, patterns and textures that we can see in the painting.

Advantages of digital painting over traditional painting

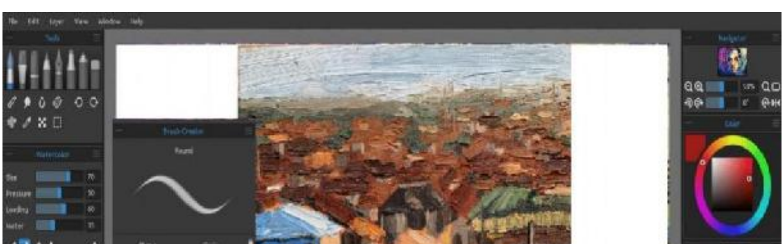
There are clear advantages that digital painting has over traditional painting, including the following:

Convenience: Unlike traditional painting that needs a setup of various hardware in actual space, digital painting is very convenient because one can work virtually on any project at any time and from any location on a tablet or computer.

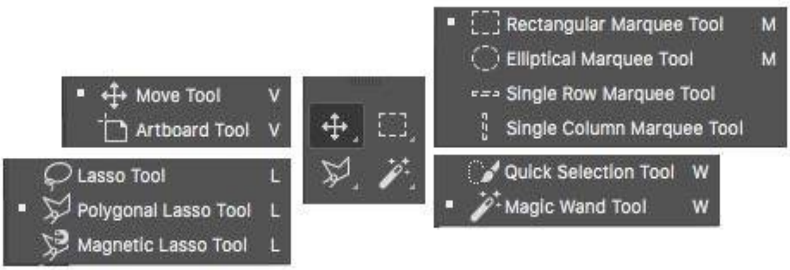
Easy duplications: While duplicating traditional paintings is as laborious as the original, one can create different versions of the same digital painting by adding or hiding components very easily and quickly.

Easy cooperation: Unlike the logistics needed to share traditional paintings, digital paintings are easier to share over the internet and social media with other people or collaborate and get feedbacks.

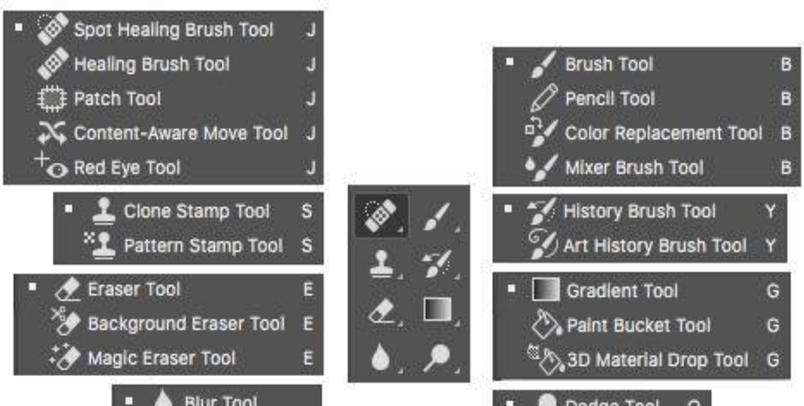
Higher efficiency: Unlike traditional painting that needs time-taking processes to make corrections, digital paintings require one to only undo to revert back to preferred earlier version, without starting from the scratch.



Selection and Crop Tools in Photoshop©



Painting and Retouching Tools in Photoshop©



Understand

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distinctive assets like a work of art, media or digital content. One can think of an NFT as an irrevocable digital certificate of ownership and legitimacy for any physical or digital asset. The unique digital identifier of an NFT cannot be copied, switched or subdivided. Certifying ownership and authenticity, NFTs are recorded in a blockchain and can be transferred, sold and traded by the owner. A blockchain is a distributed public ledger that records transactions. Anyone can create NFTs with very little coding skills. Typically, NFTs contain references to digital files like paintings, videos, photos, and audios. Since NFTs are uniquely identifiable assets, they are different from cryptocurrencies that are fungible. The act of creating NFTs from digital objects is called "minting". In summary NFTs are digital collector's items. Therefore, rather than getting an actual oil on canvas painting to display on the wall, a buyer gets only a digital file instead (Conti, 2023). Except stated as parts of contractual agreements, NFTs do not grant copyright or intellectual property rights to the buyer. For example, if someone sells an NFT of their art work, the buyer does not necessarily get copyright to that work, and the seller is able to retain the rights and create more NFT copies of the same piece of art. This is where the opportunities are, for the digital artist. As a digital artist, one can sell NFTs of works easily, without owning a gallery, and without moving physical works of art. One's entire studio is inside the Tablet or PC, just as the virtual "market" is accessed through one's same device connected to the internet.

Table 4: Some Sites to Sell Digital Arts

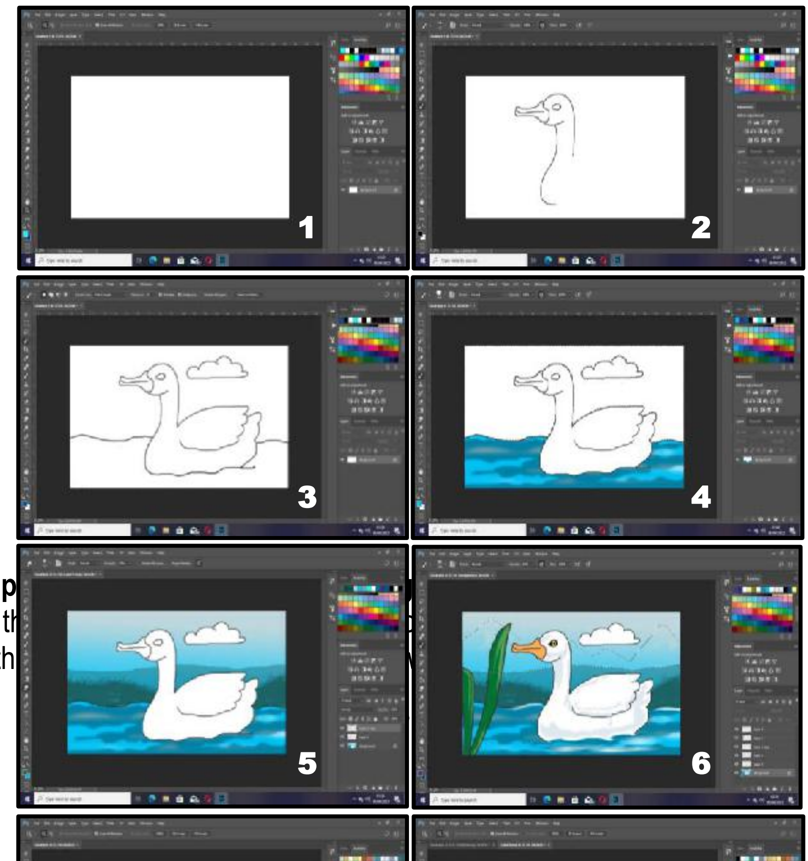
1	Design Cuts©	https://www.designcuts.com
2	Etsy©	https://www.etsy.com
3	Voice©	https://www.voice.com
4	Amazon©	https://www.amazon.com
5	Shopify©	https://www.shopify.com
6	TurningArt©	https://www.turningart.com

Selling digital arts and designs

Digital arts and designs are sold in specialised websites like those listed in table 4. However, whichever digital art selling site one chooses, there are three key processes to start: setting up a profile, uploading the art and building an exhibit (Stefyn, 2022). The first step will always be to create high-quality digital files of the artwork with any of the software packages in table 3. Then one needs to decide between online selling of digital downloads or shipping of physical arts to customers. While digital products include commissioned online art sold digitally, physical art are arts printable as posters, apparel designs, stickers and embroidery graphic. Once a selling platform is chosen, one needs establish a payment gateway linked directly to the store page. For payment gateways, one can choose between online payment gateway, third-party marketplace, email invoicing, mobile payment apps, electronic bank transfers, and crypto currency payments. Digital art products displayed on one's store page can further be promoted to target buyers using social media and other marketing tools. According to Lazda (2022) the era of e-commerce has made selling digital arts so much easier and more profitable. And, especially too, lockdowns and social distancing regulations of the Covid-19 pandemic compelled a remarkable shift from in-person to virtual business interactions using the internet and social media tools. Like all other businesses, art buyers and artists also moved online, making digital art production and consumption even more popular. And, as a digital artist, one can sell digital arts online on various websites and to several buyers without meeting them, owning a studio or even losing the copyright over one's intellectual property.

Making a digital painting

Figure 5 shows the process of making a simple digital painting of a white duck on water using Photoshop. The tools shown in figure 4 were the ones used in this exercise. Similar tools are available for use in all other digital painting software. The eight images show the stage by stage process of painting, starting from the blank page to the sketch and the finished painting. One can also see the colour pallet to the right of the workspace, and other tools to the left. The great thing about digital painting is that one can achieve every imaginable effect and it is much easier to correct mistakes, add details or even make any kind of changes without starting afresh. At the end of it, the painting is ready to be displayed for sale to a digital buyer. As can be seen, in contrast to the application of premixed paints to stretched paper or primed canvas (Ajibade, 2021) that would have been the case in traditional painting, in this digital painting of the goose, everything used was digital, inside the application software. This is a significant difference between traditional and digital panting.



Eight step

1. Set up th

2. Using th

3. Paint the surrounding water with applicable brush sizes;
4. With the gradient fill tool, fill the sky with a blue gradient, after selecting with the magic wand tool;
5. Create the background mountain with the brush tool;
6. Adjust the colours as desired with the colour adjustment tools;
7. Fine-tune the colours as desired; and
8. The filter tools from the filter menu help fine-tune the image further.

Another significant difference between traditional and digital painting is that the painting can be easily and quickly edited – cropped, recolored, resized, retextured, made transparent, given soft edge, etc with the software (Ajibade and Elemi, 2014). There are limitless possibilities in digital painting. One can use the steps above to make digital paintings. As one continues to practice and gather more experiences, one learns to use multiple software, work faster and create complex painting effects. There are no fast routes to digital painting. Continuous practice brings gradual improvements and better results.

Summary

Digital art refers to arts created with the help of technology, while traditional art is made without the use of technology. The combination of technological advances in hardware and software, including the shift to the virtual in business and social life presents limitless opportunities for creatives to produce and sell various forms of digital arts. The primary tools for digital arts are a computer, tablet and software. With these, a digital artist can literally take all studio and production facilities everywhere. Even though digital arts are made with technology, the digital tools used in creating them are in the semblance of traditional artistic tools. But digital arts have advantages over traditional forms. They are produced at the artist's convenience, they are easy to replicate, easily shared and with high efficiency in all processes. Unlike traditional arts that are sold physically, digital arts are sold digitally via the internet. There are many websites for selling digital arts. To sell digital art, one needs to mint Non-Fungible Tokens (NFTs) and sell to collectors virtually. To become a digital artist, one needs get a tablet, install and practice any of the art software. Like traditional art, a digital artist gets better only with practice and the building of portfolio. As a digital artist, one can make art without owning a studio. One can also sell digital arts online on various websites to several buyers without even meeting them. Owing to the increasing opportunities in the market for digital art, it has become important for contemporary artists to practice digital arts.

Exercise

1) State the meaning of digital art.
2) Explain the global context for digital arts and design.

3) State four types of digital arts.
4) State four software for digital art and design.
5) State two hardware for digital art.
6) Explain the difference between traditional and digital arts.
7) Explain the difference between raster art and vector art.
8) State the meaning of Non-Fungible Tokens (NFTs).
9) Explain the use of Non-Fungible Tokens (NFTs)
10) Explain how digital art is sold.
11) Use one digital art software to make a digital painting.

References

Ajibade, B. (2021). “The Basics of Art and Visual Design”. Art, Design and Promotional Communication. Eds. Babson Ajibade and Efiong Omini. Calabar: University of Calabar Press. 8-27.

Ajibade, B and Elemi, N. (2014). “Photography and Photojournalism”. Creative and Media Arts: A Practical Sourcebook. Calabar and Lagos: Spindrel International. 97-112.

Anderson, M. (2001). “Aaron: Art From the Machine”. Wired. <https://www.wired.com/2001/05/aaron-art-from-the-machine/>. Accessed 30 March 2023.

Cant, C. (2020). “The Main Types of Digital Art and Artist”. Self Employed Artist. Online. <https://www.selfemployedartist.com/blog/types-of-digital-art>. Accessed 30 March 2023.

Cass, J. (2023a). “15 Best Software for Digital Artists in 2023”. JUST™ Creative. <https://justcreative.com/best-software-for-digital-artists>. Accessed 3 April 2023.

Cass, J. (2023b). “10+ Best Laptops for Digital Art & Artists in 2023 (Ultimate Guide)”. JUST™ Creative. <https://justcreative.com/best-laptops-for-digital-art>. Accessed 3 April 2023.

Clottes, J. (2022). "Cave Art". Encyclopedia Britannica. URL = <https://www.britannica.com/art/cave-art>. Accessed 29 March 2023.

Conti, R. (2023). “What Is An NFT? Non-Fungible Tokens Explained”. Forbes Advisor. <https://www.forbes.com/advisor/investing/cryptocurrency/nft-non-fungible-token/>.

CorelDRAW (2023). The Guide to Vector Design. <https://www.coreldraw.com/en/learn/guide-to-vector-design/what-is-vector-art/>.

Inamdar, S. (2021). “The Philosophy of Traditional Art vs. Digital Art”. PortraitFlip. URL = <https://www.portraitflip.com/blog/traditional-art-vs-digital-art/>.

Lazda, J. (2023). “How to Sell Digital Art Online in 2023”. Pintify <https://printify.com/blog/how-to-sell-digital-art/>.

Meijers, L. (2023). How to Create a Color Palette. Blog. <https://www.oleanderstudios.com/how-to-create-a-color-palette-for-your-painting-a-complete-guide/>. Accessed 3 April 2023.

Photoshop Brushes (2023). <https://myphotoshopbrushes.com/brushes/>. Accessed 3 April 2023.

Stefyn, N. (2022). “What is digital painting? Your guide to getting started”. CG Spectrum. URL = <https://www.cgspectrum.com/blog/what-is-digital-painting>.
Symes, C. (2023). Art in the Middle Ages and the Origin of Oil Painting. URL = <https://www.wondriumdaily.com/art-in-the-middle-ages-and-the-origin-of-oil-painting/>. Accessed 29 March 2023.
Tate (2023). Tate Digital Art. URL = <https://www.tate.org.uk/art/art-terms/d/digital-art>. Accessed 29 March 2023.
Thomson-Jones, K. and Moser, S. (2022). "The Philosophy of Digital Art". The Stanford Encyclopedia of Philosophy (Winter Edition). Edward N. Zalta and Uri Nodelman (eds.). URL = <https://plato.stanford.edu/archives/win2022/entries/digital-art/>.
Waelder, P. (2015). “Framing Digital Art”. ETC Media, 104: 58-61.

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CHAPTER 31

BASIC DRAWING: LIFE AND STILL LIFE

By

OCHIGBO Best

Overview

Drawing, like any other course of basic instruction, requires classification of certain fundamental areas of enquiry and a spur to creative talents to evolve constant inquisitiveness about the phenomenon of drawing as pictorial expression. Drawing is capable of almost limitless extension, personal variation and individual discoveries. As a matter of fact, changes and development have taken place since man began to scribble signs in the earth and walls of their dwellings till date. This necessitated revisions in modes of drawing in the training of visual artists. Drawing stems from a desire to create, and it should therefore be a tool towards an end, though it could be an end in itself. It is a process, a gate-way to create and preamble towards any artistic creativity (Ochigbo, 1996). Through drawing, technical skills in occupation such as Medicine, Architecture, Engineering, Agriculture and Surveying as well as all other fields of endeavour are perfected.

Drawing of objects and other miscellaneous matters require a closer observation. Interpretation therefore, becomes an important factor, hence ability to draw is put to test. For a good interpretation, the subject must be studied with careful observation and thought before proceeding to draw (Ochigbo, 1996). Accordingly, Idiong (1996) asserts that the brain receives all available information and identifies, analyses, classifies and interprets the most important one before a response can be made through representation. Perception is therefore visual thinking and a crucial instrument for drawing. Drawing is a cognitive and psychomotive activity that an artist is required to bring to his knowledge, experience, observation and thoughts to reflect the artist true nature in what constitutes his mental self-improvement.

Objective

At the end of this chapter, students should be able to:

1. attain mastery of basic drawing skills;
2. create drawing that satisfies universal criteria judgment through painstaking practice;
3. exercise the artistic volition as a lot depends on the individual prowess;
4. draw to meet specific needs such as architecture, pleasure, medicine, aesthetics, agriculture and engineering;
5. know drawing intellectually and bring about it creatively; and
6. creatively propel the wheel for the development of drawing towards artistic excellence.

Drawing

Drawing is fundamental to all creative arts. It goes beyond the obvious fact to the pertinent, to characterization, to the emotional and dramatic, to selection and taste, to simplification and subordination, and accentuation. It simply implies how and what you draw. Drawing is the immediate expression of seeing, thinking and feeling. It is a tool for investigating ideas and recording knowledge as well as a reflector of experience (Simblet, 2009). Through drawing we can mirror the world through our perception of things around us. Drawing helps the artist to discover his vision and dexterity to give verve to the fluctuations of the universe. We cannot discuss drawing without mention of the act. Drawing begins with a dot on the surface and as we drag the medium, lines are created to define shapes of objects. It is the most important foundation of all creative processes. Drawing as a creative activity is dependent upon the expressive and constructive use of the specific phenomena of vision in making aesthetic decisions and that personal preferences form the inescapable bases of perception in expression (Sausmarez, 1974). The reliance on drawing as a means of orchestrating creative desires becomes pertinent in translating ideas into reality. This is a basic need, hence the concern with how drawing can be used to communicate ideas which enable artists to make realistic pictures of solid objects born on the artist drawing boards (Ochigbo, 2004). The various aspects, materials, rules, elements, types and correlates of drawing are developed in the following sections with simple practical guides. Drawing can be summed up as a visual artform that can stand as an entity or a means to actualizing other aspects of visual art and design like: Ceramics, Graphics, Painting, Sculpture and Textiles in which an artist uses a medium to make a mark on two-dimensional surfaces.

Types of drawing

Drawing covers a vast area of study. Some aspects are here discussed to broaden our horizon of the concept. For the artist, subjects include figure and animal (Life drawing) which share similarity in terms of proportion, anatomy and physiognomy that can be solved in the same ways based on analytical tools. Here, specific knowledge of anatomy can be useful based on mathematical assumptions. Categorically, drawing can be classified into realistic, symbolic and expressive modes. Drawing encapsulates other categories like still life, landscape and object, compositions, and technical drawings. Other aspects of drawing include scientific drawings of science equipment and diagrams. Drawings for specific areas of knowledge abound. However, the focus here is on the fundamentals of life-drawing and still Life drawing.

Life drawing

Life drawing refers to the act of producing a drawing of the human figure or animal figure in any of its various shapes and posture, using any choice of medium. This is based on careful observation of a live model through muscle and eye co-ordination. There are just about two main techniques of life drawings. These are formulaic techniques which allows the artist to draw figures from imagination using thumb nails and interlocking parts by locating some anatomical landmarks. This technique obliterates all refinements of observation. The other technique is the observational approach which recognizes focused studying of the subject. Observation and thought are essential for the production of a near accurate life drawing. Thought are well coordinated with the muscles of the fingers, eyes and mind, superficial drawings would be avoided. All it requires is to take concerted effort to look at the model and be fluid with the medium. Avoid rigidity in handling of the medium. Life drawing exercises are reflected in the following plates:

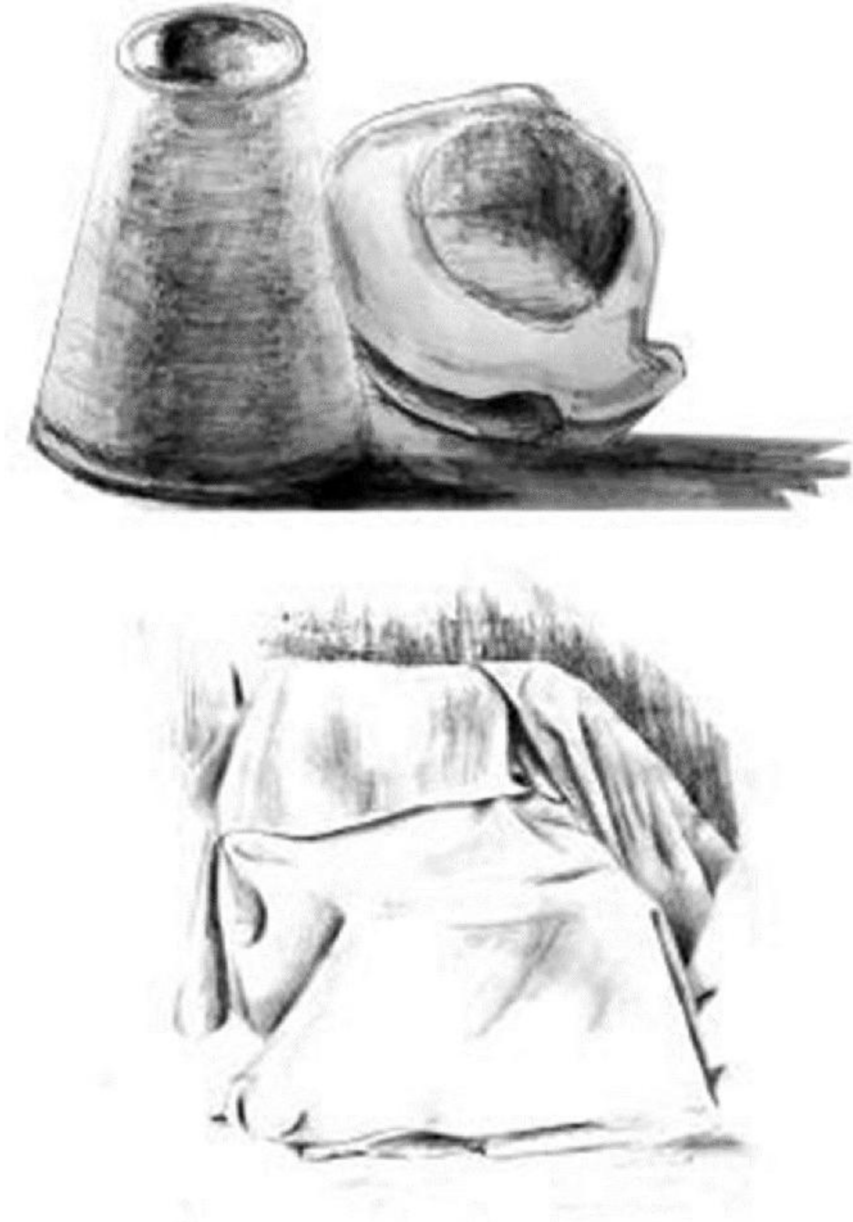
Source Ochigbo (2004)

Still life drawing

"Still life" as the name implies refers to inanimate objects from nature or man-made. Anything that cannot reproduce itself is still-life. They include plants and fruits that have been detached from their sources of life, carcasses, stone, rock, table, chair, flower vases, utensils and every other thing that are immobile. Still life may be classified into different categories like; Flowers and foliage; fruits and accessories; mechanical objects; wooden objects and ceramic wares. These objects are often displayed to be drawn by learners to demonstrate the technical virtuosity and observational, as well as the ability of the artist. Still life drawing is drawing of non-living objects, arranged in a definite pattern to create a visual effect. Still life drawing is essentially to direct the viewer's eye through the drawing to lead the viewer to what the artist thinks is important. This is the core of representation through drawing. Still life drawing is taught specifically to build skills like hand-muscle-eye coordination, observing every minute detail. There are basic rules of skill life drawing. The objects in still life can either be arranged symmetrically or asymmetrically to create either of these two types of balance. Light and lighting is key to arranging the objects to have a source of light. With a defined source of lighting, it becomes easier to give solidity to the form on a two-dimensional surface. A directional light is capable of revealing a strong solid form than an ambient indirect lighting. Our main objective of still life drawing rests solely on introducing students to the concept of parallel line shading, as related objects; and repetition of shape within a composition; introduce the students to classic method of drawing, with varied media; help students recognize that they are part of an existing tradition in art by using the methods they have been exposed to, especially as seen in the works of Jerry Buhari, Akaninyene Sampson, Best Ochigbo, Sunday Ekwere and others. For the purposes of emphasis, any inanimate object can be used in still life drawing. It includes a whole range of objects like fruits, dead animals and birds, cars, bicycles, vegetables, table wares, earthen wares, scrap- metals and wood, fabrics and household utencils remain the classic choices that are exploited till date. It is noteworthy to state that people and landscapes are not subjects of still life drawing.

How to create a still life drawing

Still life drawing is literally creating a two-dimensional image of inanimate objects which can be said to be limitless. It is created by placing objects in a compositional setting that utilizes available light and contrasts in shapes in the best eye-catching manner. It begins with identifying and sketching of the basic shapes of the object first, then the continuous filling in of details until the desired outcome is achieved. It is important to point out the prerequisite conditions for still life drawing. The drawing is accomplished by arranging specific objects on a table at an eye-level setting. Lighting is to be considered as a constant to provide the depth of contrast in defining the shapes of the objects. Different substances and media are utilized to create still life drawings. The most common mediums used in still life drawings include; graphite pencils, Pen and ink; Charcoal; Conte; Pastels; and Ink wash. Some practical still life drawing images are included to further elaborate the concept.



Source: Ochigbo (2004)

Ochigbo (2004)

Drawing medium and influences

For centuries, Charcoal, Conte', Coloured and Graphite Pencils, Chalk, Ink and wash remained the dominant mediums in used for sketches and for detailed studies of objects. Some of these mediums impose limitations on the artist and his drawing. Limitations such as the inability of charcoal to produce the richness of pencil, same as conte'. Some mediums are softer than others and therefore are not suitable or quite suitable for certain effects, depending on the intent (Ochigbo, 1996). Hence, it is not uncommon to find artists who are prone to mediums they can handle very well, and thus tend to respect such a medium and have let it influence their execution. It is therefore expected that students should be guided to utilize the medium they find easy to manipulate in their quest for creative expression.

Drawing materials

Drawing materials encompasses all the instruments and their uses. Drawing instruments are the necessary materials and tools needed and used to create visual interpretation of objects in both life and still-life drawing. Some of the drawing instruments include but not limited to Pencil (a basic and fundamental tool); Protractor (Used to measure angles), Compass (used to draw arcs and circles), Drawing Paper (One of the fundamental tools to draw on. Without the paper, drawing won't be achievable), Eraser (used to clean up any undesired areas arising from unintended mistakes while drawing on paper), Ruler (used to make straight lines), and Drawing board (used to place the support or drawing paper). These instruments are basic tools especially at the foundation for basic drawing, before mastery can be attained. Free hand drawing skills come with age and practice.

Ochigbo (2004)

Design elements in drawing

The design elements used by artists in drawing are; line, colour, perspective, texture, form, space, value, contrast, and light. These elements are the means an artist uses to organize a work of art based on the principles of art: Balance, emphasis, movement, proportion, rhythm, unity and variety. The elements and principles of art and design are the foundation of language we use to talk about art. The elements of art are the visual tools that the artist uses to create a composition (Marder, 2019). The principle of art represents how an artist uses the elements of art to create an effect and help convey the artist's intention. The artist decides what principles of art to utilize in a drawing. It is not expedient that an artist uses all of the principles in one drawing. One principle of art can influence the other for effect and impact. It is a known fact that a successful drawing is unified', while having some variety created by areas of contrast and emphasis; is visually balanced, creating a sense that the drawing feels stable and right. In other words, a good combination of the elements in drawing results in a good drawing, while a haphazard combination results in a bad drawing, causing a feeling of discomfort in the viewer. The need to emphasize this condition in a drawing class becomes pertinent.

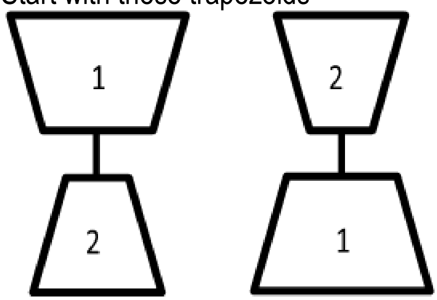
Cropping and composition in drawing

The aspects of cropping and composition as it applies to life and still-life drawing is key to a successful drawing. It has been observed over the years that most students start either life drawing or still-life drawing in the middle of the support (drawing paper). This happens because they are unaware of the relationship between what they draw and the surface they draw on. They get carried away with focus on the shape and detail of their subject, without recourse to the relationship between the subject and not the organization of the subject on paper, hence, the subject is allowed to float anywhere they think fit to locate the subject on the paper. It is most suitable to shift the figure slightly away from the middle of the surface. Before you begin to draw, think carefully about where to place the subject, but definitely not in the middle of the surface. This is so because the meaning of a drawing changes by its relationship to the space it occupies. Equally important in drawing composition is the space between objects. This creates room for shadows that define the penetration of light on the subject. A 'viewfinder' is recommended. A viewfinder is a card with a small rectangle cut off it. A student is expected to use it by closing one eye to see through the hole, by moving the card to explore different views. The student is expected to stick to the view that is most interesting and decide what to draw. With mastery, the viewfinder becomes needless.

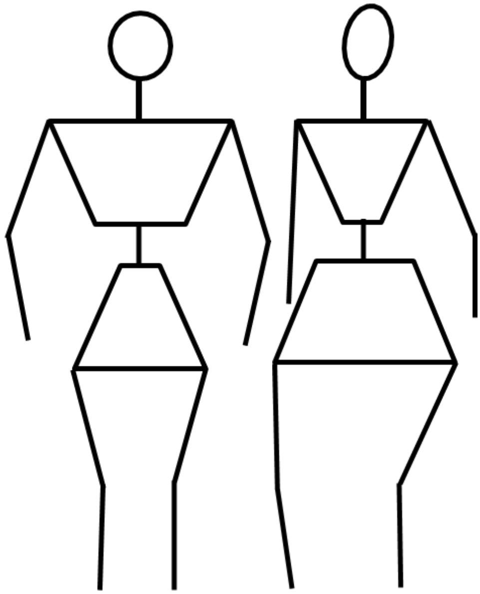
Thumbnail sketch/figurate

Thumbnail sketch or figurate is used by the artist to make-quick sketch without going into the details. This gives a preview of what the work will look like before the actual work begins. It is a small quick drawing (simplified) to help plan out a drawing.

Start with these trapezoids



Male **Female**



Ochigbo (2004)

Summary

This chapter has presented a bird's eye-view knowledge of life-drawing and still-life drawing and some of the tools necessary for its navigation. In a nutshell, its objective is to help students gain and apply basic skills of drawing from life and still-life, based on application of tools, elements and principles of design, for effective and sustainable drawing lessons. The Chapter draws on lessons learned over the years in studio practice. While presenting general information on general drawing, the discussion focuses on the specifics of life and still-life drawing which serves as foundation for drawing motivation. The weaknesses and constraints have been highlighted. The chapter goes on to present a series of life and still-life drawings with conscious guide on ways to achieving their meaningful impact on the viewers. The chapter concludes with possible means to achieving effective skills in drawing from constant practice. There is no feeling like adding levels of skill with each passing day.

Exercise

1. Basic drawing exercises are suitable for beginners, hence these exercises are listed;
2. Draw a series of vertical and horizontal lines on paper.
3. Draw all the basic shapes on your sketch pad. These are the building block for all forms – cones,
   cylinder, sphere, pyramids, circles, triangles, cubes, arcs, etc.
4. Make gestural thumbnails of human figures and still-life.
5. Draw and detail any of the thumbnails from human figure.

6. Draw the set of objects based on the composition on display by paying attention to form, space,
lighting and shadow.
7. Create more figure drawings and still-life objects in your sketch book as a routine exercise.

References

Idiong, S.O. (1996). Awareness through Perception in Eka D. (Ed) Journal of Humanities, Vol.5. Faculty of Arts, University of Uyo.

Mardel, L. (2019). The 7 Principles of Art and Design. Principles of Art and Design. Thoughtco.com. Retrieved April 27, 2023.

Ochigbo, B. (1996). Towards Artisitic Excellence: Development of Creativity through drawing. Journal of Humanities, Vol. 4, Faculty of Arts, University of Uyo. Eka D. (Ed), Uyo.

Ochigbo B. (2004) Perspective drawing: A means to Verisimilitude and Technical Perfection. In, Ben

Ekanem (ed). Journal of Environmental Design. Faculty of Environmental Studies, University of Uyo. Vol. 1, No.2.

Sausmarez, M. de (1974). Basic design: the dynamics of visual form. Studio Vista: London. Van Nostrand Reinhold Company. New York.

Simblet, S. (2009). The Drawing Book. London. DK Publishing Ltd. (Dorling Kindersley); ed. Edition.

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CHAPTER 32
ART APPRECIATION

By

ENAMHE Bojor

Overview

This chapter is to assist students, art scholars and art lovers on various ways of looking, reading, talking and writing about the visual arts. It considers, issues in the way art is conceived and perceived. It provides insight in a generalized manner into understanding art, artists, their creations and language. Some artists create but hardly want to talk about their art. Some are in the university studying the course but have no background of the subject; it becomes very necessary for the course which is a core course in all art departments to be taken to the next level. To experience the fullness of humanity for and with the arts calls for learning in art. This provides a foundation to investigate ideas, sensory qualities, deep questions and individual perceptions through the use of materials, that is for studio-based art, or through the use of texts (emphasis on art appreciation, criticism or aesthetics), for discourse-based art. It is learning in art that creates avenue in appreciating the works of art. Art Appreciation offers knowledge in the visual arts to enhance learning experience, to understand art, the ideas encompass an overarching belief, that if students have the basic tools to visualize, explore, discover and understand artistic concepts, learning becomes enjoyable, meaningful and lasting. The use of texts in visual art may suggest avenues of looking and thinking about art objects. To respond to art, addresses art criticism, which most art scholars use instead of the word criticism which is often taken in a negative manner. In school art activities, exhibitions in galleries, auctions, art fairs or art festivals, people engage in talks related to artworks. It is through such discussions that meanings, understanding and cultural values are given to artworks. The storytelling aspect of the visual art and aesthetics which interrogates visual experiences creates interest in what is seen. This interest in artwork is often considered aesthetic in nature. Aesthetics is the branch of philosophy that concerns theories of art and beauty. Thinking, talking and writing about art is using philosophy called art criticism. Art criticism is defined as the activity of analyzing and discussing artworks. To achieve this core area of art appreciation requires observation, analysis and interpretation. According to Akpang (2020), text is particularly important because it is the perfect analytical and philosophical tool needed to interpret the complexity of art, its dynamism and innovative nature. This explains why much of the artworks on display today are accompanied by texts which employ literal interpretation of visual signs to interrogate philosophical inspirations, adopted methodologies and expressed ideologies. Against the above backdrop, Art Appreciation encourages understanding of the visual arts through the knowledge of the elements and principles of art and design as funded similarly by traditions, implicit in the society. For artworks represent happenings of every age and era. Visual artists are known to showcase cultural trends in form and content. The artistry about humanity, time and space and the memories are seen in the historicity of images and ideas created by artists. In the context of the historical period and cultural framework in which they are produced. Art appreciation enables and make easy the evaluation of artworks. The materials and techniques manipulated in a creative process needs interpretation. Because artists are involved in the creative process, then interpretation should be made easy. The roles of artists and the purposes of artworks becomes clearer in their visual surroundings. Art making involves the use of the elements and principles of art, as a teacher, I believe one has a better understanding of any art object, knowledge, the details and processes of its creation. Therefore, to meet the challenges of today's world, it behooves on art students to develop skills not just in creating or making art, but to write and respond to art in diverse situations. The question may be asked that, what is the big idea? All subjects have their vocabulary, the elements of art are fundamental to understanding the visual arts.

Objectives

At the end of this chapter, students should be able to:

1. define art, art appreciation and aesthetics;
2. discuss the importance of art appreciation to artists, art institutions and art patrons;
3. identify the purposes of art and roles of artists;
4. use the vocabulary of art;
5. illustrate 2-dimensional and 3-dimensional arts;
6. know some of the materials and processes involved in art making;
7. discuss the nature of art;
8. discuss art in historical and cultural context;
9. explain the various steps of art appreciation;
10. discuss the concepts of aesthetics and art criticism.

What is art?

Art is defined as Ars (Roman) which means "skill". Ugiomoh (2012), on the definition of art, noted that, the world accommodates such synonyms as ability, cleverness, dexterity etc. The work of art is an embodiment of values that manifest as form. Likewise, White (2011) stated that art is the product of a process. Whether conceptual, experimental, emotional, or formal, the process you develop yields the image you produce. The materials you choose, the methods of production, and the sources of images should all reflect the interests that command your attention. The process does not stop with each work completed but it is ongoing. The cumulative result of that process is a body of work. Falola (2013) stated that, art affirms a definition of art that inserts how Africans perceive and define art objects into its Western meaning. Among the people of Nigeria, as well as many other African groups, a work of art may not necessarily be characterized as an entity into itself but understood in relational terms to needs and context. To be sure, definitions are contested, even when there is some agreement that artworks should evoke some kind of emotional response, display a level of technical skill, and manifest creativity. Yeah, arts should meet the above criteria, in addition to age-old definition of art in relation to beauty, admiration and appropriateness. Africans believe that, artworks have objectives that are related to aspects of culture. Done with the hands, objects are unique, characterized in individuality, as seen in collective expressions. Art is defined by its nature which will be handled appropriately later on. The visual and performing arts make up the two branches of art. The visual art houses, paintings, drawings, sculpture, ceramics, graphics, textile and fashion design. Different art institutions have different names, whether Fine and Applied Arts or Visual Arts they share similar characteristics that deals with skills, expression, representation and form, structured in creative and analytical philosophies in the studio areas.

Connoisseur is someone who understands the details, technique, or principles of an art and is competent to act as a critical judge (Merriam Webster Dictionary). Curator is someone who selects, mount, arrange and promote artworks in an exhibition or museum. Exhibition is the public display of artworks in galleries, museums, art fairs or festivals.

What is art appreciation?

Art appreciation is a foundational course, which is taught at the formative stage of art education. It prepares and shapes students with basic knowledge in the visual arts. It is understanding the technical and analytical skills in the evaluation of the aesthetic and cultural values of works of art. The course provides parameters for objective and subjective perception of artworks. It involves the general language of art that is, the vocabulary of art; the elements and principles of art and design which is to be discussed in details below. The course is highly visual with implications for students to observe and think about artworks which can be successfully achieved by analyzing the formal structure of art objects.

The nature of art

Art scholars have variously explained the nature of art to include; form, representation and expression. Aniakor (2019) referred to art as “everything in art is a manifestation of something else that manifest something else and so forth, because there is no end to manifestation. He further explained that art is mysterious in the way in which all mysteries reveal and conceal at the same time. It is an investment to the nourishing power of artistic memory. In a lecture where I sat to enjoy Aniakor’s teaching in 2019 Art Appreciation class, he described art as, “a metaphor, a symbol, an icon, art is inventive, it is unique, imaginative, harmonious, homogenous, art is immortal, it is artistically real, art is a language of signs.” Kleinbaeur (1971) stated that art is an autonomous and aesthetic object, a symbol, a metaphor because that which stands for something else, that is, a symbol has become that which it symbolizes, what makes ‘art’, art is all about the nature of art. The roles of the artist firstly, the artist is the maker of art, the artist is a storyteller, a critic, a creative activist, a preserver of culture, a presenter of culture, a promoter of culture. Art serves spiritual, religious, economic, political and social purposes; art is history; art communicates, art entertains, art is used for commemoration, it transforms people’s consciousness, art provides information and direction.

Jegede (2013) reminded us that society is static as concerns the functions of artworks, the frontiers of creativity, and the fashion of ideas. Artwork is created by an artist set apart in private and public spaces to be admired. Traditional artworks even when admired were not in museums to be appreciated solely for their aesthetic value. Even when such objects (traditional) portrayed beauty, they had utilitarian functions for decorative purposes or symbols to represent gods and goddesses. Figure 1 shows the units of visual arts.

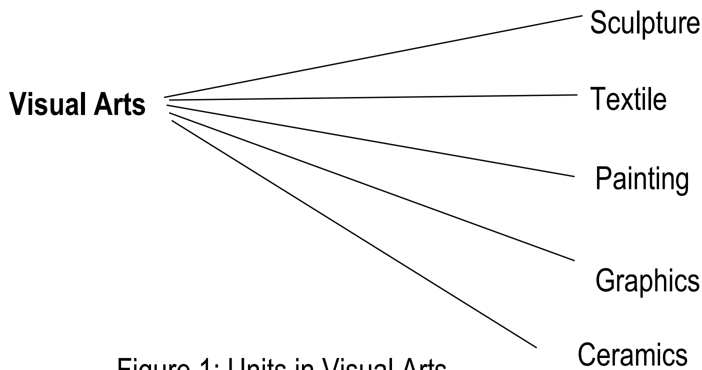

Figure 1: Units in Visual Arts

Art is 2-dimensional, that is, it has two surfaces that contains length and breath. Examples are paintings, photographs, drawings, referred to as flat or plane figures. 3-dimensional art has three surfaces length, breath and length (height, width and depth) which can be viewed from all sides and occupies space. Example is sculpture.

2-Dimensional media

Materials painting – colours, brushes, canvas, cardboard papers, palette, water colour, acrylic paints, pastels, oil paint, spray paint, spray fixative, spray adhesives, chalk, charcoal
Inspiration – preparation – sketches – creation – reflection as shown in figure 2.

Figure 2: A Painting, 2-Dimensional Art by Sukanthy
Title: Feminine Perspective 2020
Perpex, Ropes and Acrylics on Canvas
Source: Art Incubator Exhibition Catalogue (2021)

3-Dimensional media – sculpture
Sculpture in the round and relief sculpture. Casting, carving (additive and subtractive), modelling and assembling as shown in figure 3.

Figure 3: A Sculpture, 3-Dimensional Art
Title: Anyanwu by Ben Enwonwu
Source: https://1.bp.blogspot.com/-1zddkpd6nZU/VO-rtaF1wLcB/s1600/FIG-4-3-Anyanwu

Materials – Carving tools, wood, clay, cement, metal, stone, found objects, wax, popi bronze, marble, plaster tools – chisel, hammer and mallet.

What are the elements of art?
The elements of art serve as a framework for the structure of visual arts. The elements of art are:

Line, shape, colour, form, texture, value and space.

Line: Lines may be diagonal, vertical, horizontal, zigzag and curved. They may be thick, thin, solid or broken. Two lines next to themselves are called parallel lines. Lines can be bent into angles, lines have names that describe their place in space, line is a mark, an identifiable path created by a point moving in space. It is one dimensional, often used to define the edges of a form.

Shape: It is said that lines create the outline of shapes. Once a line outlines a shape, it is creating two images; the positive one that is outlined, and the negative one that is created outside the positive shape. Most shapes can be defined and named examples are: ovals, squares, circles, rectangles, crescents, trapezoids are all named shapes as shown in figure 4. Some are irregular which do not fit a definition.

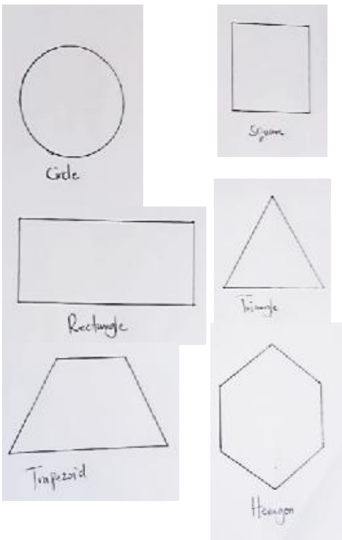

Figure 4: 2-Dimensional Geometric Shapes

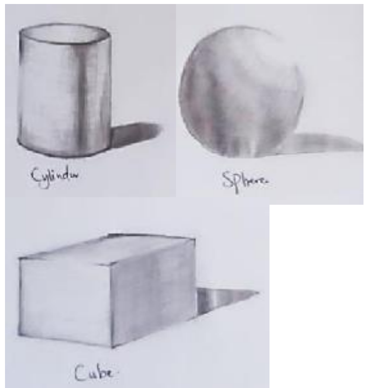

Figure 5: Illusion of Mass & Volume making the shapes appear 3-Dimensional

Colour: There are three colours red, blue and yellow called primary colours as shown by figure 6. Colour is a sensation produced by the rays of light on different wavelengths. The primary colours are so called because they can be mixed to create all the colours of the rainbow. The relationship of colour create the foundation of the colour wheel as shown by figure7. Primary colours can be mixed to create the secondary colours of orange, green and violet. There are three properties of colour. Hue is the first which means colour, the second is intensity; refers to the vividness of the colour. Value is the third property and it is how dark or light a colour is.

Contrast is the degree of the difference between colours or tones in a piece of artwork. Blue, green and violet are referred to as cool colours while yellow, orange and red are warm colours. Complementary colours are pairs of colours opposite each other on the colour wheel. Tertiary colours are colours created by mixing secondary colours.

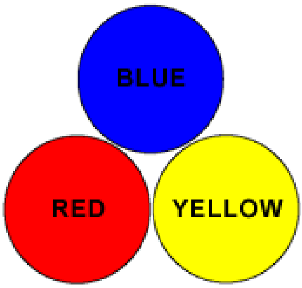

Figure 6: Primary Colours

Figure 7: Colours Wheel
Source: Ryan (2021)

Texture: It is the degree of roughness or smoothness of a surface. Texture can be created by using repetition of lines and shapes. Descriptive words for texture are bumpy, feel, gliffy, hard, rhythm, rough, grainy.
Space: Space in artwork makes a flat image look like it has form. The following ways are used to indicate spaces in artworks.
Changing size: An object that is smaller looks like it is in the distance while an object that is larger looks like it is closer.
Overlapping: Placing an object in front of another object makes the object in front appear closer than the one behind.
Using perspective: Objects can be drawn on a flat surface to give an impression of their relative position and size.
Descriptive words for space: These are change, composition, distance, front, overlapping, perspective, vanishing points.
Value: Value refers to the lightness or darkness of any colour. When colours are presented in full value, they appear strong and bright. When colours are mixed with white paint or water, they appear as muted, lighter tones. When mixed with black paint, they appear as darker tones or shades.
Descriptive words for form: These are cone, cube, cylinder, flat, prism, pyramid, sculpture, sphere, three-dimensional, two-dimensional.

Principles of art
Principles of art and design are balance, rhythm, proportion, emphasis, movement, harmony, unity and variety. The principles of art are set of criteria used to organize the elements of art to

create a work of art.

Principles of art and design

The principles of art and design are the instrument that artist applies the elements of art to achieve any creative exercise. The technicalities involved in any creative activity using the elements of art to achieve is termed the principles of art.

Balance: This is achieved when the elements of art are combined to give stability to the work of art. The two types of balance are symmetrical and asymmetrical. Symmetrical refers to similar parts facing each other, equal, similarly arranged elements. Asymmetrical, the two sides differ from one another. Note that visual balanced is achieved by the arrangement of the elements. This principle in art is achieved when contrast or diversity is created in a work of art for visual aesthetics. The elements are carefully combined in various shapes, colours, lines, sizes to guide against monotony.

Unity: This principle refers to the total arrangement of the elements to create balance, harmony not variety. The elements are united or joined as a whole which can be achieved through simplicity repetition, the examples are placing objects together or in groups.

Rhythm: The combination of elements in art to give a feeling of movement, achieved by a careful placing of repeated elements to create the illusion of motion is rythm.

Emphasis: This is used to draw attention to the main subject of an artwork. This can be done by highlighting certain elements by making them larger or bolder than other elements.

Proportion: The size of elements within a composition in relation to each other not the overall size of the composition. Proportion refers to the relationship between the different sized components within one whole composition. It can be used to create stylized or realistic styles from proportional ratios.

Harmony: Harmony is achieved when the elements appear in unity. It is not monotonous, not chaos but the ideal pairing of the two. The principles of art serve as a guide to any creative process in art.

Various steps of art appreciation

Onyema Offoedu-Okeke (2020) used the following parameters to instigate contemporary Nigerian art genera, media, style, techniques, subject matter, influence and progressiveness. Art appreciation, as already defined, is understanding the technical skills required to understand an image. Erim Panosky, an old art historian whose thoughts centers on iconographic analysis, states the following 3 levels of analysis:

1) subject matter
2) iconography
3) iconology.

The emphasis is on the content. Art scholars have researched and come up with a simpler five-step-system for appreciating art.

To write and discuss art requires visual implications for looking and thinking about artworks. In whatever way the discuss is going to stem from. Feldman (1992) describes art criticism as a performance that involves description, analysis, interpretation and judgment. Akpang, (2020) states that to carry out a comprehensive appreciation of a work of art, it should address the following: description, analysis, context, meaning and judgment – referred to as the five-step-system of Art Appreciation. The above was also researched on and was discovered that students performed well using the five-step-system of art appreciation (Akpang, 2021).

Description involves analyzing the visual attributes as seen by the viewer. The use of the physical qualities of the work, the elements and principles of art come to play. Analysis refers to a critical application of both the physical and subjective statements based on the viewer's initial reaction to the work. Analysis is a detailed account of how the elements and principles are manipulated in a work of art.

Context: This type of appreciation goes beyond the physical and formalism. This stage considers the historical conditions that inspired the work. Every artwork is described by context and knowing the context reveals its sociopolitical and sociocultural content. Investigation on the period of production is a necessary guide to knowing the context.

Meaning: Akpang refers to meaning which is the fourth step as, "a statement of the work's content, a message or narrative expressed by the subject matter. Content refers to the message or information codified into form by the artist of what the work is all about.

Judgment: The five-step system ends with a critical appraisal of art, considering its aesthetic or cultural values. This stage requires a total interrogation of the work by considering all the factors discussed and passing analysis of its physical appearance, subject matter, and context. Judgment implies a summary interpretation of the artist ability to manipulate the elements and principles of art to convey a message, uninfluenced and without prejudice.

Art exhibition

Art exhibition is a public show of artworks. It is a place where the audience meet with artworks. Art exhibition is a platform in contemporary domain for inculcating values, ideas, practices within and across borders. It provides catalytic benefit to art and artist. It is an emotional, aesthetic and intellectual activity. Art exhibition unites artist-artists exhibit their creativity using a common theme and subject matter. Mounting an exhibition is the desire of every hardworking artist. This is because it projects the artist, disseminate ideas and philosophies and contributes to protecting the values of cultures. The purpose of art exhibition is for public viewing, sales, exposition of artist to the society or for economic gains. Besides the impact of art exhibition in the global art world, it serves as prerequisite for graduation of students at the end of studies. It is a professional rite to artistic becoming that demonstrates the attainment of creativity of new artists and designers into the global artworld. Art exhibition can be solo or group. It can be juried on, invitation and open. Exhibition can be temporary or permanent. Proper management principles are requisite for successful exhibition; planning, coordinating, organizing, budgeting, directing, curating and publicity. Transportation, labeling, cataloguing, lighting and packaging gives good results to art exhibitions. However, it is a capital- intensive venture which requires sponsorship. Sponsors can be sourced for, from cooperate organizations, banks, individuals, patrons, or art collectors.

Art patronage

This refers to persons who finance art and art activities. They may be groups, organizations, or individuals. The support may come in various ways, as commission or during art exhibitions. For many years now, art exhibitions have enjoyed patronage in different ways which have contributed to the promotion of art and creativity. Traditional patronage recorded interest from royalties, priests, cult groups, age grades. A landmark event in the recognition of art in Nigeria came with the introduction of museum institutions in 1927. The production and consumption of art changed significantly with the support of government; state patronage created a different phase with introduction of museums. Private art galleries were set up thereafter, for art promotion and sales. The National Gallery of Art (NGA) became a major sponsor of art activities. Art auctions and auctioneers in Nigeria function as support for the sales and promotion of art. They have provided a strong base for professional and economic progress in the country's cultural sector, wealth, entrepreneurs. The emerging artist is an agency in the creation of artworks whose labour is compensated through the art galleries, artfairs and art auctions. The artist operates beyond the state patronage by delving into other means of reaching out, national/ international exhibitions, biennials and conferences for intellectual and social terrains of art patronage. Art patronage has developed to become more extensive, with digital applications, Facebook, Instagram and Twitter; artists can reach out to more audience.

Aesthetics and art criticism

Aesthetic originates from the Greek word aesthesis – what is perceived through the senses. From the above, it means how people respond to what they see. Art appreciation is linked to aesthetics and art history is the study of the visual arts. The concept of beauty has always been associated with aesthetics, in as much as the society desire the pleasurable, the beautiful and the good. There is the belief that beauty is linked to external appearance and that is why at the end of the sixth day, God was satisfied with creation, saw that what He created was good, because it was good, it was beautiful. Therefore, the element of goodness therefore is a variant of that which is beautiful (Ugiomoh, 2012). In many Nigerian cultures, there is hardly a difference between

English words beautiful, good, nice etc. rather one word in many languages can be used to define the concept calling attention of that which is beautiful supposedly to assume the character or meaning of the above words. Similarly, there is a way, ethics and morality become bound to the notion of goodness and beauty. Beauty is known to be a property of objects. It is the quality passed on objects that the senses cannot find out. In arts, it refers to the elements and principles that govern the creation and appreciation of art objects. It can therefore be grouped in cultural context as African aesthetics or Western aesthetics based on their philosophies. Style is associated with aesthetics to refer to an artist's overall practice that is, Bojor's aesthetic. An introduction to aesthetics is relevant at this level of study especially as students address art objects in various perspectives. Aesthetics refers to the surface qualities, physical properties or the visual elements and principles of art and design. It is the philosophical study of beauty and taste. Aesthetic judgment on the other hand is the analyses given to artworks which tends to devalue artworks due to bias in the nature of addressing the subject, it is far more intense than looking at art as a thing of beauty and taste. Egonwa (2011) points out that, one needs to cultivate a good understanding of works of art created in the different regions, including their aesthetic attributes and status. Students feel criticism means bad things about arts but criticism when used in philosophy means been analytical and insightful about art. The feelings when confronted with an artwork is aesthetic in nature. Art criticism is the evaluation and preening of works of art or objects of creative expressionism tied to theory. It involves to understand a particular work of art from a theoretical perspective and to establish its contextual significance in the history of art and the artworld. It therefore means that, because artworks are defined by theories, it becomes necessary for the art critic to dwell on discussions on theoretical implications.

Art in historical and cultural context

In analyzing art, it is necessary to have an understanding of the interrelationship of art, context and culture, this is because art is both contextual and cultural. Historiography is an approach of art criticism and appreciation that gives meaning to art objects at a particular time in the history of a civilization. Artworks are analyzed based on the belief systems of its society, religions, political and social institutions within the society it becomes necessary to understand divergent cultural perceptions. The elements and principles of art and design have different meanings in various cultures so the interpretation of artworks cannot have the same language. To understand artworks content; subject matter and iconography is important. To flow and have artistic experiences requires familiarity with the culture of the works. The background knowledge will open opportunities for clearer interrogation of the art objects. Artworks are interpreted within their time and period, that is, at the time of their creation, likewise arts reflect a people's customs, practices and values.

Summary

Reading through the chapter should encourage students to spend quality time when confronted with art objects. The culture of been in a hurry leaves a lot to be captured. Lots of approaches are available for students to appreciate art. As art critics, art objects are to be analyzed by the successful manipulation of the elements of arts. This does not mean formalism out doing iconography, content analysis reveals also creative philosophy and aesthetic vision. Art appreciation, aesthetic judgment and criticism can be grouped into two. One is visual analysis that centers on physical qualities of art, the other interpretative which explains the content. The framework already created in the study how art can be analyzed and interpreted should question and challenge critical sensibilities. By exercising one's critical faculties, engage with the elements presented in an artwork, its context, social, political and cultural situations in form of creation. Students can however, interrogate artworks from their visual narratives, content and contextual implications. Language ability so created from the study also establishes confidence from visual to verbal and literal discuss.

Exercise

1. Visit an art's gallery or museum, pick an artwork of your choice, subject the work to visual analysis and interpretation.
2. Mention the different ways in which artworks can be appreciated.
3. What is media? Is it true that the differences in media gives character to a work of art?
4. A work of art is mysterious, it is autonomous and symbolic. What is art?
5. Distinguish between form and content in the visual arts.
6. Can the same skills be used to appreciate a 2-dimensional work and 3-dimensional work?
7. The elements of art and design cannot be separated from the visual arts, with illustrations discuss the above statement.
8. Write short notes on the following:
   i. Perspective and space
   ii. Value
   iii. Texture
   iv. Harmony
   v. Colour tones
   vi. Mixed media

References

Akpang, C. E. (2001). "Analyzing Art and Artworks: Introducing New Theoretical Frameworks to Address the Problem of Art Appreciation and Criticism in Universities/ Colleges." Journal of Visual Literacy, Doi: 10.1080/1051144x.2021.1994729.

Akpang, C. E. (2020). Analyzing Art: A Short Guide to Art Appreciation, Criticism and Research in Visual Arts, Nigeria. University of Calabar Press.

Aniakor, C. (2019). M.F.A Exhibition Catalogue, Department of Visual Arts and Technology,

CRUTECH – Calabar, Nigeria.
Egonwa, O. (2011). Nigerian Art: Introductory Notes. Nigeria, Ababa Press Ltd.
Feldman, E. (1992). Varieties of Visual Experience. Englewood Cliffs. NJ. Prentice – Hall.
Folola, T. (2013. Art Parody and Politics Dele Jegede's Creative Activism, Nigeria and the Translational Space.
Kit, W. (2011). 101 things to Learn in Art School. Cambridge London: The MTI Press.
Kleinbauer, W. E. (1971). Modern Perspectives in Western Art History: An Anthology of Twentieth Century Writing on Visual Arts (Vol. 25) Toronto: University of Toronto Press.
Offoedu-Okeke, O. (2012). Artists of Nigeria. S. O. Ogbechie (Ed.) 5 Continents.
Ugiomoh, F. A. O. (2012). Inaugural Lecture Series No. 92. University of Port Harcourt, Nigeria.

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CHAPTER 33

Fabric Care and Clothing Maintenance

By

AMUBODE Adetoun Adedotun and AGBO Diana Ada

Overview

Laundering is a word for combined actions of washing, drying, folding, pressing, ironing, and proper storing of clothing items and household fabrics like towels, bed sheets, and draperies. Laundering is an age long cleaning exercise, dating back to when people began to wear clothe of various sizes and shapes. Laundering involves the use of clean water, cleaning agents and drying procedure. Laundering was handled by individuals for self needs, homemakers for family members. In the villages, laundering activity is carried out in flowing rivers and water wells. Due to growth of work and services, multiplicity of activities for individuals, laundering services are now offered as entrepreneurial ventures by professionally trained persons for individuals, families and cooperate organizations; particularly to help those too busy to attend to laundering of their clothes. Hence in big cities or towns laundry services have expanded to automated procedures with use of washing machines, ironing and pressing equipment, chemical agents not just for washing but removal of various types of stains, finishing to enhance the quality of fabrics. This advancement in laundering provide employment for persons, business openings for people and enhance prolonged shelf life for clothes and household fabrics. Care label means a permanent label or tag, containing regular care information and instructions, that is attached or affixed in such a manner that it will not be separated from the garment/fabric and will remain legible during the useful life of the garment. Care label is given in words or in symbols. The care label contains information on how to take care of the apparel. The beautiful textile materials can deteriorate due to exposure to the specific environment and conditions such as washing, drying, ironing, bleaching and dry cleaning (Raha, 2019). Following the instructions on care labels provides assurance that the appearance and the fit of the garment will be maintained after repeated cleaning treatments (Intertek, 2019). Thus it has been imperative to have care label on apparels so as to retain their original properties (Raha,2019).

Objectives

By the end of this chapter, students should be able to:

1. define the term laundering, explain the meaning and need for laundering clothes;
2. list major tools/ equipment for laundering;
3. outline differences between agelong and contemporary laundering;

4. list and explain the processes involved in laundering different fabrics;
5. outline advantages of laundering and discuss challenges encountered during laundering;
6. write and discuss different finishing substances;
7. use appropriate washing methods and finishing agents for different fabrics;
8. explain the processes involved in ironing and pressing;
9. write and explain the meaning of stain, types of stain and how to remove stains from fabrics, textiles, and other substances;
10. remove stains using appropriate reagents and techniques;
11. identify care labels, symbols and meaning;
12. store laundered clothes appropriately; and
13. discuss the types/ techniques in clothing repair, darning of tears in fabrics/apparel and methods of renovation/ remodeling of clothes.

What is laundering?
Laundering entails washing of clothes (garments) and household fabrics like bedsheets, curtains, kitchen napkins to remove dirt and stains; to keep them clean and hygienic. Use of finishes, stain removers, ironing and pressing improve the appearance of the laundered clothes (Anyakoha and Eluwa, 1999).

The primary substances used for washing:

a. Water (Running, well, tap)
b. Soaps (Solid or Liquid)
c. Detergents (granules or liquid)
d. Stain removers (optional)

Common tools for laundering:

1. Open bowls (plastic or metal)
2. Buckets
3. Hard Surfaces like concrete slabs, rock, logs of wood

Local drying tools for laundered fabrics/garments:

1. Ropes attached to metal poles.
2. Ropes attached to wooded poles.
3. Hot sand.
4. Grass
5. Shrubs

Contemporary modern drying equipment for laundered fabrics/garments:

1. Washing machines
2. Washing – Drying machines
3. Drying stands or racks for indoor and outdoor use.

Washing machine

A washing machine is a home appliance used primarily to wash clothes, sheets, and some textiles. Regular top-loading machine or side loading cabinet washing machines are the most used by households. Functions of washing machines include washing, rinsing and spinning to dry.

Figure 1: Indoor/outdoor cloth drying rack Figure 2: Washing machine/ dryer

Source: http/www.jumai.com.ng

Source:https://timesofindia.indiatimes.com

Purpose of laundering.

Laundering of clothes is done to:

1. remove bacterial.
2. remove dirt.
3. kill fleas.
4. kill mites.
5. remove anything will irritate the skin or cause infection.
6. remove smell or foul odour.
7. make the cloth appear clean and presentable.

Laundering or washing of clothes must be done using clean water that will not impart odour or colour, microorganisms in order to meet the listed purposes.

Procedure for laundering different fabrics.

Laundering can be done manually or by use of washing machines. Irrespective of the choice of laundering, there is need to follow set procedure for effective management of time, finance, and preservation of the clothes. The procedure for effective laundering is outlined as follows:

1. Separate the clothes based on the:
   a. type of fabric type (delicate, sturdy, light, cotton, silk ,etc)

b. colour of fabrics (light, dark/dull, flowery, colours that spill)
c. level of soiling or dirtiness
d. age of users

2. Where the washing is to be carried out using washing machines:
   a. Load the washing compartment with the sorted clothes.
   b. Choose the Right Washing Cycle (depends on built in cycles)
   c. Set the water temperature, based on recommended temperature for different fabrics.
   d. Add Detergent and/ Fabric Softener into compartment in the detergent drawer.
   e. Turn on the Washer using the on/off nob.
   f. Set drying temperature based on type of fabric.
   g. Remove clean cloth from the washing machine.
   h. Clean Washing Machine (occasionally).

Most washing machines have inbuilt functions for rinsing, spinning to dry. Care must be taken to ensure that appropriate recommended temperature is selected to avoid destruction of fabrics. Recommendation of temperature can be read from the clothing labels.

Finishing agents/ substances

Finishing in textile represents application of chemical substances or subjecting the textiles to mechanical processes after manufacture. Finishing takes place before the textile is cut and sewn into garments or other household items. Textile finishing is used to achieve desired effects and it can have aesthetic or functional benefits that make the textile more useful or serviceable. Fabric finishes be permanent, lasting throughout the life of the fabric or temporary, lasting through one or two cleaning (Weber, 1990). The purpose of finishing can be summarized as to give the fabric desired appearance, shine, texture or handle (softness or hardness), drape, look or appearance. Other advanced effects of finishing fabric production are water repellence, flame retardancy, anti-static, anti-odour, deep colour, anti-slip, hydrophilic (moisture management), sewing improver, antibacterial, antimicrobial and antiviral.

Finishing of textile fabric during laundry is carried out by adding fabric finishes to increase attractiveness and/or serviceability of the fabric. Examples of finishing required in laundry are shrink resistance treatment, wrinkle resistance treatment, and starch treatment, which increase the weight and shine of fabrics. Different finishing substances are available by various trade names. Each gives its characteristic effects by adding value to the basic textile fabric material. The two groups of finishes are chemical and mechanical finishes. Examples of each group are:

1. **Chemical finishes:** Also known as wet finishes, they include antimicrobials, antistatic agents, water repellants, wrinkle-free finish, flame retardants, anti-soil finish, material and grain/grainline.

2. **Mechanical finishes:** These include calendaring, compressive, shrinkage, sanforizing, raising,
peaching, shearing, cropping, mesmerizing and sueding.

Ironing and pressing

Ironing and pressing are often used interchangeably. However, these two terms are not equal especially as unit operations in garment construction. Ironing is what you do to remove wrinkles by sliding a hot iron back and forth and to straighten a piece of cloth. Ironing is an operation in clothing that requires pressing to flatten and smooth clothes with a hot ironing tool at a regulated temperature. Some irons have built in steamers, so they are called steamers. Both irons and steamers have adjustable heat settings for different fabrics.
Pressing is the process of lifting and putting the iron down on a specific part of a garment piece to bring out shapes and points of emphases like edge of collars, head of sleeves, sleeve cuffs etc. A quick press takes a specific wrinkle out of a piece of sewing project too. Due to the need to shape and bring out folded in or concealed edges, special tools may be needed.

Ironing/pressing tools and aids

Essential ironing/pressing tools are a sturdy ironing board, a steam iron and a pressing cloth. Although, an iron that produces pressurized steam is ideal, one with a surge-of-steam feature is acceptable. Useful aids for details such as shaped pieces, narrow and inaccessible seams, fabrics with a pile, pound block, pressing mitt, Tailor's ham, sleeve board, point presser and block (this could be one unit or separate). Some pressing tools and aids, as shown in figures 3a to 3h are: (a) ironing table, (b) professional steam iron, (c and h) pressing cloth, (d) point presser and pounding block, (e) tailor's ham, (f) sleep board, (g) seam roll, (i) pressing mitt.

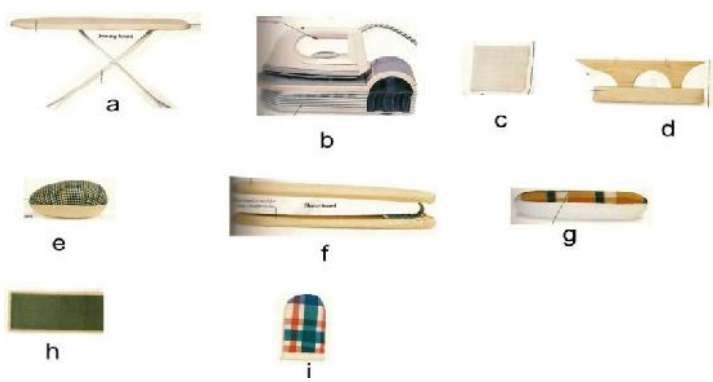

Figure 3a to 3h: Ironing/Pressing Tools (Agbo, 2023)

Stains and stain removal

Meaning of stains

A discoloration produced by foreign matter that have penetrated another object or material. Stains are spot, patch of color different from that of the basic color not easily removed. Stains can occur on walls, garments, household fabrics and textiles, clothing accessories, kitchen equipment and utensils, etc.

Types of stains

Stains are classified based on their origin and characteristics. Examples are: blood stains, coffee stains, grass stains, grease stains, ink stains, ketchup/sauce stains, sweat stains and wine stains.

Stain removal

Stain removal is the process of extracting the foreign patch of different colour from the surface of the material where it has dropped and stained. Some stains can easily be removed by simple washing with water and rubbing. Other stains need the application of stain removers. The technique to use in treating a particular spot or stain depends on both the nature of the stain and the type of surface stained. The process of removing stain may require soaking in the liquid, spraying with stain remover or rubbing off. This may need some duration of time to completely remove.

Stain removal techniques

Physical stain-removal techniques include brushing, flushing, freezing, presoaking, pretreating, scraping, sponging and tamping. Fabric stains are best removed when socked in cold water and rinsed with hot water. Different stains require the use of one more technique as:

1. Brushing: Brush is used to remove hard stains from fabrics with hard texture, piles and ridges.
2. Flushing: Useful toilet closets for removing salt stains. Scrub surface with stain removing liquid like harpic, leave for about 30 minutes before flushing.
3. Freezing: Use ice block directly or stored cubes on surface of the stained item to freeze it. For instance, gum stains can be frozen and remove from the surface of a piece of fabric.
4. Presoaking: Fabric is soaked in chlorine bleach or colour-safe bleach.
5. Pretreating-apply detergent, soil-and-stain-removing pretreat spray, bar soap. directly on the stain.
6. Scraping: Using the edge of scraping tool, gently scrape stain from surface.
7. Sponging: Absorbent pads are used to remove stain with the stained surface. facing down on the pad.
8. Tamping: Requires the use of soft brush to remove stain from tightly woven fabric.

Powerful stain removal substances

1. Chlorine bleach and colour-safe bleach.
2. Color remover.
3. Dry-cleaning fluid or petroleum-based pretreatment solvent.
4. Mild dishwashing detergent.
5. Household ammonia.
6. Paint remover.
7. Petroleum jelly.
8. Prewash spot removers.

Importance of stain removal

Stains on clothes portray dirtiness especially, if found in very conspicuous areas. It leaves a poor impression about the wearer. Stained walls and household utensils make the environment look poor, dirty, unhygienic and un-welcoming. Stains on clothes reduce the value attached to it. Dirt in form of stains on clothes are breeding ground for bacteria, rodents and produce bad odors (Weber, 1990). It is very important to quickly remove stains from garments and other surfaces when they get stained. Stains are best removed when fresh before it sticks on.

Fabric care labels

Care labels are essential when making the decision to purchase items, especially clothing. Clothes that are bought ready-to-wear have care labels. Care labels are care notes on pieces of fabric or garments sewn onto the wrong side attached to the back neckline, side seam or waist seam. The ruin of a garment or fabric can be prevented with accurate information on the care/content label. On the label that a garment or fabric carries, all the information about it is established; that is the type of fabric in which it was made, the proportion of each material, the place in which it was manufactured, the sizes, and the indications for its washing and care in general. The exact instructions on the washing, dry cleaning, bleaching, drying and ironing of a garment is usually contained in care label. It is advisable to follow the instructions.
It is important to read clothing care labels because:

1. Care labels help to make good decisions in the purchase of clothing items. Without correct care/content label information, it would be difficult to know the proper care of a garment or fabric.
2. Care labels enable one to avoid clothing damage as a result of improper care. Garments or fabrics that are not properly cared for will either rip, shrink or tear.
3. At times, when washing clothes without care labels, the colours of one clothe might run into another, in fact, some clothes may require dry cleaning instead of washing.
4. Care labels on garments are usually sewn into the wrong side of the fabric, so that consumers are aware of the care instructions for the garments.
5. Care labels also explain to consumers the required heat a garment or fabric can withstand if put in a dryer or is to be ironed.

Laundry/care symbols and meaning

The international accepted care-labelling rule requires clothing manufacturers, importers and exporters to attach permanent care labels to their products. Information on the labels include the fibre type, fibre content, brand name, country of origin, the manufacturer's Registered Number (RN), ironing temperature, dry cleaning, drying and bleaching instructions. Care instructions on care labels mainly consists of symbols and words. The International care labelling code has five basic symbols. The symbols are: - washtub for washing, triangle for bleaching, iron for ironing, circle for dry cleaning and square for drying. It is important to note that a cross across any of the care label symbols denotes the cancellation of the process as shown in figure 4.

Figure 4: Care label to be fixed on a garment

Source: https://www.weavabel.com/blog/what-are-care-labels-and-can-you-brand-them

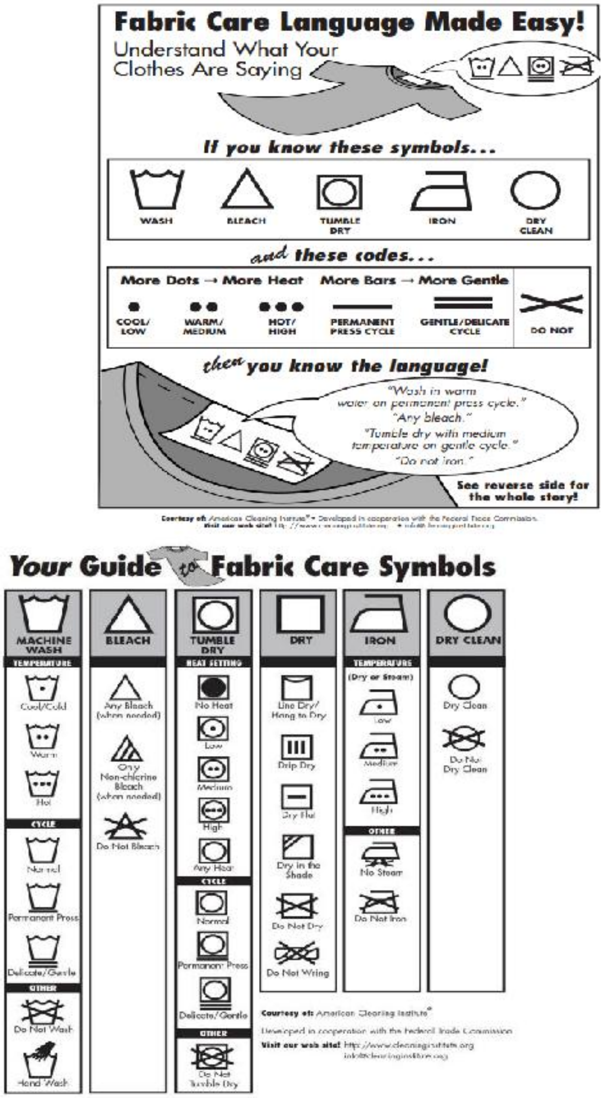

Figure 5: Care label symbols and meaning

Source: American Clothing Institute (n.d.) FabricCareSymbols.pdf (cleaninginstitute.org)

Care instructions for fabrics without care label

In case a garment or fabric does not have a care-label or does not have all the details regarding fabric care as mentioned above then take note of the following necessary care instructions for washing, drying and ironing. Natural fabrics are derived from the fibre of animal hides, plant seeds, stems and leaves, and silkworm cocoons. Natural fabrics are soft and Ultra Violet light does not cause discoloration. Examples of natural fabrics includes cotton, silk, linen and wool.

Basic characteristics of cotton:
Cotton is cool, soft, durable and comfortable. It absorbs and releases perspiration quickly. Cotton gets wrinkled easily.

Cotton fabric care instructions:
Washing - Cotton can be hand or machine washable and it is advised to use warm water.
Drying - Cotton clothing should be hang-dried.
Ironing – Fabrics may be ironed at medium or high temperature.
While taking care of cotton fabric, it is important to note the following:
1. Don't use bleach unless the garment is white
2. Avoid over bleaching as it can cause damage or yellowing

Basic characteristics of silk:
Silk is soft, comfortable and versatile. It is the strongest natural fibre. Silk drapes well and retains shape; absorbs and releases perspiration quickly and can be dyed easily. Silk is weakened by sunlight and perspiration.

Silk fabric care instructions:
Washing – silk fabric can be washed in a machine on delicate cycle, however, it is better to hand wash silk in lukewarm water.
Drying – Do not wring silk clothing, hang or lay flat to dry.
Ironing – use low or warm temperature to iron silk.
While taking care of silk fabric, it is important to note:
1. Don't use bleach
2. Don't use dryer
3. Avoid direct sunlight and high temperature

Basic characteristics of linen:
Linen is a natural fabric from the stems of flax and it is two times stronger than cotton. Linen is lightweight, stretch resistance, it absorbs and releases perspiration quickly. Linen gets wrinkled easily.

Linen fabric care instructions:
Washing – hand wash linen in lukewarm water or dry clean.
Drying – linen can be dried in machine on low temperature or hang dried.
Ironing – use medium temperature to iron linen. Linen can also be ironed from the wrong side when it is damp.
While taking care of linen fabric, it is important to note:
1. Do not bleach except the colour of the garment is white.

2. Over bleaching can damage the fabric.

Basic characteristics of wool:
Wool fabric absorbs 30% of its weight in moisture without being damp, wool is stronger when dry and available in many varieties from extremely soft to scratchy. Wool is flame and dirt resistant, it acts as an insulator, absorbs and releases moisture quickly.

Wool fabric care instructions:
Washing – Some wool fabrics are washable. However, wool should be dry cleaned.
Drying – Drying – roll wool on towel to squeeze out excess water and lay flat to dry.
Ironing – use low temperature and steam to iron wool.
While taking care of wool fabric, it is important to note:

1. Wool does not need washing after every wear.
2. Soak wool in cold water before washing.
3. Don't rub, twist or wring the wool against itself, this make the fabric/garment felt.
4. Knead and squeeze gently.

Importance of caring for clothes/fabrics
All fabrics and clothing's need proper care in order to maintain their lustre, texture, shape, appearance and strength. The life of fabric increases with proper care. Washing of clothes is an essential part of good grooming and healthy life style.
Clothing are cared for to keep them fresh, clean and comfortable to use. Caring for clothes prolong the life of a piece of the clothing, prevents diseases, infections and embarrassment. Regular washing of clothes and fabrics prevents infection from bacteria, scabies, mites, fleas, and other skin infections. Fabric care helps in maintaining the condition and serviceability of the garments and other products.

Storing and packing clothes
Clothes require care not only during their use but also while they are stored. Good storage and packing practices in clothing care ensures the freshness of the clothing items. The weather is not the same all the year round; hence there is a need for specific fabric storage. Proper storage saves time, energy and facilitates accessibility of clothing. Items used to store clothing include:

1. Wardrobe- clothes may be hanged and neatly folded in wardrobe.
2. Chest of drawers- clothes and accessories may be kept in drawers but shoes and bags should not be kept in drawers because they will become moldy or they may peel.
3. Trolleys- all clothing items and cosmetics can be kept on trolley.
4. Open shelves- clothes may be folded and arranged on shelves. Accessories may also be arranged on shelves.
5. Boxes- - clothes and accessories may be kept in boxes.
6. Bags- garments may be folded and arranged in bags.

7. Hangers- hangers are of different kinds and sizes and they hold clothes to prevent them from wrinkling.
8. Shoe rack/ shoe bags- shoes can be arranged on shoe racks, or put in shoe bags.
9. Trunks and suitcases- Clothing that are not used often may be kept in trunks or suitcases

Guidelines for clothing storage

1. Ensure that the clothing item is in good condition before storage.
2. Wash clothes before storing.
3. Brush the clothes to remove dust, empty the pockets and expose to the sun before storing.
4. Do not store damp clothes because the moisture will cause the clothes to mildew and damage the clothes.
5. To prevent mildew, make sure all clothing is completely dry before storing; press garments with hot iron to remove all dampness.
6. New white coloured cloths that are to be stored for a long time should be wrapped to avoid yellowing.
7. Regularly change the folds of clothes that are to be stored for a long time to avoid crack at the folds.
8. Clothes that are starched, should not be stored for a long time because of mildew and some insects get attracted to the starch.
9. Mend all tears on the clothes before storing to prevent the tears becoming larger.
10. When the weather is dry, air out storage spaces. The storage space should be dry, insect free and away from dust and dirt.

Mending clothes

Clothing repairs involves the mending of damaged portion on articles or dresses such as spoilt zip, worn out portion of a dress, tears, holes, manufacturing faults in lose hem, or lost button. Damages on clothes or articles weakens and reduces the life span of the clothes or articles. Damaged clothes may expose parts of the body that are not for public view. Clothes should be mended as soon as damages is been noticed.

Different ways of clothing repairs

1. Patching- Worn areas on articles or garments may be mended by patching. This is done by replacing a strong piece of fabric in a worn-out area of an article or garment and stitch permanently. Patching is the process of mending worn areas or tears on a garment or fabric. The patch is usually sewn using a stronger piece of fabric over the area that needs repair. Patching can also be used to decorate or embellish garments. Patching can either be for functional or decorative purposes.
   a. Functional patching is using the same fabric to repair damaged, torn or weak areas of a garment.

b. Decorative patching is using varieties of materials such as ribbon, sequins, lace or fabrics to create a unique design on a garment as embellishment.

Darning- darning is a process of repairing holes or worn areas in fabric or re-weaving using needle and thread. Often times, darning is done by hand, however, sewing machine can also be used for darning using zigzag stitches on the cut area. Darning is done using running stitch by anchoring the thread in the fabric at the exact edge of the hole and passing the thread across the gap to the other side. Enough threads should be used to crisscross over the hole until it is fully covered. In machine darning, zigzag stiches are run through the hole at right angles. . This is a fast way to darn.

2. Re-stitching- re-stitching is done on loose stitching lines in such a way that the original stitching line, seam allowance and length of stitches are maintained. Use the same type and colour of threads to re-stitch splits in seams, loose bands and broken top-stitches.
3. Replacing and re-fixing - frequent use of clothes make fastenings become loose, spoilt or come –off and needs to be replaced or re-fixed. Sleeves, collar, pockets and belts often come off and have to be mended. These features have to be replaced or re-stitched depending on the extent of damage, Forster, (2016).

Renovation and remodeling of clothes

Renovation involves making minor changes in the appearance of clothing to renew them to suit current fashion. For instance, the length of a dress may be reduced by decreasing in length. Methods of Renovation includes:

a. Decreasing or increasing in measurements the length of a garment.
b. Changing small sections or style features such as changing the style of the collar, sleeves, necklines, adding lace, frills or ribbons.
c. Re-dyeing of faded or light coloured garments or re-design the garments using either batik or tie and dye design techniques.

Remodeling- remodeling is making different article or garment out of existing one. For instance, a curtain may be remodeled into a bag, table cover, head and arm rest or a dress into a skirt, etc.

Summary

Clothing are cared for to keep them fresh, clean, neat and comfortable to use. Laundering entails washing of clothes and household articles. This chapter highlight the primary substances used for washing, common tools for laundering, local and contemporary drying tools for laundered garments/ fabrics. Also, it featured stains as a discolouration in an article or a garment, the various types of stains and stain removal techniques. Care labels are information on pieces of fabrics or garments sewn on the wrong side for accurate laundering of clothes. Care label/ laundering symbols and meaning were presented. Care instructions for fabrics from natural sources without care label were stressed. Storage and packing practices in clothing care, the various storage items and guidelines for clothing storage were highlighted. The chapter also provides information on the different ways of clothing repairs such as patching, darning, re-stitching, replacing and re-fixing, renovation and remodeling of clothes.

Exercise

1. Explain how laundering is carried out in your family.
2. Outline the processes involved in ensuring that garments are clean for usage.
3. List common tools and advanced tools for laundering.
4. Explain the processes involved in laundering different fabrics.
5. Explain the importance of using finishes during laundering.
6. Identify common fabric stain removal substances in your locality
7. Demonstrate how to use a washing machine in the Laboratory.
8. Write out five reasons why care label is important.
9. Draw the care/laundry symbols for: do not bleach, hand wash, iron at low temperature, dry and dry clean.
10. Explain the care instruction for wool and cotton.
11. Write out five guidelines for storage of clothing.
12. Explain remodeling and suggest five articles that could be remodeled out of a bed sheet.

References

Agbo, D. A. (2005). Fabric Care, solution to colour fading in locally produced Nigerian. Fabric. *Journal of Home Economics Research (JHER),* 6 (1), 161-165. Retrieved March 21, 2023, from: www.heran.org

Agbo, D. A. (2023). *Introduction to garment construction.* 2nd edt. Makurdi. El- Snob. American Clothing Institute (n.d.). Fabric Care Language Made Easy. Retrieved April 21, 2023, from: FabricCareSymbols.pdf (cleaninginstitute.org).

Anyakoha, E. U. and Eluwa, M. A. (1999). *Home Management for Schools and Colleges.* Onitsha. Africana-FEP.

Cleanpedia (2023). How to remove stains from clothes. Retrieved March 23, 2023 from: https://www.cleanipedia.com/ph/laundry/how-to-remove-stains-from-clothes-a-laundry-stain-removal-guide.html

Forster, P. (2016). Clothing and Textile. Accra, Ghana, WINMAT Publishers Ltd.

Intertek (2019). Care Label Recommendations. Retrieved March 11, 2023 from: https://www.intertek.com/uploadedFiles/Intertek/Divisions/Consumer_Goods/Media/PDFs/Services/Low%20Res%20CompleteCareLabelling.pdf

Lanny x Studio (2021). Fabric Finishing - An Overview. Retrieved March 23, 2023, from: *https://www.lannyxstudio.com/blogs/news/fabric-finishing-an-overview*

Raeisaenen, R., Miilunpalo, S. M. (2019). Clean Laundry with Pure Conscience - A Study on Laundry Practices among Finnish Consumers. Retrieved March 23, 2023, from:

https://www.researchgate.net/profile/Riikka-Raeisaenen. DOI: 10.1111/ijcs.12493
Raha, S. (2019). Wash Care Instructions for Selected Garments. National Institute of Fashion Technology. Retrieved March 19, 2023, from: https://www.researchgate.net/publication/343683055_WASH_CARE_LABEL_ANALYSIS
Rapinchuk, B (2022). The winner is the Method Stain Remover. Retrieved March 19, 2023, from: https://www.wob.com > author >
Smith, B.W. (n.d). Understanding Care Labels, What Everyone Needs to Know. Agricultural Extension Service, The University of Tennessee. Retrieved April 11, 2023, from: https://www.leavenworth.k-state.edu/fcs/clothing_textiles/tenncarelabels.pdf
Stain (2023), from: https://www.vedantu.com/question-answer/are-the-different-types-of-stains-class Retrieved March 21, 2023, from: https://home.howstuffworks.com>s...
Weber, J. (1990). *Clothing Fashio*n. *Fabric*. *Construction*. Glencoe, Macmillan/ McGraw-Hill.
Webb-Lupo, A. and Lester, R. M. (1987). *Clothing Decisions*. Lake Forest, Illinois. Glencoe Macmillan/ McGraw-Hill.

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CHAPTER 34

Introduction to Clothing Techniques

By

BAKARE Kudirat Oyebisi and DIYAOLU Idowu Jamiu

Overview

Clothing is one of the basic human needs. It is used every day from cradle to death. Having a good knowledge of clothing theories, functions of clothing, and specifics about clothing construction will help learners develop interest in the programme and contribute to solving clothing needs. The chapter will expose students to the major equipment and basic processes in clothing construction: the sewing machine, care and handling of machine faults, seams, stitches, fastenings, measurements. The knowledge of clothing construction is significant to entrepreneurial ability of learners (Bakare, 2016).

Objectives

At the end of this chapter, students should be able to:

1. state and discuss the five clothing theories;
2. list and explain the different types of seam;
3. mention the different methods of fullness disposal and identify them on a garment;
4. discuss fastening and give examples of fasteners;
5. identify parts of the sewing machine;
6. identify and proffer solutions to specific machine faults;
7. list types of stitches and demonstrate the making of some hand stitches;
8. list the steps involved in taking accurate body measurement; and
9. explain the concept of fashion and colour combination.

Introduction

Clothing is as old as mankind. It is one of the basic essentials of life. Clothing is a fundamental aspect of human culture, and it serves both functional and symbolic purposes. From the earliest days of human history, people have used clothing to protect themselves from the elements, as well as to express their social status, mood, identity, and beliefs. Over time, theories of clothing have emerged, offering insights into the ways in which clothing functions in society and how it affects individuals' experiences. Clothing today is applied to all human endeavor and space. Examples of clothing/textile applications are; fashion, home textiles, automobile, architecture, and industry.

Theory of clothing

Clothing as one of the basic essentials of life has its theories traced back to some historical evidences, anthropologists (people who study on humanities) and few more scientists framed the theories on origin of clothing to the book of Genesis and human needs. Thus, Abraham Maslow's theory of need had been deployed to frame clothing theories. According to Aishwariya (2018), clothing theories are: protection/climate theory, modesty/fig tree theory, adornment/beautification theory and combined need theory.

Protection/Climate theory

Man invented clothes to meet the need to prevent harsh effect of weather hazard on the skin. One of first challenges man encountered was weather elements (cold and heat). He was spontaneous enough to source covering for protection from weather hazard based on experience purpose (self actualization). Man invented clothing to accommodate himself to climates he encountered. Animal skin - warmth and insulation, leaves or tree barks to cover genital sex organs, animal skin tied at feet for warmth and comfort during long walks. Shells and other items were placed close to sex organs in belief that it would prevent sterility and pain.

Modesty/Fig Tree theory

This defines that need for clothing arose when Adam and Eve ate the forbidden fruit from the tree of knowledge in the Garden of Eden as quoted in the book of Genesis) which brought about realization of nudeness and thus the feeling of shame and consequent sense of self-esteem to cover the body with few leaves. Dressing can form a personal identity that defines a person's credo, belief, values, culture, status, ideology, and it can just be an endeavor to gain attention and admiration of people without any string attached as in the case of a coquette. Modesty is a concerted effort to overcome misrepresentation and misguided perception arising from exposure of the body and therefore seeking its concealment with clothing. Modesty is relative and depends on culture, tradition, faith, age, and environment hence, what it is considered modest in one community may not matter to modesty in others. Man has used different articles for covering - beads, leaves, paintings, and tattoos among others. For example, the women of Botocudo tribe are ashamed when seen without wooden plug in earlobes and lower lip but are unaffected if their breasts are left exposed. Also, among the Australian tribe aborigines it is a great shame when seen eating but are perfectly ok if seen naked. In western world there has been period in history where it was sinful to expose from ankle to shoulder, while later it was socially accepted that an unmarried woman can expose her breasts rather than any part of her body (Aishwariya, 2018).

Adornment/Decoration theory

This is the inception of accessorizing clothing with found objects both for love and belonging (intimacy, and sense of connection) and safety and security (health, employment, social ability). In this connection, man tries to add more value to clothing for the purposes of beautification, special activities, and health. It is part of the drive for uniform among military, doctors, and students in uniform wears to conform to the job requirements. Social status is excluded and reflected in clothing accessories. Obas in Yorubaland adore themselves in beads.

Combined need theory

This suggests that clothing evolved as a result of the combination of various needs like safety, protection, self-esteem (your status in the society), self-actualization (clothing as a reflection of what you are) and belongingness (to merge with peer group/society). In other words, the deployment of other clothing potentials to present humans in different characters for skit creation, play-lets, satire, comedy, animation, and movies are part of ancillary need of clothing. Clothing has advantage of pliability and versatility properties to assume shapes in different prints to mimic animal skin, shapes, and other hilarious forms in form of costumes (Bakare, 2022). This suggests that clothing is used to create a certain assumed impression or image of oneself to others. It is a way of presenting oneself in a particular way to achieve a desired outcome or response from others. Clothing can be used to convey social status, personality traits, and even power dynamics. Clothing is a tool for impression management and social interaction. Outfits are constructed to create the characteristics of a particular period, person, place, mood, or thing; for example, Halloween costumes, masquerade costumes, Spiderman costumes, and so on. Thespians across the world make use of costumes to act different characters at different times as may be suggested in the scripts. Masquerades wear costumes that portray them in the light of the theme of the festivals different from the conventional mood and status.

Functions of clothing

Like every human need, clothing is an essential requirement for any living human in his right senses. It is usually applied to situation, status, condition, culture, and location among others. Clothing defines the demographics of an individual or assumed impression to create intentionally or unintentionally. It reflects the age, sex, mood, sanity, activity, ideology, belief, and intention of a person.

Protection

The commission of safety surpasses other purposes for clothing. Clothing safeguards the body from danger. The respective hurting and biting effects of heat and cold weather are quite lessened with clothes on. Clothing provides protection from heat, cold, wind, and rain; insect bites and stings are often prevented from the body with appropriate clothing. The body naturally gets rid of waste product through sweating. Clothing absorbs perspirations and prevents the skin from harbouring dangerous microbes. Clothing provides shield for specific body parts such as: safety hat for the head, safety glasses for the eyes, joint pads for the knees and elbows. Fire-fighters wear asbestos clothing in hazardous situations, police officers wear bullet proof vests, boots are worn to protect from thorns, pebble shocks, shards, and other dangerous objects, gloves are worn for protection from hurts and bruises, etc. Appropriate garments insulate the body against extreme temperatures. People who live in extreme cold weathers dress in heavy coats made of fur so that they can keep their body and thus survive the harsh weather; whereas in deserts, nomads protect themselves from the hot sun from dehydrating their bodies with long flowing robes and headdresses.

Covering/concealment

For modesty, sanity and elegance, clothing is a requirement. Individuals in the right senses will endeavor to cover nudity. In the context of immoral dressing, people still engage use of clothing. For any human to be adjudged normal in any society and civilization, there is a level of covering. There are casual wears, party wears, official wear, sportswear, etc.

Adornment

Beautification is a step next to functionality. Every individual love to look good therefore; each person tries to add beauty value/element to functionality by using certain style of clothing, jewelry, and cosmetics to enhance appearance and personality. During socio-cultural events like the Ojude-Oba festival, participants adorn themselves in different apparel to impress viewers (Diyaolu, 2010). Adornment or decoration also helps people to express uniqueness and creativity. For gracefulness, there is need to add some touch of aesthetics for pleasing effects.

Status

It is by their appearance we know them. Clothes are one of the important factors that represent the status symbol of an individual. In the olden days, the kings and queens had a specific style of dressing which was very unique from the other people, which made it easier to identify them and understand their status and rank in royalty. No one can mix up an Oba with an ordinary citizen in any gathering. A police boss can easily be identified by the stars on his uniform. An Oba is easily referred by his beaded accessories, *irukere*, and crown among others. Chiefs have special ceremonial appearance, likewise, *Olori*, princes, and princesses. Some of the clothing items representing high-status today, are designer clothes, designer jewelry, fur coats, pure leather item, cost of classy fabrics etc. because these items tend to be more expensive than others.

Identification

Clothing is one of the important factors that represent the status symbol of individuals,. Kings and queens have a specific style of dressing that is different and very unique from other people. Without being spoken, statuses are revealed by mode and manner of dressing. Certain types of clothing, colors, and accessories have become representative of certain groups, activities, and occupations, and cultures. This means that a specific style of dressing along with a specified accessory helps to easily identify people and what they stand for. It is not hidden to behold Christian and Islamic clergymen robed in cassocks and thobes respectfully. Likewise, occupations of people are reflected by the type of uniform they wear. Lawyers wear wigs, doctors/scientists wear laboratory coats, students, police, and other professional groups wear uniforms. It is a common parlance to say, the way you are dressed is the way you are addressed. Dressing reveals more about the wearer than one can imagine. Clothing creates impressions based on appearance. It is expedient for everyone to apply clothing carefully to avoid bad and miscommunication of self-image. Efforts are required to dress to portray your actual self. Wearing unique kinds of clothing and accessories has proved to create self -identity or logo for some people. Keeping to a particular colour especially white has distinguished some people from others in the society. For example, Ooni of Ife, Oba Adeyeye Ogunwusi has added glamour to his royal appearance by restricting to white regalia at all times. Some individuals in the society have resorted to a particular design of cap, a particular styling of head gear to create unique self-identity. Attending a funeral occasion may warrant attendants to appear in a uniformity or "teamage". Depending on the mood of the event, people may be asked to appear in black or any other approved dress code. This concept gives rise to Aso - ebi paradigm. Others are insignias such as badges, crest, sashes, head bands, wrist bands, and muffler that show membership in a group. Patches, broaches or emblems can be worn on jackets or blazer pockets.

Garment construction techniques

Seams

These are the techniques of using stitches (hand and machine) to bind two or more pieces of cloth together to form a two-dimensional or three-dimensional piece. There are different types of seams that perform and create different purposes and effects. Seamline is the line of stitching that runs the length of the seam. Seams are both functional and decorative elements on a garment.

Types of Seams

There are several different types of seams, each with its own characteristics and appearance as shown in figure 1.

Plain Seam: In a plain seam, a line of stitching is used to bind two pieces of textile material together along the seam line. Plain seam is the simplest and quickest to sew. In its simplicity, it can be used on almost any item. A plain seam is defined as any seam that attaches two pieces of fabric together with the wrong sides facing as shown in figure 1.

Run and fell seam: This type of seam is just like a plain seam except that there are two lines of stitching attaching the fabric for extra strength as shown in figure 1.

French seam. A French seam should only be used on delicate, lightweight fabric, like chiffon or organza, as the seam uses a lot of material and can get bulky with heavier fabrics. Since the edges of the fabric do not show with this technique, a French seam is also great for garments where you want to hide the seams, like an unlined jacket. The raw edges of the seam are completely enclosed in a neat double seam. French seam is particularly useful when a fabric is delicate and prone to fraying, such as chiffon. Raw edges are concealed inside a double-stitched seam as shown in figure 1.

Bound seam: It looks like a French seam on the right side of the fabric. There are no visible stitches on the right side of the fabric, and on the opposite side, the fabric edges are neatly

enclosed.
Corded/piped seam: It is a seam type that makes use of extra piece material to create; usually a strip of material that is slotted in the middle with an attempt to create a little space that will accommodate passage of twine, wire or any string/rope and give a raised effect for aesthetics.
Overlap seam. A lapped seam is typically used with fabrics that don't fray, such as leather and fleece. For a lapped seam, the right side of the fabric faces up and the pieces overlap, instead of right or wrong sides together.

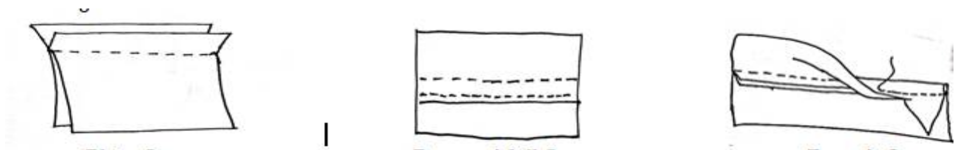

Figure 1: Types of Seams
Source: Authors, 2023

Seam finishing: In open seams, where the seam allowance is exposed, the raw edges need to be finished to prevent fraying.
Pinking shears: Pinking shears are serrated scissors that create a zigzag edge. Trimming a seam allowance with pinking shears can prevent fraying as shown in figure 2.
Bias tape: Bias tape is a narrow strip of fabric that can be folded over an exposed seam to secure and hide the edges. This is often used for unlined garments and bags, and for the edge of quilts.
Overlocking: Otherwise called Serged seam, it is a special type of sewing machine that cuts the raw edges of the seam and creates overlocked stitches around the edge as it is sewn. This is a very professional way to finish a seam, and serged seams are found on most store-bought clothing.
Zig-zag stitch: Zig-zag stitching along the raw edge of the seam will secure the edges and prevent fraying as shown in figure 2.

Figure 2: Types of Seam Finish
Source: Authors, 2023

Fullness control techniques
Darts: Darts are used to create 3D shaping in flat fabric in order to fit the figure. A dart in the fabric is useful at the waist, bust, and hips where a pointed fold is made to shape the garment panel to control fullness on the waist and to accommodate extra fullness of the bust, shoulders, and hips. Darts are stitched along the fold line and pressed down, towards the side seam. There

are two types of darts. Contour dart and half dart. These can be in varying length depending on the location, style, and size of the garment.
Pleats: A pleat is a systematic fold in the fabric; it is pressed in order to keep its edge creased down along a section of the fold. Pleats give graceful effect on garments. There are four types of pleats: knife, inverted/kissing pleats as shown in figure 3.
Tucks: Tuck is similar to pleat. It is equally a systematic fold of fabric and the fold is creased and sewn to hold down in place. There are 3 types of tucks: pin tucks, released tucks, and spaced tucks. Tucks are often used for decorative effects on garments, upholstery, and household linens.
Gathers: Fabric volume is controlled by two lines of long/baste stitches at the top edge of the fabric being the control end. The two threads on one side of the fabric are gently pulled taut as the fabric is eased back along the length of the threads. This technique is useful when inserting sleeves; the sleeve top is gathered and the fullness distributed according to the fit around the armhole opening when the majority of the gathering around the shoulder as shown in figure 3. To ease in fullness at the top of the sleeve, make a row of machine stitching along the seam line and 6 mm inside seam line between notches, using long machine-stitches.
Shirring/smoking: This is similar to gathering. It is achieved by running baste stitch from the control end through the width of the piece to create a smoking effect like seer sucker.

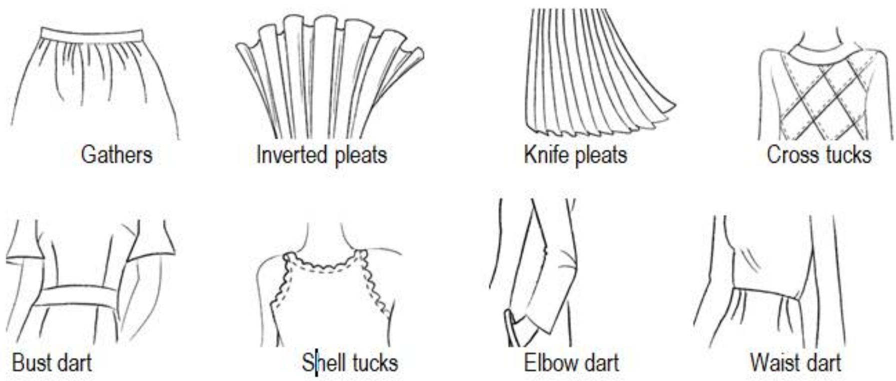

Figure 3: Fullness Control Techniques
Source: Adapted from Smith (2009).

Fastenings: Fastenings refer to use of devices (fasteners) to control openings on garments so that they stay closed and easy to wear and remove. Fasteners are essential part of clothing construction. They serve both functional and decorative purposes. Examples of fasteners are shown in plate 1.
Zippers: are popular choice of fastenings for dresses, skirts, pants, and upholstery. Zippers come in different length, sizes, and colours as shown in plate 1.
Buttons: Two holed buttons usually have the holes lined up parallel to the fastening edge. Four holed buttons are stronger than two holed buttons. They work well for heavier fabrics as shown

in plate 1. Buttons with shank are those with flat or protruded holes without showing up on the right side.

Hook and bar/ hook and eye: These are simple closure systems that are widely used for zip openings on dresses and blouses made from lightweight fabrics as shown in plate 1.

Velcro: is used on medium and lightweight casuals. It is available in different sizes and colours. It has positive and negative sides that attract.

Plate 1: Samples of Fasteners

Buttons

Zipper


Hook and eye


Press studs

Source: Adapted from Scrappy Mel (2010).

The sewing machine

The sewing machine is the major sewing equipment in clothing construction. It is used to join pieces of fabrics together and also used to make different decorative designs on garments and clothing articles. It is faster and more efficient for construction than hand sewing. The sewing machine must be available and functional in any clothing construction firm (Diyaolu, 2022a). Different types of machines are available ranging from manually operated to computer-programmed machines.

Types of sewing machines

1. Hand machine - is operated by turning the handle to make straight stitches
2. Treadle machine - has stand and a flat table for cutting fabrics. It is operated by a foot paddle.
3. Electric machine - is electrically operated. It can make straight and embroidery stitches.

Apart from the sewing machine, there is an over-locker (serger) machine that trims, sews and overcast in one step. It uses 2-5 threads. The choice of the machine to be used will depend on the output, compatibility and the technical know-how of the designer (Diyaolu, Irefin and Akarakiri, 2018).

Parts and care of the sewing machine

The sewing machine has the following parts as shown in figure 4:
Head: The upper part of the machine, not including the bed (base).
Spool pins: Hold spools of thread.
Bobbin winder: Holds bobbin for winding.
Hand wheel: Controls the up-and-down movement of the needle and the take-up lever.
Stich-width control: Found on zigzag stiches.
Feed dog: Moves fabric under the presser foot.
Throat plate: Metal plate directly under needle. Has guidelines that help you keep the stitching straight as you sew.
Presser foot: Holds fabric against the feed dog.
Tension discs: regulate looseness or lightness of upper thread that goes through the needle).
Presser foot lifter: Lets you access to some of the machine's inner parts.
Take-up lever: Moves up and down, pulling thread from the spool for each stich.
Pressure dial: Controls pressure of the presser foot on the fabric.
Thread guide: Holds and guides the upper thread when stitching.
Tension dial: Regulates the tension (freeness) of the upper thread; usually, the lower the number, the lower the tension.
Thread cutter: Convenient for cutting threads.
Bobbin: Metal or plastic spool that holds lower thread.
Bobbin case: Holds bobbin and regulates tension of bobbin thread. Some cases are removable while some are not.
Hand wheel knob: can be loosened to stop needle from moving when bobbin is winding.
Knee or foot control: Used to start and stop the machine and to regulate the speed.

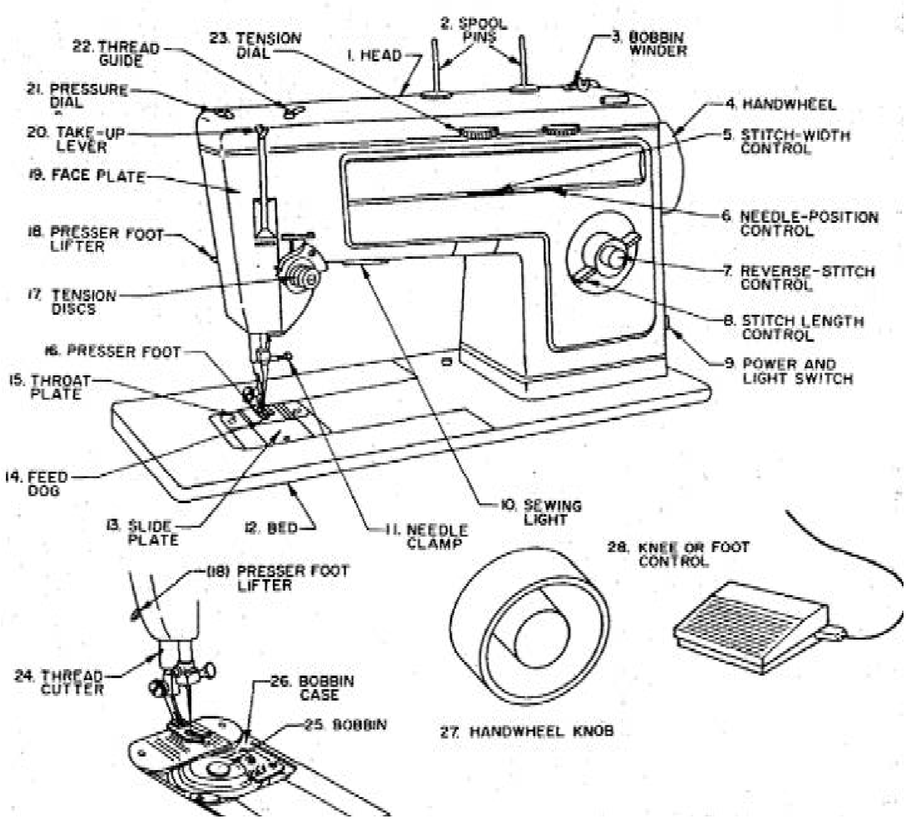

Figure 4: The Sewing Machine
Source: Webb-Lupo and Lester (1987).

Care of the sewing machine

There is the need to take care of the sewing machine for work efficiency and durability. Care of the machine is one of the total quality management principles that can promote the production of quality of materials in the fashion industry (Diyaolu, 2022b). This includes:

1. oil each of the points on the machine (holes) as indicated in the manual. Based on regular use, oil the machine once a week.
2. after oiling, be sure you wipe up drips. Place a piece of scrap fabric in the unthreaded machine; lower the presser foot and stitch back and forth. Wipe excess oil.
3. clean the machine before and after use.
4. cover the machine from dust.

5. do not use the machine when any part is loose.
6. use machine brush to clean dirt, lint and loose threads.

Machining

Winding the bobbin

In order to wind the bobbin:

i. Put the thread reel on the spool holder
ii. Put the bobbin on the bobbin holder or pin
iii. Lock the machine
iv. Run the reel thread on the bobbin till full

Threading the machine

The threading of the machine is in two parts: upper or needle threading and lower or bobbing threading.

i. Put both feet flat on the treadle.
ii. Turn the hand wheel from the top toward you to start the machine moving.
iii. try to keep the wheel turning using just your feet on the treadle to rock it back and forth.

To stop with the needle in a certain position, use your feet on the treadle as a brake, and move the hand wheel to position the needle up or down.

Table 1: Machine faults

Machine faults	Causes	Remedies
Machine does not stitch	Thread entangled around the bobbin.	Move the balance wheel back and forth to release the thread.
Spool thread breaks	Too tight tension on the tension disc or the thread is weak.	Reduce the tension or change the thread
Inconsistent stitch length	The fabric is pulled at times when stitching	Guide the cloth lightly and do not pull
Bobbin does not wind	Improper winding of thread and wrong placement of bobbin	Make sure the thread is wrapped around the bobbin in the proper direction, also check to see if bobbin has been placed properly in the winder
Bobbin winds unevenly	Failure to pass the thread through the guide and running the machine too fast	Check that the thread passes through the thread guide. Reduce the speed of the machine if too fast. Adjust the tension spring
Fabric layers	Light weight fabric	Adjust the foot pressure. If the fabric is

feeds unevenly		lightweight, add tissue paper while stitching
Fabric puckers during stitching	Needle could be blunt or stitch length is not ideal for the fabric, adjust. The thread may be too thick	Change the needle and adjust the stitch length
Machine runs noisily	No lubrication oil in the machine or loose bobbin /bobbin case	Oil and clean the machine Tighten the case
Needle bends or break	Too bulky fabric or fabric pulled with the needle	Lift the needle above the fabric by turning the fabric before pulling out the fabric
Needle skips stitches	Needle is too high or low in the needle groove on the needle clamp.	Check the position and fix the needle properly

Source: Adapted from Foster (2014).

Stitches

A stitch is a loop of thread or yarn resulting from a single pass or movement of the needle in sewing, knitting or crocheting. Stitches are the essential construction process during sewing projects. Some stitches are created by hand, while others are made on the sewing machine or serger. Stitches are used to join pieces of fabric together and they often help in perfect sewing. Basically, the two types of stitches are:

(i) Temporary stitches and
(ii) Permanent stitches (constructive and decorative).

Temporary stitches: Temporary stitches are those that are used to loosely attach two pieces of cloth to ensure that pieces fit together, and are removed as soon as they are replaced with the permanent stitches. These also help to keep pieces in places while being stitched.

Basting stitch: This is used to join two pieces of cloth together. This helps to keep slippery material in a straight line together while stitching.

Types of basting:

Even basting: All stitches are of equal length. This is achieved by taking an equal quantity of thread for the upward as well as downward stitch, at equal distances.

Uneven basting: All stitches are at varying distance but of the same length, i.e. the length of thread taken for upward and downward stitch is the same but at different distance from each other.

Tailor's tacks: are used for transferring pattern markings from patterns on to fabric.
Diagonal stitches: are used for holding two or more pieces of fabrics together.

Permanent Stitches - Permanent stitches are grouped into two: constructive and decorative stitches.
Constructive stitches: are used for holding two or more pieces of fabric together permanently. Examples of permanent stitches include:
Hemming: Used for finishing garment hems. This is almost invisible on the right side of the garment and as very small stitches on the wrong side.
Running stitch: Running stitch is probably the easiest to start with followed by oversewing. With these two stitches you can make clothing.
Oversewing: Also called over-casting or ugly stitch or whip stitch.
Backstitch: Is the strong hand sewing running stitch.
Blanket: Also called buttonhole stitch.
Decorative stitches: are stitches that are worked to beautify or decorate garments. Examples of decorative stitches are: chain, satin, stem, couching, herringbone or catch, fern, ladderhum, arrowhead, feathers, laizy daisy, chevron, interlacing, double laced effect, zig-zag, faggoting, etc.

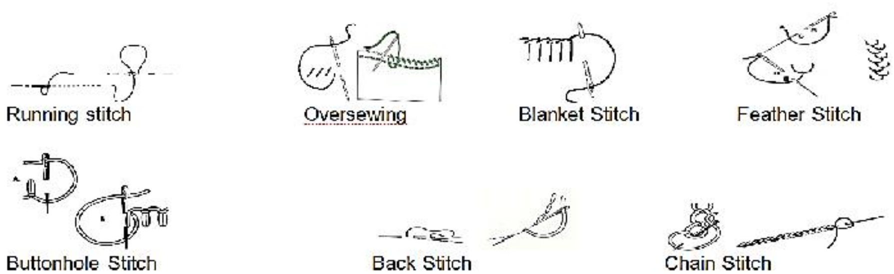

Figure 5: Types of Stitches
Source: https://www.brainkart.com/article/Temporary-stitches_1790/

Taking measurements
Accurate measurement entails taking the precise and exact body measurement. It is necessary to take accurate body measurements so as to get the correct pattern sizes for clothing construction. Materials needed include a tape measure, string, ruler, pencil, and an exercise book for recording.

Tips for accurate measurements
The principles underlying taking accurate measurement are:

i. use the non-stretch measuring tape
ii. stand straight and adopt good posture when measurements are being taken

iii. measurement should be taken over a fitted garment
iv. record measurements as soon as they are taken
v. you may have to remove your shoes
vi. ask a friend to take your measurement

Taking the following measurements:

Chest: Measure above the bust, high under the arms, keeping the tape measure flat and straight across the back.

Full bust: measure over the fullest part of the bust.

Waist: measurement around the smallest part of your waist. Wrap the tape around first to find your natural waist, then measure.

Hips: This measurement must be taken around the fullest part of the hips, between the waist and legs

High Hip: This is just below the waist and just above the hip bones

Shoulder: hold the end of the tape measure at the base of your neck (where a necklace would lie) and measure to the dent at the end of your shoulder. To find this dent raise your arm slightly.

Neck: measure around the neck— snugly but not too tight—to determine collar size.

Arm: Bend your elbow and place your hand on your hip, then measure from the end of the shoulder over the elbow to the wrist bone

Back waist: Take this measurement down the center of the back, from the lumpy bit at the top of the spine, in line with the shoulders, to the waist.

Outside leg: Measure the side of the leg from the waist, over the hip, and straight down the leg to the ankle bone.

Inside leg: Stand with your legs apart and measure the inside of one leg from the crotch to the ankle bone

Crotch depth: Sit upright on a hard chair or stool and measure from the waist vertically down to the chair

Concept of fashion

Fashion is the dress and style that are in vogue at a particular time. It is the manner of expressing oneself through appearance in conformity with the perceived general acceptance of the time, vogue of the day. Fashion is expressed through clothes and other accessories like shoes, bags, hats, necklace, make-up, hair-do, etc. Style is the design of a garment. For example, a pleated skirt or a bell bottom trouser.

However, fashion is the style that is in vogue or popular at the present time. Extreme fashion that lasts only a very short time is called, fada. Outdated fashion is called a dud.

Colour wheel

Colour is the most appealing of all elements on a garment. The colour wheel is a chart showing the relationships between colours. There are primary, secondary and tertiary colours.

i. **Primary colours** are the natural hues and not formed by mixing any colours. They are red, yellow and blue.
ii. **Secondary colours** are formed by mixing primary colours. Green, orange and purple are examples. Green is formed from a mixture of blue and yellow. Orange is from red and yellow while purple is formed from mixing red and blue.
iii. **Tertiary colours** are formed by mixing primary colour and secondary colour. Examples include yellow-orange, blue-green, red-orange etc.

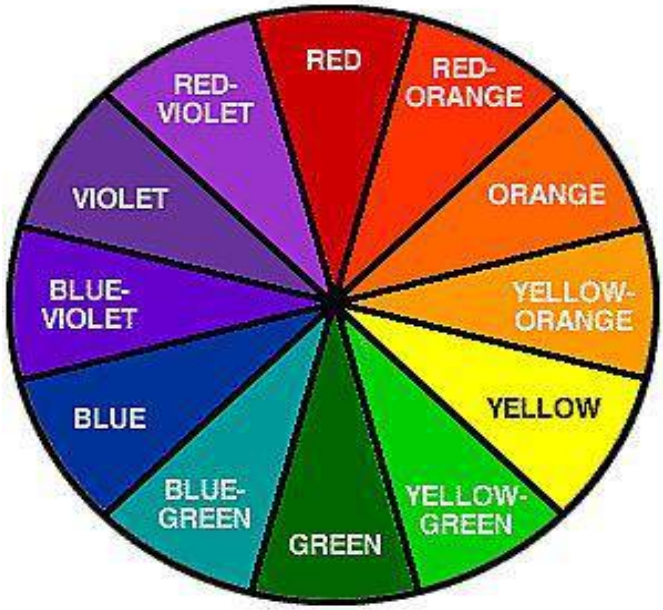

Figure 6: The Colour wheel
Source: Sunshine Designs (2009) (sunshinedesigns-carolynphi.blogspot.com)

Construction of clothing items

1. Choose the clothing style to construct. You may need to sketch as inspired or get from a fashion album.
2. Take the measurements
3. Draft the pattern following the body measurements. This helps to make your cuttings on the fabric easier.
4. Select fabric and notions. Carefully select the fabric that will bring out your desire. Also select zippers, bottons, etc
5. Construction: cut out the fabric using the pattern. Sew the pieces together and add the notions as necessary.

Glossary of sewing terms

Alter: to change or modify the shape, size and position of various constructional lines in the garment to fit the individual exactly or as desired. This alteration is made by increasing or decreasing the depth of the seams, darts, fullness etc.

Allowance: an extra fabric which can be used to accommodate gathers, ease, tucks and pleats or during alteration of a garment.

Applique: piece(s) of fabric or embroidered item applied on garment or any sewn article for decorative purposes.

Arms eye: arm hole of a garment.

Back stitch: a small hand stitch that resembles machine stitch on the right side but with overlapping stitches on the wrong side.

Baste: a loose-long temporary stitch made by hand or machine. It is usually used to temporarily hold pieces of textile material for testing and at times for gathering and shirring/smoking.

Bespoke: a means of holding two pieces of fabric together with a long open hand stitch, in preparation for the permanent stitch.

Bias: the diagonal line formed when a piece of fabric is folded so that the crosswise threads run in the same direction as the lengthwise threads. A true bias makes an angle of 450 across the length-wise and width-wise grain and has the maximum stretch.

Binding: enclosing of the raw edge of a garment section by another section.

Block pattern: also called as basic pattern or master pattern or sloper, with the basic darts made to a set of special measurement for an individual or in standard size. It is used like a template. A set of block patterns consist of front bodice, back bodice, sleeve, front skirt and back skirt. It is usually made without seam and hem allowances and style.

Bodice: close-fitted upper part of women's dress, down to the waistline.

Casing: a hem with an opening to accommodate passage of ribbon, string/rope, or elastic

Clip/slash: a small cut made in the seam allowance of a pattern, which allows a curved area to spread and lie flat.

Cutting line: the line marked on pattern pieces parallel to and outside the stitching line.

Cutter or trimmer: a small tool used to trim thread ends after stitching.

Constructional lines: the lines on which the garment is stitched to fit an individual perfectly. The construction lines in the garment always match with imaginary constructional lines of the silhouette. They are also called stitch lines.

Crease: a pressed fold line.

Dart: a triangular folded fabric stitched to a point at one end and used for fitting the fabric to body curves.

Designer: a person who is able to sketch and produce the original styles for the garment trade.

Draft: a sketch or plan of a garment; working out the style on a flat piece of paper from the block patterns.

Drafting: a system of drawing patterns on paper with mechanical precision on the basis of body

measurements.
Draping: a method of pattern making in which patterns are made directly
Ease: the extra allowance of fabric allowed in a pattern design for ease of movement, breathing etc., unlike any form of fullness. It is also the difference measurement between the stitching line and the actual body measurement along that line.
Face of the fabric: the right side of fabric.
Facing: a shaped or bias piece of self-fabric applied to the raw edges in a garment as a finish and to support the shape of neckline, armhole, collar etc.
Fasteners: the mechanical aids that helps to close an opening of a garment. Examples are: buttons, press buttons, zippers, hooks and eyes are called fasteners.
Findings/notions: any extra items attached to a garment during the manufacturing process. This can include trims, buttons, hooks, snap, or embellishments.
Fitting: a process of making a garment fit the body with optimum ease for movement and its seam lines following the silhouette of the body.
Flaws: defects in material, caused by faults in weaving and finishing of the fabric. These can be marked for visibility during fabric cutting. Before cutting any fabric, it is advisable to examine the material carefully for imperfections/damage and to mark any damaged part with chalk or pins, to avoid those parts in a garment.
Fraying: the threads that tend to come out from raw cut edges during handling of fabric. It is also termed as raveling.
Fullness: addition made to the basic block meant to give good shape, proper fit and allow freedom of movement and comfort. Examples are: gathers, pleats, tucks, etc.
Grain: the direction of warp and weft yarns in a woven fabric. The grain running parallel to the selvedge is length-wise grain and the grain running from selvedge to selvedge is the cross-wise grain.
Gusset: a shaped piece of fabric inserted usually at the underarm and crotch of a garment to provide freedom of movement.
Layout: an economical arrangement of pattern pieces on fabric to ensure proper cutting.
Lining: a fabric used inside the garments made of sheer or coarse fabric. This is added for support.
Miter: diagonal seaming of two edges at a corner to reduce bulk.
Muslin: an inexpensive, medium weight, plain weave, low count (less than 160 threads per square inch) cotton fabric. In its unfinished form, it is commonly used in fashion design to make trial garments for conducting preliminary fit.
Nap: it is a fuzzy surface on the fabric produced by a special finishing process.
Notch: small v-shaped cuttings made within the seam allowance of garment section to match design details or to serve as a balance mark.
Pivot: it refers to a way of stitching a sharp corner by keeping the needle in the fabric raising machine presser foot, turning the fabric to desired angle, lower the foot and to continue stitching.
Placket: a finished opening in a garment that allows for ease in dressing and undressing.

Raw edge: any unfinished edge.
Seam: a means by which two pieces of fabric or parts of a garment are joined together.
Seam allowance: the fabric edge that extends beyond the stitching line. This is a minimum extension without which a seam cannot be done.
Selvedge: the self-edge or finished edged of a woven fabric that runs parallel to the warp threads.
Silhouette: the shape, outline or profile of a garment when it is worn.
Slash: an even cut in the pattern or a fabric along a straight line, longer than a clip.
Trim: to cutoff ragged edges or a part of seam allowance, to prevent it from being bulky and to give neat seam edges.
Trimmings: ornamental decorative additions used on garments.
Yardage: the quantity of fabric needed to make a specific garment.

Summary

Clothing is as old as mankind hence; the theories of clothing are anchored on the basic needs of man as highlighted in Maslow's theory of needs. It is used for personal protection, identification, and status among others. Clothing has many functions which include identification, protection, covering, and beautification among others. The sewing machine is the major clothing construction equipment; its categories are hand, treadle, and electric machines. The sewing machine requires certain care and maintenance which include oiling, replacement of damaged spares, keeping away from dust, etc. to remedy the faults for optimal performance. Stitches and seams are important aspects of clothing construction as they have functional and aesthetic purposes. Taking accurate body measurement is critical to fittings of apparels; cautions are needed to take correct body measurement. The chapter ends with useful terms for clothing and textile production.

Exercise

1. Explain the concept of clothing theories.
2. Discuss the importance of clothing.
3. What are seams? List and explain the different types seams.
4. Define fastenings and give four main examples of fasteners.
5. *a)* The stitch in which the needle goes through the fabric from one side and then is brought around the edge to go through the fabric again from the same side is _______

   b) ________ stitch is used to finish edges

   c) The stitch is done similarly to a running stitch, but each stitch backtracks when it comes back up through the fabric, resulting in a looping thread track is_______

   d) ________ stitches are used to beautify garments

   e) Two basic types of stitches are ________ and __________

   f) Constructive stiches are divided into______ and _____

   g) Tailors' tack is an example permanent stitch, True/False

6. a) The part of the machine that moves fabric under the presser foot is called _____
b)_________ holds fabric against the feed dog.

7. a) The stitch used to finish the eyelets is_________
b) Examples of decorative stitches are ________, _______and ________

References

Aishwariya, S. (2018). A Review on the History, Theories and Early Forms of Fashion and Clothing. *International Journal of Engineering Sciences & Research Technology, 7*(7), 270-275.

Bakare, K. O. (2016). Tourism Entrepreneurship and Youth Engagements in Host Communities in Ogun State, Nigeria. *Annals of Child and Youth Studies, 7*(1): 86 - 98.

Bakare, K. O. (2017). Tourism Business and Livelihood Outcomes of Host People in Southwestern Nigeria. *Journal of Tourism Research,* 15: 99 - 114.

Bakare, K. O. (2022). Theory of Clothing. Lecture note on Clothing Construction. Department of Consumer Sciences and Hospitality Management, Obafemi Awolowo University, Ile-Ife, Nigeria.

Diyaolu, I. J. (2010). Role of Dress in Socio-cultural Events among the Ijebu-Yoruba, Ogun State, Nigeria. *Journal of Home Economics Research*, *13*, 35-41.

Diyaolu, I. J., & Goriola, O. R. (2014). Perception of Cross-dressing among Undergraduates in Obafemi Awolowo University, Ile-Ife, Nigeria. *Journal of Art, Design and Technology, 4*(7), 105-119.

Diyaolu, I. J. and Omisakin, M. (2018). Use of Customized Dress among Undergraduates in Obafemi Awolowo University, Ile-Ife, Nigeria. *International Journal of Costume and Fashion, 18*(1), 79-88. DOI: 10.7233/ijcf.2018.18.1.079**.**

Diyaolu, I. J., Irefin, I. A., & Akarakiri, J. B. (2018). Technology Choices in Nigerian Textile Industry. *International Journal of Home Economics, 11*(1), 3-8.

Diyaolu, I. J. (2022a). Advocating Assistive Technologies in Clothing and Textiles Work-Based Learning among Persons with Special Needs in Nigeria. *Commonwealth of Learning, https://doi.org/10.56059/pcf10.5362,* http://hdl.handle.net/11599/4260 (Accessed 27/3/2023)

Diyaolu, I. J. (2022b). Total Quality Management Practices in Nigerian Textile Industry. In: Msahli, S., Debbabi, F. (eds) Advances in Applied Research on Textile and Materials - IX. CIRATM 2020. Springer Proceedings in Materials book series, vol 17. Springer, Cham. https://doi.org/10.1007/978-3-031-08842-1_39 (Accessed 30/3/2023)

Forster P. (2014). Clothing and Textiles. Winmat Publishing Ltd. Ghana

Leibovitz, A. (2021). Featured Masterclass Instructor. MasterClass Last updated: Aug 12, 2021 https://www.masterclass.com/articles/fashion-terms (Accessed 26/3/2023)

Scrappy Mel (2010). Images of Fasteners in Clothing Construction. https://www.bing.com/images/search?view=detailV2&ccid. Accessed 21/4/2023.

Smith, A. (2009). The Sewing Book. DK Publishing, New York

https://firstclassunisexfashion.blogspot.com/2021/05/common-sewing-machine-problem-and.html (Accessed 26/3/2023)
Sunshine Design (2009). (sunshinedesigns-carolynphi.blogspot.com) (Accessed 20/3/2023).
Webb-Lupo, A. and Lester, R. M. (1987). Clothing Decisions. Macmillan, Illinois.186

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CHAPTER 35

Basic Design in Textile Production

By

BAKARE Kudirat Oyebisi and ADIJI Bolajoko Esther

Overview

Textile design production just like any design endeavor requires certain processes. Critical evaluation of any design will reveal the elements and principles of design. The design outcome may not hit the purpose if efforts are not geared toward understanding and careful application of the basic ingredients. The concept of design is applied to any art work for beautification, function, and utility. Design is the product of interplay of a series of elements to create a piece that will suit a purpose. Design in any context is not totally different from design in textile production. Colour is one of the elements of design but it carries greater energy as it is the most appealing of all the elements. Discussion on colour in any design context cannot be overemphasized, hence, deep understanding of its characteristics aids its creative application. Motif is the basic unit of any design endeavor. The manner and pattern of placement of a motif gives rise to the creativity and pleasing effect of a design.

Objectives

At the end of this chapter, students should be able to:

1. differentiate between elements and principles of design;
2. list and explain elements of design;
3. list and explain principles of design;
4. explain the characteristics and categories of colour;
5. define concept of contour lines and illustrate the edges of objects in basic textile design;
6. identify different types of lines and illustrate lines to create form and texture;
7. explain the cohesive and balance design through the use of motifs;
8. create a sense of movement and a flow through design by repeating motifs;
9. illustrate motif arrangements by varying the size and placement of motifs;
10. explain the development of pattern repeat system;
11. develop motifs, repetition of various kinds of repeats forms; and
12. define colour wheel and colour theory.

Elements of design

Elements of design are the ingredients and/or components that constitute the building blocks of a design. Critical analysis of any design piece reveals a combination of two or more elements interacting to give appeal to sight and render certain utility quality. A design is a deliberate or well considered plan, not a hit-or-miss result. Design is defined as an arrangement of lines, forms, space, textures and colours. It involves the effort of choosing these elements and arranging them in order to get a good result. Beauty in design can be achieved through order and functional restraint. To create or judge in good taste, it is helpful to rely on fundamental art principles of design which are the building blocks of any design composition. Like in other production endeavours, the importance of elements of design cannot be over emphasized in both fabric production and garment construction. The elements of design are the basic components used as part of any design. They are the objects to be arranged, the constituent parts used to create the composition itself. In most situations the elements of design build upon one another, the former element helping to create the latter. These elements include line, form (shape), texture and colour.

LINE: Line is a series of connected dots or points. It occurs in different directions depending on design intention and purpose. Lines can be curved, straight, zig-zag and or a combination of types. Curve lines give softness and relaxed feelings; straight lines give effect of stability and stiffness; they may be vertical, horizontal or diagonal. Zigzag lines give the appearance of forcefulness and agitation. Lines can be visible or invisible, thick or thin, and can help direct the eye to a specific spot. The thickness of a line can communicate certain cues. Bold and thick lines can draw attention, while thin lines are the opposite. Lines in clothing construction are formed by seams, stitches, folds, hems, trims, and edges. Lines formed in the course of construction to achieve a structure of garment are structural lines while those formed to improve the appearance are decorative lines. With lines psychological effects such as illusions, agitation, and calmness are created. When a line starts from a point and comes back to the same point, it is said to have enclosed a space. Enclosure of a space will create a form with a definite identity called shape as shown in figure 1.

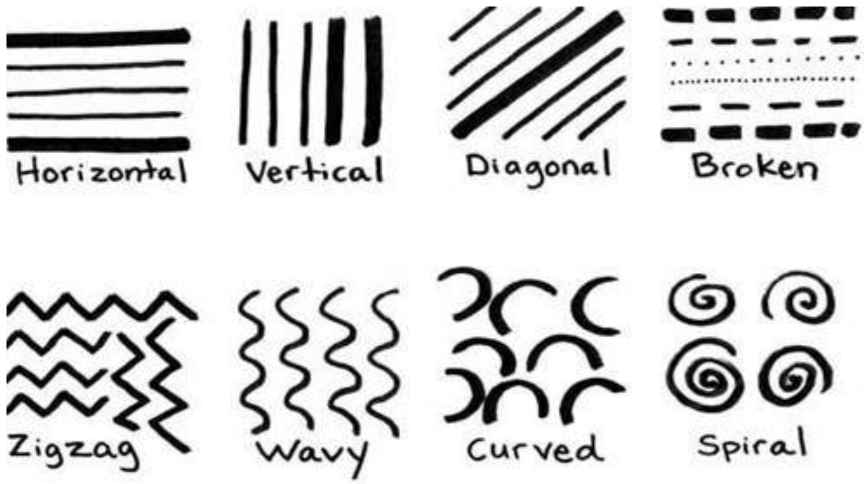

Figure 1: Different types of lines
Source : Pinterest

Colour: Colour is the sensation of light on a surface. It is the most visible of all design elements in a fabric / garment. Colour communicates moods and feelings. Another name for colour is hue. In other words, the originality of a colour is determined by the hue. Oftentimes, the three basic hues are the primary colours: red, blue, and yellow. Other colour categories are derived from the original hues. Colour has peculiar characteristics that form the basis for its description and formation. These are:

Hue: the foundation of all colours. These are the natural colours that cannot be produced by any formula but are used in different proportions and combinations to form other colours.

Value: is the degree of lightness and darkness of a colour. This is achievable by adding white, black, or a combination to a colour. Addition of white gives a tint, black to a colour forms a shade. And a combination of white and black will produce a tone.
Intensity/chroma: is the degree of brightness or dullness of a colour. A colour of high intensity is bright and a colour of low intensity is dull. Hence, the original hue of a colour sets the bar for its intensity. The closer a colour is to a primary colour, the higher the intensity or brightness and vice versa.

Categories of colours
Primary colours: These are basic colours like red, yellow and blue.
Secondary colours: They are products of mixing two primary colours together: red and yellow (orange), yellow and blue (green), and red and blue (purple).
Tertiary colours: They are products of mixing one primary colour with one secondary colour.

Also, colours are categorized based on their position on the colour wheel. The arrangement of colours in a circular pattern on the basis of the relationship with the hue is known as the colour wheel. Black and white are non-colours as they are colour influencers, but not part of hue and not created by mixing other colours. Colour is used by designers to portray mood, light, depth and point of view, and intentions. Designers use the colour wheel for standard description and choice. Colour scheme results through mixing, combining, and manipulating colors. Colour scheme gives the narratives of relationship between colours. They are:

Harmonious colours: These are created when two or more colours are chosen from their positions on the color wheel.

Complementary colours: They lie opposite one another on the colour wheel. They are highly contrasting, and can express vibrancy and energy or be visually jarring, depending on how they are used. Red and green are complementary colours.

Analogous colours: Colors that lie next to one another on the color wheel. They are visually pleasing and can create a sense of harmony and calm in a design. However, they can also seem dull if used incorrectly, or if they don't have other contrasting elements to energize them.

Texture: This is the spectacle or tactile roughness or smoothness of a surface. Texture is expressed by feeling/tactile and sight/spectacle (visual). Spectacle texture is often created by use of colour, lines, form, and space. Surfaces of fabric may be loopy, fuzzy, soft, rough, smooth, slippery/glossy, crisp, or scratchy. It is often apparent to the eye, for example gloss of a glass tile, stiffness of an organdy fabric, whereas, tactile texture can be appreciated by touching them, for example roughness of the bark of a tree, smoothness of a satin fabric. The hand and character of the fabric depends upon the fibre, yarn and weave used and the finish applied or any super-imposed pattern example printing, embroidery, etc. The texture of clothing affects the appearance. Smooth surface gives the appearance of thinness; fussy textures add bulk. Crisp textures increase size as they bolt out of the body. The understanding of texture is very important in fabric and garment production. With the use of textures, illusions are created to suit function and purpose of the design as shown in figure 2. Textures can be described as smooth, rough, fine, glossy, coarse, supple, stiff, lustrous, dull, metallic, stony, transparent, hairy, sticky, thorny, fluffy, opaque, etc.

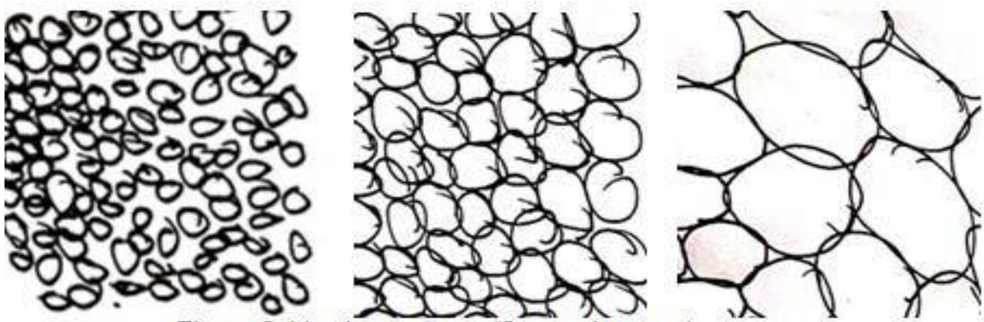

Figure 2: Varying textures (fine and coarse)

Texture effects colour, drape and silhouette. Different fabrics absorb dye (colour) and finish differently and, according to closeness or looseness of the weaves, absorption and light reflection occur differently. Smooth textures reflect light, making the colour more intense while rough textures absorb light, making a colour appear duller. For example: the black colour of a silk will appear brighter as compared to black colour of a woolen fabric which would appear to be darker and duller. A texture could be light (organdy) medium (linen) and heavy (worsted). The weight of the material would partially determine its behaviour and function. i.e. some fabrics will drape well, while others can be tailored and molded to your figure. For example: clinging fabrics like chiffon will reveal the contours of the body. Therefore, it is suitable for well- defined feminine figure. Heavy textures will add bulk, thus, making it unsuitable for short and stout figures. Also, soft textures would serve best for style with gathers, while stiff or crisp textures stand away from the body, increasing the apparent size and can be well used to hide figure defects. Texture as an element of art can be intelligently and interestingly used to create contrast which appeals more. At the same time, it is more important that one texture dominates. Thus, texture helps your design to be distinctive or have identifying character and characteristics. With the proper texture, your design will look more fascinating than the average design.

Shape/form: This is a product of a line enclosing a space to form a boundary. Shapes are two-dimensional and can be described as geometric, organic, and abstract. Shape and form are interchangeably used in designing while form is the three-dimensional version of shape as shown in figure 3. The next element of design is shape which is a closed line. Shape is distinguished from its surroundings by its outline within the design. Shape is a 2-dimensional line with no form or thickness and can express length and width. A flat figure shape is created when actual or implied lines meet to surround a space. A change in colour or shading can define a shape. The simplest definition of shape is a closed contour, an element defined by its perimeter. Shapes can be divided into several types: geometric (square, triangle, circle) and organic (irregular in outline). Any 2 - dimensional object is called a shape, and Forms are three - dimensional shapes, expressing length, width, and depth. Balls, cylinders, boxes and triangles are formed.

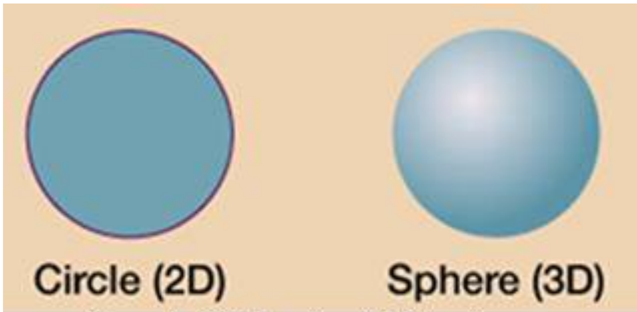

Figure 3 : 2D (shape) and 3D (form)
Source: Pinterest

Form is similar to the idea of shape. Form is the structure of the design having volume and thickness. It is the illusion of a 3-D effect that can be implied with the use of light and shading techniques. Form can be viewed from many angles. Form can be both two-dimensional and three-dimensional and can be realistic, abstract or somewhere in between. The terms form and shape are often used synonymously.

Geometric shapes: They have definite structure and are precise (squares, circles, triangles, rectangle, cubes, oval, pyramids, cylindrical, pentagons, octagon, hexagon, decagons, ellipses, and spheres). They are often symmetrical. Shapes add emphasis to a layout and give focus.

Organic shapes: lack well-defined edges and often feel natural and smooth. They can be symmetrical and asymmetrical.

Abstract shapes: are minimalist representations of reality. It is an intentional dramatic variation of the real outline. These include natural shapes, such as leaves, crystals, and vines. Any real object can have a non-realistic shape that will seemingly have the resemblance but not actual. A line that encloses a space results in a form and the definition of the form is a shape as shown in figure 4.

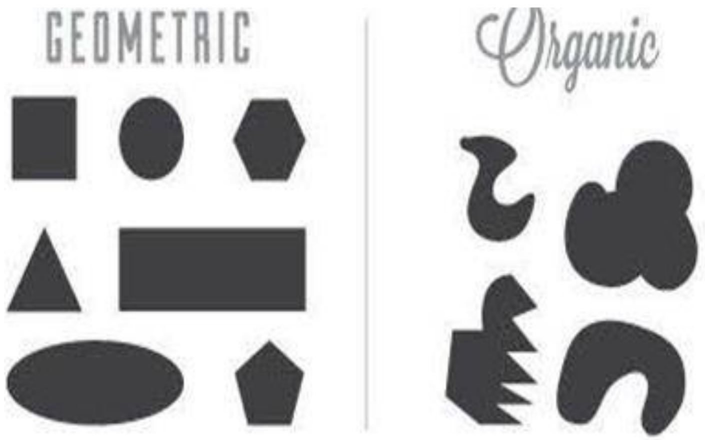

Figure 4: Organic and abstract shapes
Source : Pinterest

Principles pf design
These are the guidelines and policies that guide the application of elements of design (line, colour, texture, shape/form, etc.) to create a desirable design effect on a piece. They are: balance, emphasis, rhythm, proportion, and harmony.

Balance: This is as fundamental in visual arts as it is in life itself. It is the stability in a design. It is the even distribution of visual weight or size. It can be formal/symmetrical or informal/asymmetrical. Formal balance is created with the same design (line, colour, and texture) on both sides. It is informal with different designs on the two sides. The effect is achieved by manipulating elements such as line, colour, and texture to make specific parts of a design unique. It produces a feeling of rest. It is the result of the equalization of attractions on either side of a central point. Balance can be attained in colour, texture, pattern, light as well as in weight. In most cases, balance is desired. However, imbalance may be intentionally desired in some instances. The understanding of balance will be applied to create imbalance/unbalance. To keep design balanced, the measurements should be as accurate as possible. Keeping the design symmetric is a good technique for good balance, but not necessarily the best for all types of designs. There are three types of balance:

- Formal or Symmetrical,
- Informal or Asymmetrical
- Radial Balance

Formal Balance: results when objects of equal weight are placed on each side and at the equal distances form the center, when they are identical the balance is formal or symmetrical. Under normal circumstances it assumes identical forms on both sides of the axis. In addition, it is possible to build a composition equally around a central point resulting in radial balance symmetry. Formal balance gives a feeling of neatness, strength, straight forwardness, thus it seems suitable for tailored clothes which have the same pockets, tucks or darts on one side as on the other. Figure 5 below showed the asymmetric (formal) and asymmetric (informal) balance as shown in figure 5.

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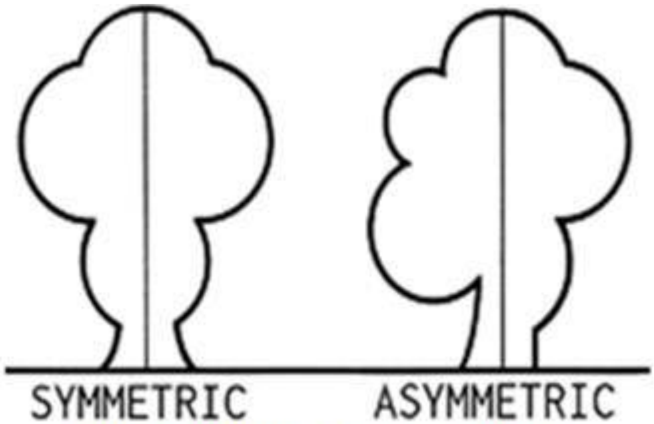

Figure 5: Symmetric and asymmetric balance
Source: Pinterest

Informal Balance: This is the asymmetrical balance. It results when objects are so arranged that a large one near the center balances a small one from the center. Asymmetrical balance occurs when the weight of a composition is not evenly distributed around a central axis. It is more creative than formal balance, because there are no rules or regulations to guide one in its production. Informal balance is not easy to achieve or analyze. It is softer, more graceful due to transitional lines, and suited to gay or dramatic mode dresses.
Radial balance: is equidistant balance created around the radius of the design composition.

Emphasis: It is dominance of part with subordination of others. It is that design principle by which the eye is led first to the most important part and then to the other parts in order of their importance. An object gains emphasis if given enough plain space for the background. This principle of design can be applied to one's clothes by accentuating one's good figure point and concealing one's figure defects. In applying such a principle, it is necessary to know these three considerations: What to emphasize.? ii. How to emphasize? iii. How much to emphasize?
Simplicity is the keynote to all good designs, but when doubtful it is better to under emphasize rather than over emphasize a design. Emphasis is given to an area within the design because the area is meant to be
seen or is more important to be noticed when compared to other parts of the design. For example, a design has white parallel lines going up and down, the center of the design has a circle. The

circle will be a part of the design that is emphasized. Thus, emphasis is the part of the design that catches the viewer's attention at a glance. Usually an artist makes one area stand out by contrasting it with other areas with respect to size, color, texture, shape, etc. Emphasis is thus a specific area of interest created by the designer to passively pass a message.

Rhythm: This is achieved by specific or organized placement of the unit of design to create a systematic flow. Rhythm can be created by repetition, variation, and progression.
Types of rhythm: Random rhythm: occurrence of elements without any regular pattern.
Regular rhythm: applying the elements in a regular size and length and interval
Progressive rhythm: a sequential flow of elements of design. For example: a colour gradient.
Flowing rhythm: it is a natural pattern where the intervals are organic.

Proportion: This is the comparison of one side to another and in relation to the total look. It is the relationship between two or more elements in a design, particularly the size and scale. ‘‘Proportionate” means there is a coordination between the elements that makes the design look aesthetically appealing.
It gives pleasing space divisions. It states the relation between parts of design with each other and with the whole. It deals with relationships in size, shape, colour, light, texture and pattern. Differing proportions within a composition can relate to different kinds of balance or symmetry, and can establish visual weight and depth. For a design to be pleasing, its parts should be close enough in size to appear to belong together but varied enough to apply interest. The human figure is considered to be of beautiful proportion. If it were to be divided into eight equal parts then three parts fall above the hollow of the waist and five below it. In the below examples, notice how the smaller elements seem to recede into the background while the larger elements come to the front. Descending proportion is illustrated in figure 6.

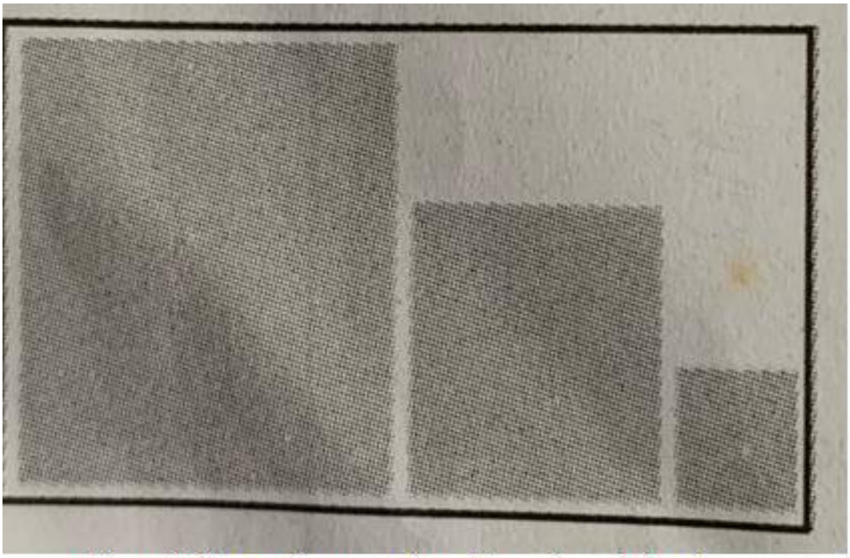

Figure 6: Descending proportions / Proportion relative size
Source: Pinterest

Harmony: It is the agreement that binds all elements together for a pleasing effect. The elements should be in accord for pleasing design. It is relatedness without sameness but suitability. It is the feeling of unity (oneness) without monotony throughout the design by appropriate use and choice of lines, shapes, forms, textures, size, value, and intensity of colour. When all the principles of art are followed, it will result in complete harmony/unity of design. In order to secure harmony in a design, the following rules should be observed:

- spaces must be interestingly distributed.
- shapes must be similar and properly balanced.
- structural and decorative lines must be consistent.
- texture must be pleasingly combined.
- ideas must be related.

If a design composition has wavy lines and organic shapes present, the use of geometric shapes in the same, would not result in harmony of the design. This concept of unity describes the relationship between the individual parts and the whole of a composition. It investigates the aspects of a given design that are necessary to tie the composition together, to give it a sense of wholeness, or to break it apart and give it a sense of variety. Thus, effective use of the elements and principles of design would surely lead to a creative and appealing design composition.

Contour and outline

Contour is a line that defines the outline of an object. The word contour comes from a French word, it is defined as the outline of a subject, it is often the line contour defines a form or an edge of a subject. As such the line contours define the boundaries of a shape or object. A contour drawing does not include details in it, such as shading, it is an outline of the form only. Contour drawing is an essential technique in the field of textile production, because it is a strong foundation for any drawing, fashion drawing or painting. It can modify a subject form through variation within the lines in the hands of a talented master, the lines that convey contour can deliver an astonishing amount of visual delight. Contour line drawings are often used as a starting point for more complex basic design works, such as fashion drawings. They help fashion designers to create a framework for their work and provide a foundation for exploring the subject further.

Concentrate on the outer form or outline of the object and quickly draw and contour the form. This is the style of drawing that children or beginners start with. We can see the idea of contour drawing in stick figures that many people have drawn in their lives to capture simple human drawing forms as shown in figure 7.

Figure 7: Contour lines for shaping
Source: Pinterest

Formation of motifs and pattern repeat

Motif is the basic unit of a design/pattern. It is the raw form of design. Most designs incorporate the basic elements and principles of design which are very important and essential to develop a good design. A designer creates designs on the basis of new design ideas or gets inspired from records, such as magazines, books, imagination from nature and the environment. Design is synonymous to pattern, figure or motif which is repeated at regular or irregular intervals either in weaving or printing. These could be grouped as follows:

1. Naturalistic motif-use of natural things, shapes etc.;
2. Geometrical motif- based on lines, shapes and forms;
3. Stylized motif- inspired by nature, compose and distort;

4. Floral motif-inspired by flowers and foliage; and
5. Abstract- based on non-figurative designs.

Many design compositions with different effects could be created through variations of placement and diverse appearance of a motif or a pattern in different units.

- **Straight or simple repeat:** the design repeats exactly in the same way as seen in figure 8A.
- **Mirror repeat:** this makes a mirror repeat in horizontal and vertical direction in figure 8B.
- **Half-drop** repeat: it is also called brick repeat. The designs are arranged like bricks in a vertical direction as in figure 8C.
- **Half-slide:** it is arranged in a brick form just like half drop but in a horizontal form. By these, when a design will reappear on a fabric forming different repeat patterns it would create varied styles and effects on the fabric surface.

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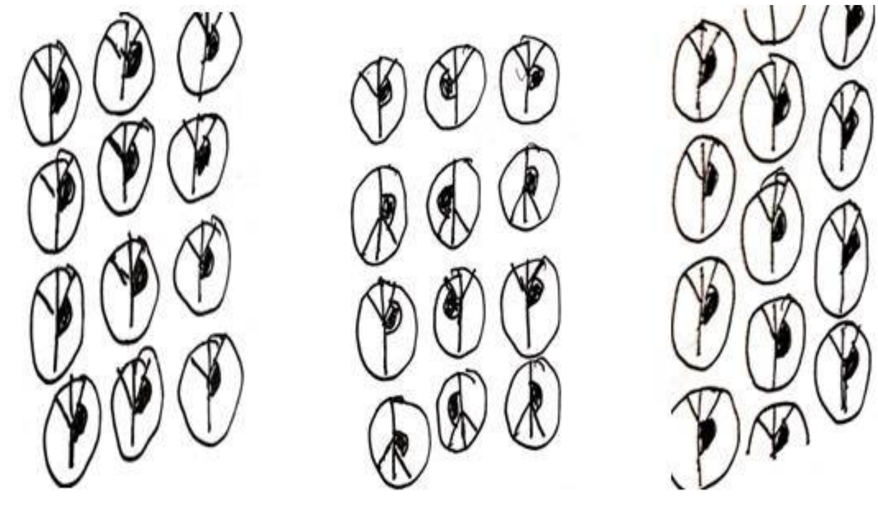

A. Simple / full drop repeat B. Mirror repeat C. Half drop

Figure 8: Repeat types

Colour

Colour is one of the most noticeable attributes in the world around us. Colour plays an important role in our lives and it can change moods, reduce or increase tensions, cause excitement and can stimulate a soothing effect on a fatigued person. For babies and small children, understanding colour is an essential building block during their formative years. Colour is the element of art that refers to reflected light on a surface. Colour theory is defined as a theory because it cannot be proved. Colour is one of the most important features of art and design. It renders a meaning to the design. When there is harmony in colour, a pleasing sensation is produced. However, a clash in colours can cause discord. Colour can be similar and related, colour can also be contrasting, and can be harmonious. Similar and related colours are produced from colours that lie adjacent to each other on the colour wheel. There are two related colour harmony: monochromatic colour and analogous colour. Monochromatic colour is where several values of one colour illustrate this harmony, while analogous is a combination of neighboring colours with one colour in common. E.g.: yellow-green, yellow, yellow-orange; Yellow is the common colour here. There are contrasting colours that could also be used and there are colours that also compliment and harmonize in accordance with the law of areas. Light, dark or dull colours can be used in large areas. Colour has an effect on feelings and acceptance of objects, how we behave, and how our bodies react to circumstances. Colour affects our mood.

Colour wheel

Colour wheel was first invented in the 1600s by one of the most renowned scientists in western history, Sir Isaac Newton. It is an important part of colour in art because it provides a visual colour key so to say, of the different color categories and how they relate to one another. Colour is a universal perception. Our eyes see something (the sky, for example), and data sent from our eyes to our brains tells us it’s a certain colour (blue). Objects reflect light in different combinations of wavelengths. Our brains pick up on those wavelength combinations and translate them into the phenomenon we call colour. The colour wheel has three different types of colours basically - Primary, Secondary, and Tertiary as shown in figure 9. The primary colours are red, yellow, and blue. They are primary colours for they cannot be formed from other colours but they are mixed to form other colours. In other words, primary colours can only be created through the use of natural pigments hence, they are called natural hues. The secondary colours are orange, green, and purple. Secondary colours are created by mixing equal parts of any two primary colours. Yellow and blue will give green; red and blue will create purple (violet) and red and yellow will form orange.

Tertiary colours are created by mixing equal parts of a secondary colour and a primary colour together. There are six tertiary colours - red-purple, red-orange, blue-green, yellow-green, blue-purple, and yellow-orange.

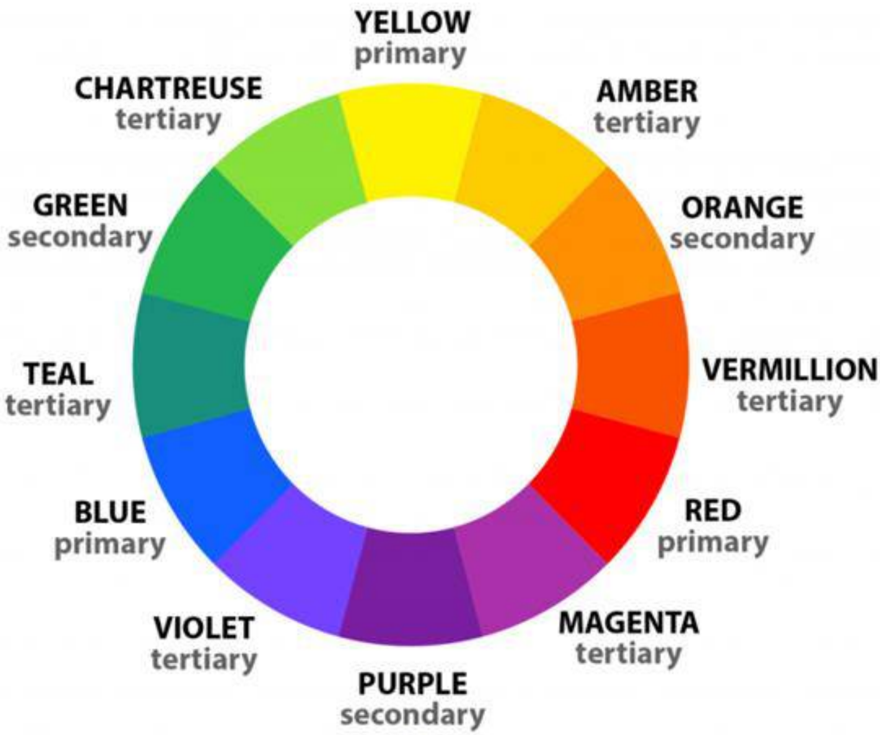

Figure 9: The colour wheel
Source: Pinterest

Colour theory
Colour theory is the collection and combination of rules and principles that guide designers in the use of colour and its communication with end users through visual interfaces and descriptions. Colour theory guides the collective adherence to certain terminologies and description of colours to the basic understanding of players (designer and end users). Colour theory can be simplified by breaking it into 3 aspects: colour system, and color scheme, and colour spectrum.

Colour system is the method of mixing colours to create other colours.

Colour scheme is the combination of an arrangement or combination of colours, especially one used in interior decoration:

Colour spectrum is the arrangement of colours in a row that reveals the relationship between colours. The colour wheel was developed by Sir Isaac Newton by bending the colour spectrum into a circle.
Understanding each section of colour theory will help to better communicate colour language and attributes to a significant advantage in the creation of art/design. If you follow the colour wheel, you will find the same order on the colour spectrum- red, orange, yellow, green, blue, indigo (blue-

violet), and violet; acronym- ROY G BIV.

Summary

The chapter is about basic design in textile production. It delineated the various ingredients and guidelines necessary for design creation (elements and principles). The concept of design and motif formation was also discussed. The chapter explained the importance of motif in any design composition, its formation and repeat system. Although the skill of designing is quite multifaceted, it requires the designer to understand its basic principles, elements and concepts to produce varied patterns, colour uses, effects, and styles for textile and apparel production which constantly demand changes and innovations. Most importantly, the concept of colour, colour wheel, and colour theory was comprehensively discussed.

Exercise

1. What are the elements of design?
2. What is the importance of principles of design?
3. Differentiate between elements and principles of design
4. Mention and illustrate the different motif arrangements
5. What are the various sources of motif?
6. List the different types of motifs.
7. Define colour wheel and explain the different relationships between colours
8. What is the importance of colour theory in textile production?

References

Adiji, B. E. (2019). Lecture Note on Basic Design. Department of Industrial Design, Federal University of Technology, Akure, Nigeria.

Bakare, K. O. (2021). Lecture Note on Elements and Principles of Design. Department of Family, Nutrition and Consumer Sciences, Obafemi Awolowo University, Ile- Ife, Nigeria.

Charm Swami (2011). Textile Design Theory on concepts. New age International Publishers Materials.

Heather, P. J. (1948). Folklore, vol 59, pg-165-183 published by Taylor and Francis, ltd.

Woodball and Constantine (2004). What you wear can change your life. A methodology for semotic. Analysis of fashion collections chromatic project: Halo Jose de medeuros Dantas 1, camila assis peres sil val.

Federal University of Compina grande, Brazil. Colour symbolism: part 1, pp 46.

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CHAPTER 36
Textile Materials
By
AMUBODE Adetoun Adedotun

Overview

Textile is a woven fabric made of fibers that is used to make items such as garments, shoes, bags and home wares like bed sheets, cushions, and towels. It can be from natural or synthetic sources. There's a huge range of fabric types, and it can be thick or thin, rough or smooth, heavy or lightweight. The properties or characteristics of different types of fabric depend on what it is made from. There are different methods of constructing fabrics. This includes weaving, knitting, quilting, crocheting, lacing, netting, felting, among others. Fabric finishes such as beetling, calendering, flame resistance finish, moth proof, etc. are applied to fabrics before or after production of the yarn/fabric to improve the fabric performance and properties. The various types of fabrics include: cotton, canvas, linen, silk, rayon, wool, chiffon, lace among others. The fibres of these fabrics can be combined to produce either blends or mixtures of fabrics. The fibres or fabrics can be identified through visual inspection, microscopic examination, burning test, absorbency test, and solubility or chemical test.

Objectives

At the end of the course, students will be able to:
1. identify the sources and classification of fibres;
2. describe the characteristics of natural and man-made fibres;
3. explain common terms in textiles;
4. identify different methods of constructing fabrics;
5. explain the purposes of fabric finishes and be able to describe the types of finishes;
6. identify the different types of fabric;
7. explain the reasons for fabric combinations and differentiate between fabric blends and fabric mixtures;
   and
8. identify the uses of different fabrics.

Introduction

Textiles are fabrics produced by weaving, knitting, crocheting, lacing, felting, bonding, netting or through lamination. Textile is use in our daily life and the knowledge of textiles will enable us to purchase good quality materials. Textiles are produced from fibres or yarns. Fibres are the fundamental units used in the production of textile yarns. Yarns are produced by twisting or spinning of the textile fibres. Fibres can either be from natural or man-made sources. Natural fibres can be from plants or animals. Fibres that are derived from plants are called cellulose or vegetable fibres while fibres from animals are protein fibres. Fibres have different properties which determine their characteristic behavior or performance, however, fibres of the same source, have similar characteristics. Fibre or fabric contents can be identified using either or a combination of visual inspection, microscopic examination, burning or/and absorbency test. Textile manufacturers usually add treatments to fibres or fabrics to change undesirable characteristics of the fabric so that the product is acceptable to consumers.

Sources and classification of textile fibres

The origin of textile fibres are either natural or man-made. Fibres which exist in nature are called natural fibres, while those manufactured are called man-made fibres. Natural fibres may be obtained from plants or animals while man-made fibres are manufactured from chemicals. A fibre which has components from both natural and chemical sources is called a regenerated fibre such as rayon and acetate. Fibres from plants such as cotton and linen are cellulose fibres; fibres obtained from hair of animals or secretion from cocoon of silkworm are protein fibres such as wool and silk while man-made fibres are synthetic fibres.

Properties/characteristics of textile fibres

The properties of fibres determine their characteristic behavior or performance. Fibres of the same source, have similar characteristics.

General properties/ characteristics of cellulose fibres

1. Cellulose fibres are staple in length.
2. They have great tensile strength and this makes them strong and durable.
3. Cellulosic fibres have low resiliency which make them to wrinkle badly and need ironing to smoothen them.
4. The fibres have high absorbency rate therefore they are comfortable to wear in hot weather.
5. They have low elasticity, so they do not stretch much.
6. They have low lustre and therefore look dull.
7. Cellulosic fibres are highly inflammable and burn readily and quickly with yellow flames.
8. They can withstand high temperature, so they can be ironed with high temperatures.
9. Prolong exposure to sunlight will bleach or whiten and weaken cellulosic fibres.
10. Cellulosic fibres will develop mildew when stored under damp conditions and will be damaged by insects and bacteria.
11. They are good conductors of heat, so, they are cool to wear and are therefore suitable for warm weather.

12. They are highly resistant to alkalis. Therefore, soaps and other alkali base chemicals are safe to use on cellulosic fibres.

General properties/ characteristics of protein fibres

1. Protein fibres are relatively light in weight.
2. They are lustrous fibres.
3. They do not burn easily when exposed to flame.
4. They are poor conductors of heat. Hence, they are suitable for cold weather.
5. Wool fibres are in staples but silk is a filament fibre.
6. Both wool and silk are strong in their dry state but weak in water. Wool is comparatively weaker in water than silk.
7. Silk is less absorbent than wool. In relatively dry weather, wool and silk may develop static electricity and give shocks.
8. Sunlight causes white protein fabrics to discolour slowly and turn yellow.
9. Silk is resistant to attack by mildew and is relatively resistance to bacteria and fungi.
10. Protein fibres are harmed by chlorine bleaches.
11. Protein fibres have poor resistance to alkaline, so they can be damaged by soap.

General properties/ characteristics of synthetic fibres

1. Synthetic fibres are very strong whether dry or wet so they are durable.
2. They are easy to wash with little or no ironing and do not wrinkle easily.
3. They are thermoplastic so they melt when exposed to high temperature but they accept warm temperature.
4. They have low absorbency rate and so dry quickly.
5. They easily absorb oil, so oily stains are difficult to remove from synthetic fabrics.
6. They are resistant to many chemicals.
7. They are resistant to insect attack and they do not develop mildew.
8. They are dimensionally stable, so, they do not stretch or shrink.
9. They do not conduct heat, so they are warm to wear and are not suitable for warm weather.
10. Synthetic fibres shrink away from flame on approaching it, they melt and form gummy residue, so it is dangerous to use them close to fire.

General properties/ characteristics of regenerated fibres

1. Regenerated cellulose fibres are lustrous, have low resiliency in rayon and to some extent in acetate, but triacetate has good resiliency.
2. They are resistant to dry cleaning solvents and stain removal agents.
3. Mildew will develop on all types of regenerated cellulose fibres.
4. Rayon is very absorbent but acetate and triacetate have fair absorbency rates.
5. They have medium strength hence they are durable.
6. They deteriorate when exposed to sunlight but have good resistance to aging.

7. Rayon burns rapidly with yellow flame; residue is off white, fluffy or light grey and it is a good conductor of heat. Acetate and triacetate fuse away from flame and turn black in flame, they burn quickly, melt and in case of triacetate, it drips like burning tar. When out of flame, they continue to burn and melt.

Definition of textile terms

Textile: Textile is a fabric (Woven or knitted) made from yarn.
Fabric: Any cloth made from yarn or fibres by weaving, knitting, felting, etc.
Fibre: It is any hair like substance, natural or manufactured, which is fine and flexible and can be processed into fabric.
Natural fibre: Natural fibres are the fibres that are obtained from plants, animals or mineral sources.
Man-made fibre: This is a fibre that is artificially produced and not of natural origin.
Yarn: is a mass of fibres twisted together to form a thread which can be used to make fabric.
Fabric: Fabric is a cloth produced by weaving cotton, nylon, wool, silk, or other yarns together.
Filament: a filament is a long fibre measured in kilometers. Silk is an example of natural filament fibre.
Staple fibre: is a short fibre measured in centimeters. Cotton, wool and linen are staple fibres.
Selvedge: this is a finished neatened edge of a fabric. A fabric usually has two selvedges. The warp yarns are always parallel to the selvedge.
Grain: the grain of the fabric are the vertical and perpendicular threads which are woven together to create the fabric.
Warp yarns: these are yarns laid on loom on which fabric is woven. Warp yarns are parallel to the selvedge.
Weft yarns: these are filling yarns for the warp yarns. Weft yarns run perpendicular to the warp and selvedge of a fabric.
Fabric thread count: this is the number of warp and filling yarns (weft) per cm or inch. It is an indication of the quality of the fabric. The higher the thread count, the better the quality of fabric and less likely the fabric is to shrink or fray.

Methods of fabric production/construction

Fabric may be produced by weaving, knitting, quilting, crocheting, lacing, bonding, netting, felting and by lamination. The most common methods used in fabric production are weaving and knitting.
Weaving is the interlacing of warp and weft yarns at right angles with one another. The warp yarn must be able to withstand the weaving tension. The warp yarn lies parallel to the grain of the fabric and does not stretch. The weft yarns are also called the filling yarns. Weft yarns stretches. There are three basic methods of weaving. These are plain weave, satin weave and twill weave. All the other weaves are derivatives of these basic weaves or their combination.

Plain weave: Plain weave is the simplest of all patterns. Each weft yarn goes alternately over and under one warp yarn and each warp yarn goes alternately over and under each weft yarn. This is done by interlacing horizontal weft threads on vertical warp threads, going over the first and under the second, over the third and so on. Fabrics of plain weave include calico, voile, crepe, taffeta, organdy and muslin. These are shown in figures 1a and 1b.

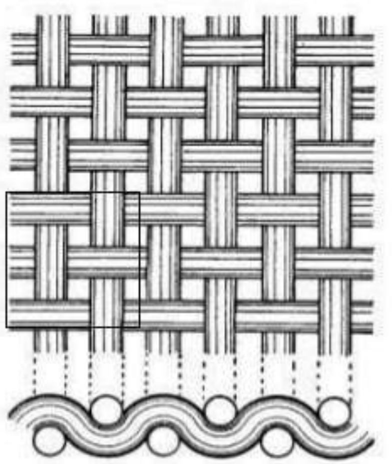

Figure 1a. Plain weave

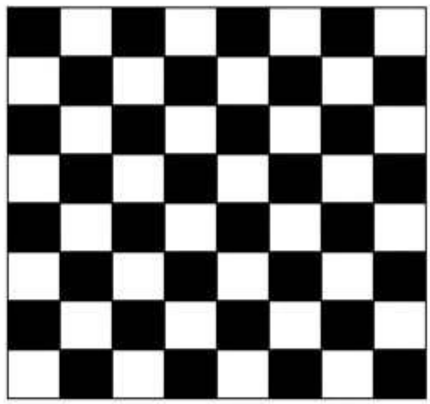

Figure 1b. Plain weave

Source: Kiron (2021)

Twill Weave: - This weave is created through moving the weft yarn over and under several warp yarns alternately which produce a diagonal ribbed pattern on the material's surface. In this weave, one or more warp fibers alternately weave over and under two or more weft fibers repeatedly (weft-faced) or one or more weft fibers alternately weave over and under two or more warp fibers repeatedly (warp-faced), creating a characteristic diagonal appearance as shown in figure 2. Twill fabrics include denim, tweed, gabardine, jean and flannel.

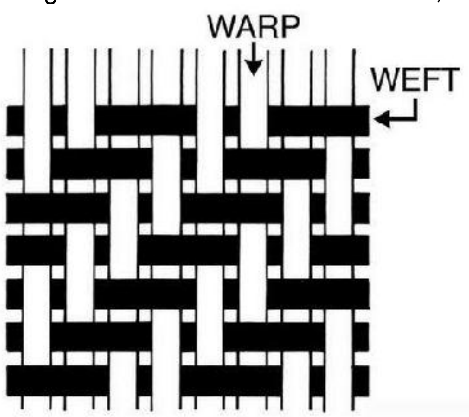

Figure 2. Twill weave

Source: Kiron (2021)

Satin weave: - The satin weave is known for its silky and elegant appearance. Satin weave has a very smooth, shiny surface due to the effect of the weft threads that seem to float over the warp yarn. This weave is produced by the interlacing of four or more weft yarns over one warp yarn or vice versa, resulting in a smooth face. Satin weave can be either be warp faced or weft faced. The fabric surface of a warp faced satin fabric will show on the warp threads while weft faced will show the weft threads. Weft faced satin weave is also called sateen.

The fibers used to create this fabric are known as filament fibers and include silk or nylon. Satin is used nowadays for bridal gowns, evening dresses, ballet slippers, and more. Satin woven fabric includes satin and antique satin as shown in figure 3.

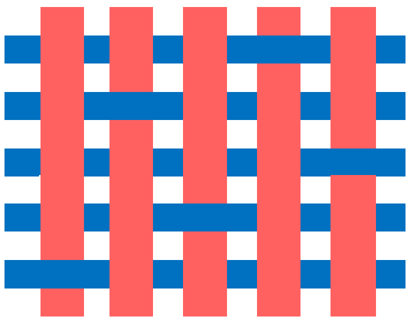

Figure 3. Satin weave
Source: Kiron, (2021)

Knitting: Knitting is the inter-looping of one or more sets of yarns. It is the traditional method of producing sweaters, hosiery, baby wear and blanket. Knits are stretchy elastic fabrics, porous, resilient and bulkier than woven fabrics. Knits are used for apparel, furnishing and industrial products.

Quilting: This is the combination of three layers of sheets of fabrics (face fabric, fibre fill or batting and backing fabric) to produce a single fabric. The layers are stitched and chemically fused with adhesive to form one fabric. Quilt fabrics are often used to make bedspread, oven mitts and place mats.

Crocheting: This is a continuous loop of a single yarn to produce fabric or an article.

Lacing: This is a network of threads or yarns formed into designs. Examples include lace fabric, and lace trim.

Bonding: This is the combination of two fabrics into one fabric with foam. Examples include some floor covering and bags.

Netting: Yarns are used to make an open mesh fabric called net. Net is used for making clothes, curtains, millinery, veils and in inter-lining.

Felting: Felt fabrics are made directly from the fibres. The fibres are compressed to form a film. Felts are usually made from wool but synthetic fibres may be used for the same purpose.

Lamination: This is the combination of two layers of fabrics into one fabric with adhesive, e.g. an oil cloth fabric which has an oil-cloth on one side and cotton on the other side.

Fabric finishes

Fabrics have the same properties of the fibres used in their production. Manufacturers usually treat textile products to change undesirable characteristics of the fabrics to make the products acceptable to consumers. These treatments given to textile products are called finishes.
Finishes may be given to fibres, yarns and most often fabrics before or after the production of the yarn or fabric to alter the basic properties of appearance, feel, or performance and make them more marketable.

Types of finishes

1. **Abrasion resistant finish:** This is a process designed to improve the abrasion resistance of fabric. It is commonly used in linings.
2. **Absorbent finish:** This improves the absorbency of the fabric for better comfort.
3. **Antiseptic finish:** This inhibits the growth of bacteria or destroys bacteria on textiles. Fabrics for medical use are given antiseptic finish.
4. **Antistatic finish:** This is a compound that is added to the fabric surface to absorb moisture, conduct electricity or neutralize the build –up of static charges. This finish is applied to synthetic and protein fabrics since they have the tendency of being electrically charged.
5. **Beetling:** This is a mechanical finish applied to cotton and linen to flatten the yarns to increase lustre or sheen.
6. **Bleaching:** A yarn or fabric is treated with chemicals to whiten it in preparation for dyeing.
7. **Calendering:** This is a mechanical finish similar to pressing. The fabric is passed through rollers to give a smooth, flat, ironed finish.
8. **Carbonising:** This is cleaning of wool before processing to improve the appearance and performance of wool.

9. **Durable press:** This is a type of aesthetic finish. The fabric is finished to maintain a smooth, flat, unwrinkled appearance during use, care and storage.
10. **Embossing:** Embossing is a particular calendaring process through which a simple pattern can be engraved on the fabric with the application of heated.
11. **Flame resistance finish**: This is a finish that is applied to fabrics to reduce the flammability of the textile product. Fabrics given this finish do not catch fire.
12. **Flocking:** This is a type of aesthetic finish where particles of fibres are sprayed in different designs onto the surface of another fabric to beautify it.
13. **Mercerisation:** This is treating a cellulosic fabric or yarn with an alkali such as caustic soda to straighten the fibres and makes them shrink, become stronger, more lustrous and more absorbent. It is used on cotton, linen, ramie and rayon fabrics.
14. **Mildew control:** This is a finish that reduces the growth of mold and mildew especially on cellulose fabrics.
15. **Moth proof:** The fabric is treated with chemicals to make it impossible for moth to attack it. This finish is often given to protein fabrics.
16. **Napping:** This is a finish in which the fibre ends are brushed to the surface to produce a soft feel as in carpets.
17. **Scotch guard:** This is a fabric finish given to fabrics to resist staining.
18. **Shape retention:** This is a finish that controls wrinkling or creasing with heat or resin. This includes crease retention and durable press finishes.
19. **Shrinkage control:** This is a finish that minimizes tension on fabrics to reduce shrinkage during use.
20. **Shrinkage resistance:** This is a finish which enables a textile product to retain its original size during cleaning.
21. **Singeing:** The fabric is passed over flame to burn off loose fibres on the surface of woven fabrics. It gives a smooth surface.
22. **Sizing:** Starch, resin or gelatinous substance is added to fabrics to increase the abrasion resistance, especially in preparing warp yarns for weaving.
23. **Soil-release finish:** This is a chemical surface coating on fabrics to improve the removal of soil during laundering or other cleaning procedure.
24. **Water-proof finish:** This is a coating to prevent the penetration of water as in fabrics used for umbrella.
25. **Weighting:** This is a treatment of metallic salts given to silk to increase the weight, and dyeing.

Methods of fabric identification

Knowledge of fibre properties/ characteristics is essential in identifying fabrics. However, the fibre contents can also be identified through visual inspection, microscopic examination, burning test, absorbency test and solubility or chemical test.

A. Visual Inspection: - this is the first step in fabric identification, but it is not reliable because synthetic fibres can resemble natural fibres. Visual inspection provides clues to narrow the number of possibilities in fibre identification. For example, touching a fabric which feels rough may be wool and not silk. In visual inspection, the length of the fibre, the lustre or dullness, and the texture of the fibre is examined.

To inspect the length of the fibre, one has to remove the yarn and untwist to see the fibre length. Any fibre can be made in staple length but not all fibres can be in filament form. Filament fibres are usually man-made except silk. Silk is the only natural filament fibre. In lusters or dullness inspection, a fibre may be shiny/lustrous or dull. Cellulose fibres generally tend to be dull while protein fibres tend to be shiny. Synthetic fibres may however be shiny or dull depending on how the manufacturer wants them to look like. Texture identification involves the use of the hand to feel the fibre or fabric by touching. Touching the fibre or yarn or fabric will help to feel the texture and weight. Fibre texture may range from soft to hard, rough to smooth, warm to cool and stiff to flexible. Silk feels smooth and light, wool feels bulky while cellulose fibres (cotton, linen, jute etc) are firm with medium density, Forster (2016).

B. Microscopic Examination: - fibres can be identified by examining the structure through a microscope. Natural fibres are best identified under a microscope but it is not possible to identify synthetic fibres through this method because many of the synthetic fibres look alike and their appearance may be changed by variations in the manufacturing process. Microscope pictures showing cotton, flax, wool and silk fibres. Cotton looks like a ribbon with twists (convolutions) along the length of the fibre; linen looks like a single fibres (ultimates) have nodes at intervals along the fibre length and irregular width. Often a bundle of fibres tightly packed in the lengthwise direction, rather than individual fibres. The outer surface and edges of wool is rough because of the overlapping surface scales. Animal hair show different surface. Silk looks like cylindrical, smooth rod with periodic bulges, Schwenck, (n.d.), Forster (2016).

C. Burning Test: - this test can be used to identify the chemical composition of a fibre. Fibre blends and mixture cannot be identified by this method. Burning test can be very effective when combined with visual inspection. To perform burning test, take a small sample of the fibre and burn it. See how the fibre burns or melts, and smell carefully. Take a look at the ash, cellulose fibres smells like burned paper, protein fibre smells like burned hair while synthetics fibres will melt.

Burning characteristics of textile fibers

Fibre	Approaching Flame	Stationary in Flame	Withdrawing from flame	Odour	Residue
Cotton	Ignites at first	Burns rapidly	Smolders glows smokes	Burning papers or leaves	Soft gray not much

Linen	Ignite quickly	Burns rapidly	Burns actively	Burning paper	Soft gray, fine
Wool	Draws away from flame	Melts, Burns	Self-extinguishing	Burned feathers or hair	Crushable brittle black
Silk	Draws away from flame	Melts, Burns	Self-extinguishing	Burned feathers or hair	Crushable brittle black
Rayon	Ignites in contact	Burns	Burns slowly	Burning paper	Little or no ash
Acetate	Melts before contact	Melts burns with yellow flame	Melts	Burning paper and vinegar	Hard dark bead
Nylon	Draws away and melts	Melts, burn and drips	Burns with difficulty	Celery	Hard bead cream color or dark
Polyester	Melts before contact	Melts burns black smoke	Burns for a while ; self-extinguishing	Sweet chemicals	Hard bead cream color or dark
Acrylic	Melts burns before reaching flames	Melts burn	Sputters, burns	Boiled fish	Hard irregular bead

Source: Khan, Abir, Rakib, Bhuiyan and Howlader (2017).

D. Absorbency Test: - this test can only be used to identify the source of the fibre. Natural fibres absorbs moisture very well but synthetic fibres have low absorbency rate. Some regenerated fibres like rayon also absorbs moisture very well because it has greater percentage of its components being cellulose.

E. Solubility or chemical test: - Chemical test are also used to identify fibers, because they give accurate analysis, however this test is not intended for the consumers.
Stain test: This is also known as the Double Barrel Fiber Identification (DBFI). To perform this test, a fiber will be treated with stain. Each fiber has two distinct colour reaction to stain when treated with dilute acetic acid and when stained with mild alkali
Solvent test: Fibers can be identified by treating with certain solvents/chemicals, however, this test is difficult to perform because most of the man-made fibers and their

blends are chemically similar and there is no chemical or solvent that can be used to separate or identify fibers in combinations, Khan et al (2017).

Types of fabrics

1. Cotton is a staple fiber, made from the natural fibers of cotton plants to produce cotton fabric. Cotton is primarily composed of cellulose, an insoluble organic compound crucial to plant structure, and is a soft and fluffy material. Cotton is spun into yarn that is then woven to create a soft, washable and durable fabric used for everyday garments, like t-shirts, and home items, such as bed sheets, (Agiboo, 2020).
2. Canvas is a plain weave fabric made from cotton and linen yarns. It is durable, strong, and heavy. A blend of cotton with synthetic fibers will make canvas to be water resistant or waterproof, making it a great outdoor fabric, MasterClass, (2021).
3. Linen is another natural fabric, made from the flax plant. It tends to be more expensive than cotton, but it's stronger, light weight and likely to last longer. Linen is often used to make summer clothing, towels, tablecloths, napkins, and bed sheets. The material is also used for the inner layer of jackets, hence the name "lining." It has good absorbent properties making it suitable for summer clothing. The lightweight qualities moderate the body temperature by allowing air to pass through, MasterClass, (2021).
4. Wool is a natural fabric made from animal hairs such as sheep and goat. Wool is strong, gives warmth, slightly itchy, and moisture-wicking. Wool is mostly used in sweaters, socks and gloves, Skill Share (2021).
5. Cashmere is a wool fabric made from cashmere goats and pashmina goats. It has extremely soft feel, and a very good insulator. Cashmere is significantly warmer and lighter than sheep's wool and the texture is almost like a silk fabric. Cashmere fibers are very fine and thin. In other to give it added weight, cashmere is often made into a wool blend or mixed with other types of wool like merino. Merino wool is made from Merino sheep MasterClass (2021).
6. Silk is made from fibers produced by the silkworm. Silk fabric is known for its shine, smooth, fine and softness. It is the most luxurious high-fashion fabric, relatively expensive, strong, durable and often used to make beautiful drape, high-end dresses, skirts, blouses, formal attire, accessories, bedding, upholstery, etc., Skill Share (2021).
7. Chiffon is a lightweight, plain-woven fabric with shine made from twisted yarn that gives it a slightly rough feel. Chiffon fabric can be woven from both synthetic and natural fibres, like silk, nylon, rayon, or polyester. Chiffon can be easily dyed and is usually seen in scarves, blouses and dresses, including wedding gowns and prom dresses, due to its light, flowing material, PICO Cleaners (2020).
8. Lace is a web-like, delicate and decorative fabric used for dresses and home décor items. Lace can be made by machine or hand with various designs from natural, abstract or traditional/cultural sources. Lace can be made from natural fibres such as cotton, linen or silk, it can also be produced from synthetic fibers. Handmade lace can be used

to trim sleeves, collars, and handkerchiefs. Lace is often used for embellishment on clothing, lingerie, bridal gowns, and veils and can be found in shirts and nightgowns, MasterClass, (2021).

9. Leather is not made from fiber but from the hides or skins of animals like cows, sheep, pigs, goats and crocodiles that are treated with chemicals to soften and strengthen it. Leather is a durable, strong, wrinkle-resistant and waterproof fabric. Suede is a type of leather made from lamb to create soft, velvety surface and it is soft but not water-resistant. Suede are often found in jackets, shoes, footwear, bags and belts and the material keeps the body warm in cold weather. Vegan is an artificial leather made from polyvinyl chloride (PVC). Vegan is shiny and waterproof clothing, (Varkki, 2023; MasterClass, 2021); Skill Share, 2021).
10. Velvet is a soft, thick, luxurious fabric made with tufted fibers. Velvet fabric can either be stretchy or inelastic and it can be made from cotton, linen, silk, nylon or polyester. Velvet is used in blouses, shirts, coats, skirts, evening wear and outerwear.
11. Jackets and evening gowns are the most common types of clothing made from velvet; it's also used to make furniture, upholstery fabric, throw pillows, curtains, and cushions, PICO Cleaners (2020).
12. Hemp is a natural fabric made from fibers of the hemp plant. It is commonly used for industrial purposes, like sacks, ropes, and sails, because, it is tough and durable. It can also be made into clothing, usually when mixed with another fabric like cotton, to make it softer and more comfortable, Hemptique (2023).
13. Satin is actually a fabric weave rather than a type of fabric itself. Satin fabric has lustrous surface on one side and a dull surface on the other side. The fabric is elastic, shiny, and soft with a beautiful drape. Satin was originally made from silk and is now made from polyester, wool and cotton. Satin is often used to make glamorous items like evening gowns, bridal wear, and lingerie or sleepwear, CarrierUk (2021).
14. Denim is a twill weave cotton fabric mostly dyed in indigo colour with vivid texture, sturdiness, durability and comfortableness. Denim is usually used for jeans, jackets and dresses, PICO Cleaners (2020).
15. Crepe is a lightweight, twisted plain-woven fabric made from cotton, wool, silk or synthetic fibers. Crepe is usually called after its fiber, e.g. crepe chiffon, or crepe cotton. Crepe is soft and easy to work with. It is used in designer clothes, scarves, pants, skirts and shirts, PICO Cleaners (2020).
16. Damask is a reversible, woven, jacquard-patterned fabric made from silk, cotton, wool, linen or synthetic fibers. The fabric's design can either be multi-coloured or one colour using a combination of two different weaving techniques. Satin weave is used to create the damask design, while the background of the damask fabric is achieved through either a plain, twill, or sateen weave, MasterClass, (2021).
17. Jersey is a soft stretchy, light to medium weight knitted fabric that was originally made from wool. Presently, jersey is also made from cotton, cotton blends, and synthetic

fibers. The fabric is used for clothing and household items such as sweat shirts, MasterClass, (2021).

18. Muslin is a loosely plain weave cotton fabric. Muslin is known as the material used in fashion prototypes to test patterns before cutting and stitching the final product. Muslin is ideal for testing patterns, as it's lightweight and gauzy, therefore it can mimic drape and fit well and is simple to sew. Muslin is soft and light, so it is often used to make baby blankets as well as summer clothing. It is also sometimes called cheesecloth as it is used in some traditional cheese making, MasterClass, (2021).

19. Organza is a lightweight, sheer, plain-woven fabric that was originally made from silk. The material can also be made from synthetic fibers, primarily polyester and nylon. Synthetic fabrics are slightly more durable, but the fabric is very delicate and prone to frays and tears. Organza is a plain woven fabric characterized by very small holes between the warp and weft yarns. The quality of organza is defined as the number of holes per inch—more holes indicate better quality organza. Organza is extremely popular for wedding gowns and evening wear, because of its shimmery and translucent quality which creates decadent silhouettes, MasterClass, (2021).
20. Polyester is a synthetic fabric produced from petrochemicals. It is commonly used to make clothes and home furnishings because it is strong, durable and stain-resistant. Polyester won't wrinkle, or stretch easily, and is easy to care for. It doesn't absorb liquids well, like sweat because it is designed to move moisture away from the body. Polyester is not very breathable (it does not have the ability to allow perspiration, evaporated by the body to escape/ diffuse to the outside) alone but is often mixed with cotton for clothing. Polyester blends are also very popular as the durable fiber can add strength to another fabric, while the other fabric makes polyester more breathable. Most T-shirts, trousers, skirts and sportswear are made from polyester, (Sewport, 2020).
21. Taffeta is a plain-woven fabric in light to medium weight produced from silk. It can also be made from polyester, nylon, acetate, or other synthetic fibers. Taffeta has lustrous, shiny appearance and used for lining, evening wear and home decoration, MasterClass, (2021).
22. Rayon is a semi-synthetic fabric that's made from fibers from wood pulp. Rayon is an alternative to silk.

Modal and Viscose are types of cloth related to rayon. Modal fabric is a semi-synthetic fabric made from beech tree pulp. Modal fabric is used as underwear and pajamas. It can also be used for household items, like bed sheets and towels. Modal is slightly more durable and flexible than rayon and often blended with other fibers like cotton and spandex to increase its strength. Modal is considered a luxurious textile with soft feel and it is more expensive than either cotton or viscose MasterClass, (2021). Viscose is also a semi-synthetic type of rayon fabric made from wood pulp and used as a silk substitute. Viscose is silk-like, versatile fabric and is cheaper to produce. It is used for clothing items such as blouses, dresses, and jackets, it is also used in

carpets and upholstery, MasterClass, (2021).
Spandex is also known as Lycra or elastane made from polyurethane. Spandex is a synthetic fiber, lightweight and characterized by its extreme elasticity. It is often mixed with cotton. Spandex is incredibly stretchy and often used to make figure-hugging clothing like sportswear, swimwear, dresses, hosiery (leg wear such as socks) and underwear, MasterClass, (2021).
Nylon is a synthetic fiber made of polymers. It is long lasting, flexible and exceptionally elastic. It is often used in tights, stockings, sportswear, bulletproof vest, shirts, foundation garments, lingerie, raincoats, swimwear, underwear, and cycling wear, Sewport, (2023).

Fabric combinations, blends and mixtures
Fabrics and yarns may be combined to consist of different kinds of fibres to improve their natural characteristics and provide the consumers with special appearance and performance qualities. This combination may be at the yarn spinning stage or fabric production stage. Through combination, performance, care and beauty or aesthetic properties of fabrics can be improved. Cost can also be reduced and fabric of special properties can be produced.
Combination is a fabric of two or more different fibre types. Strands of different fibres are plied to form yarns used in producing the fabric in other to improve the fabric properties. For example, combinations of cotton and polyester impart coolness from the cotton and wrinkle resistance from the polyester. Combination of fibres to produce fabrics can either be a blend or a mixture.
Blend fabric consists of various percentages of fibres that are spun together to make yarns for fabric production. A blend fabric may be 50% cotton and 50% polyester or 65% cotton and 35% polyester or vice –versa. Blends cannot be separated and their fibres are not easily identified.
Mixture is when the yarns used for the warp are different from the yarns used for the weft in the production of a fabric. Unlike blends, mixtures can be separated and their fibres can be easily identified.

Uses of different fabrics
There are so many types of fabrics in the market and each type is suitable for specific purposes. In order to get maximum satisfaction from money spent on fabrics, it is important to acquire knowledge and skills about the right use of different fabrics. Fabrics can be used for clothing, household furnishing or for industrial purpose.
Woolen fabrics are used for shawls, blankets, upholstery, and coats. Silk fabrics are used for garments worn on important occasions, wall hangings, home decorations, dresses, blouses, accessories that sell at high prices, scarves, men’s tie, hats, underwear and umbrellas.
Cellulosic fibres such as cotton, linen, ramie and hemp are used as underwear, outerwear, children’s garment, night wear, sportswear, accessories, curtains, cushion covers, towels, table cloth, napkins, bed sheet, upholstery, kitchen cloths, foot mats, ropes, strings, sacks, conveyer belt, canvas, and tarpaulin.
Synthetic/man-made fabrics such as polyester, polyamide, acrylic, rayon, acetate and triacetate are used for floor coverings, bed coverings, upholstery, pillow and mattress cover, raincoats,

sleeping bags, disposable hospital theatre clothes, undergarments, outer garments, accessories etc. Rayon fabrics are used for children's wear, toweling, toys, conveyor belts, curtains and blankets. Acetate fabrics are used for evening wear, lingerie, linings and underwear while triacetate fabrics are used for staple tufted bat mats, rugs, bedspreads, and dresses.

Summary

This chapter provides information on the various sources of textile fibres and their properties, some textile terms were defined and various methods of fabric construction were highlighted. The alteration of fibre or fabric properties using fabric finishes to make the textile material attractive, produce variety and improve its suitability and utility were explained. Varieties of fabric can be produced through combination of two or more fibres either as a blend or mixture. The chapter also identifies different fabrics and their uses for either clothing, household furnishing or for industrial purpose.

Exercise

1. What are the properties of cellulose and protein fibres?
2. What are the three basic weaves?
3. Explain how the pattern in each is being produced.
4. Briefly explain five methods of producing fabrics.
5. List ten fabric finishes and explain any five of the listed fabric finishes.
6. Briefly explain four ways to identify fibres/ fabric contents.
7. Define the terms: fabric combination, fabric blends and fabric mixture.
8. List ten types of fabrics and their uses.

References

Agiboo (2020). 12 Interesting Facts about Cotton. Retrieved April 6, 2023, from: https://www.agiboo.com/12-interesting-facts-about-cotton/

CarrierUk (2021). What is Satin Fabric? Types and Characteristics. Retrieved April 9, 2023, from: https://carrieruk.com/satin-fabric-properties/

Commercial Garment Technology, CGT, (n.d.). Classification and general properties of textile fibres. Retrieved April 3, 2023, from: https://www.researchgate.net/profile/Balamani -Jeevanandham/publication/304232601_CGTPaperII/links/576a115008ae3bf53d3325ec/

Eduqas (2016). Fabric Construction. Retrieved April 3, 2023 from Forster, P. (2016). Clothing and Textile. Accra, Ghana, WINMAT Publishers Ltd.

Hemptique (2023). 15 Benefits of Hemp Clothing. Retrieved April 9, 2023, from: https://hemptique.com/pages/benefits-of-hemp-clothing

Khan, A. N., Abir, N., Rakib, M. A. N., Bhuiyan, E. M. S. and Howlader, R. (2017). A Review Paper on Textile Fiber Identification. *Journal of Polymer and Textile Engineering*, 4(2), 14-20. Retrieved April 3, 2023, from: (10) (PDF) A Review Paper on Textile Fiber Identification (researchgate.net) Kiron, M.I. (2021). Different Types of Fabric Weave Structure. Retrieved April 3, 2023, from:
https://Different Types of Textile Weave Structure - Textile Learner
https://textilelearner.net/types-of-fabric-weave-structure/
MasterClass, (2021). 28 Types of Fabrics and Their Uses. Retrieved April 3, 2023, from:
https://www.masterclass.com/articles/28-types-of-fabrics-and-their-uses
PICO Cleaners (2020). The 12 Different Types of Fabric. Retrieved April 3, 2023, from:
https://www.picocleaners.com/blog/the-12-different-types-of-fabric/
Sewport, (2020). What is Polyester Fabrics: Properties, How it's made and Where. Retrieved April 3, 2023, from: https://sewport.com/fabrics-directory/polyester-fabric
Sewport, (2023). What is Nylon Fabric: Properties, How it's made and Where. Retrieved April 5, 2023, from: https://sewport.com/fabrics-directory/nylon-fabric
Schwenck, B. (n.d.). Identification of Fibres and Fabrics. University of Applied Art- Institute of Conservation.
Retrieved April 3, 2023, from: https://ncch.gov.mn/Files/Method/
Skill Share (2021). 15 Types of Fabric and What to Use Each For. Retrieved April 9, 2023, from: https://www.skillshare.com/en/blog/15-types-of-fabric-and-what-to-use-each-for/
Varkki, A. (2023). Leather. Retrieved April 9, 2023, from: https://vonbaer.com/blogs/blog/leather

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CHAPTER 37

PRINCIPLES and TECHNIQUES of TEXTILE DESIGN

By

MAKINDE David Olajide and OGUNDUYILE Sunday Roberts

Overview

Principles are integral part of textile design that are responsible for textile manufacture, choice and patronage by the consumers. These principles when professionally applied in planning and production of any textile products often satisfied the emotions of the designer, the marketer or consumer. Available records made it explicit that 'Design principles' often add values in terms of aesthetics and marketability to any textile products; however, they do not exist in isolation (Makinde, 2017). Therefore, there is need to understand the concept and meaning of textile design before identifying the purpose, meaning and types of principles of textile design. The word 'textile' was previously conceived to mean 'a woven fabric'. However, due to innovations and technological development; the term textile today is considered to cover any product that is produced through the processes of weaving, knitting, felting, embroidery, lace-making and applique among others. The product of these processes includes; fabrics, clothing, bags, rugs, carpet, furnishing, apparel among others is what professionals referred to as 'textile design'. Technically, textile design can be referred to as the final product of many textile activities which starts from planning to production of any textile materials such as fabric, rug, mat among others. The use and acceptability of these products however depends on two main factors; aesthetics of the product and the consumer choice's which is also technically influenced by the right or wrong application of the principles (Ojo, 2016). Notably, these activities are carried out by different professionals at various levels of operations such as; conceptualization of design, colour selection, surface appearance, cost and properties of the textile product. This has led to the creation of yarn designers, knitted fabric designers, woven fabric designers, carpet designers, print designers, embroidery designers, knitwear designers, garment designers, accessory designers, print producers, stylists and colourists. Therefore, Textile designers need to have a good knowledge, understanding and judgement for colour and aesthetics to produce an acceptable, marketable and consumable products.

Objectives

By the end of this chapter, students should be able to:

1. write and explain the term "design";

2. list and explain the various types design;
3. explain the meaning of Textile design;
4. explain the processes of Textile design;
5. explain the elements of design;
6. identify and explain the principles of textile design;
7. list and explain the principles of textile design;
8. determine the choice and use of principles of textile design; and
9. state the importance of principles in textile design.

What is design?

Design is a plan set of activities that is carried out towards achieving a goal in any profession. In textile, design is the outcome of the use of elements and principles of design in a visual form (Makinde, 2018). These could be in form of print (drawing, sketches, maps and use of images) on any platform or on fabrics. Generally speaking, design is the process of envisioning and planning the creation of objects, interactive systems, buildings, arts, vehicles and other man-made objects. Design is user-centered and it is all about creating solutions for people, physical items or more abstract systems to address a need or a problem. Design is a broad concept and its meaning greatly vary from one field to another. It permeates many aspects of our lives and branches out into many different subtypes which ranges from; product design for cars, interiors, fabrics, computers, farm tools, buildings among others. Design is not about aesthetics, good, bad or by adding just ornaments to an item but rather; it is basically about function. For example, the creation of an aesthetically pleasing spoon will not change its primary role as a tool for eating. A design is a plan of activities that is executed to provide solution to human needs.

What is designing?

The process of designing patterns to be printed on woven, knitted, or other forms of fabrics is at the heart of the highly creative field known as textile design. Pattern creation and production management are both aspects of the discipline of textile design. A superior eye for colour, pattern, and texture as well as an appreciation for the finer points of textiles and fashion are all qualities shared by textile designers. They are also talented artists who can draw. They comprehend textile processes, are strong communicators, have problem-solving abilities, like a challenge, and are able to keep to a budget and timeline while also recognizing changes in trends and fashion.

What is textile design?

Textile design is a process of creating aesthetically pleasing visual form (images, drawings, symbols and object) to create patterns on paper, leather, nylon or on other textile materials or create patterns for mix-media, woven and printed fabrics or other surface ornamented fabrics. Textile design begins with the idea, plan and production of any textile materials. It is a process that starts from the processing of raw material to finished product. Textile designers are involved with the production of these designs which are used, sometimes repetitively, in clothing and interior decoration items. Therefore, it is very important for the textile designers to consider fiber, yarn and finishes as key elements during textile design procedure.

Why do we need a textile designer?

The craft of textile design requires both artistic talent and an in-depth understanding of fabrics. In this industry, having an eye for design isn't enough because how a print looks on a certain fabric also has a big impact on how clothes are made and decorated. Using a textile designer's ability in creating a design is rewarding and a fantastic way for a fashion firm to expand its product line and to stand out in any competition.

Who is a textile designer?

According to Quinn (2009), textile designers are individuals who create patterns and designs for woven, knitted, printed and any other form of textiles which can be used as apparel furniture or interior design. Textile designers are professionals who use designs generated through unique, and conscious application of the principles and elements of designs to create patterns Makinde, (2018). However, due to financial limitations, small firms frequently ignore this style of design. A textile designer is also a professional who combines the principles with the elements of design to create an acceptable and marketable textile designs.

Textile designers are found, in fashion, arts, and technology. Home products and the apparel or clothing sector are two common uses for textile design. As a result, while some textile designers produce fabrics and print patterns for garment fabric, others focus on designs for the home. Designers of various media, particularly those of clothes and interiors, collaborate with textile designers. Creating a design is a personal activity which may be good or bad. Designs are often determined by the experience of the designer and other technical factors like; ability to understand and apply the principles of design. It should be noted that "Textile Design is produced by the arrangement of elements and good application of principles of design. (Ogunduyile, 2018). Since the principles of design are complimentary it therefore becomes necessary to identify and understand all the elements of design before the principles are discussed.

Types of textile design

There are three main types of textile design which are categorized as printed, woven, and mixed media textile designs. Each of these textile designs use different methods to produce a surface ornamented fabric for various uses and markets. Textile design involves the use of different materials and professionals to produce textile products. It should be noted that every textile design requires the use of both elements and the principles of design to achieve a desirable result in the production of printed, woven and mix-media textiles.

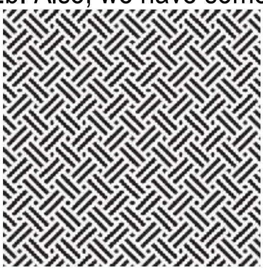
1. **Printed textiles**

Textile printing is the process of applying colour to fabric in definite patterns or designs. In properly printed fabrics as shown in figures 1a & 1b, the colour is bonded with the fibre. It is the application or transfer of colour unto fabric surface to register an impression (Makinde, 2018). Printed fabrics can be produced using industrial or manual processes. Example of printed fabrics include; Adinkra, Adire Eleko and Batik as shown in figure1b.

Figure 1a: Printed Fabric
Source: Jiboku, 2023

Figure 1b: Adire Eleko
Source: Jiboku, (2023).

2. **Woven textiles design** (Fig 2a, 2b &2c**)**
   Woven textiles are produced using the loom and through the process of interlacing the weft yarn with the warp yarn at 90^0. Technically, the loom determines or dictates the size and structure of the fabric while the pattern is pre-conceived by the artist (Makinde, 2021). There are three basic types of woven fabric: plain weave, satin weave and twill weave. Example of this in Africa include; Aso-Oke, Kente and Blanket as shown in figure 2b. Also, we have some industrially produced woven fabrics like chiffon and corduroy.



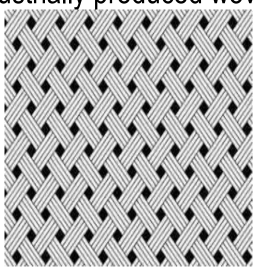


Figure2a: Woven Textile   Figure 2b: Woven Textile   Figure 2c: Aso-Oke Textile
Source: Makinde, (2018).

3. **Mixed media textile design**
   Mixed media textile designs are put together by employing embroidery of different fabric manipulation techniques similar to packing, appliqués, laser cutting, and pleating

as shown in figure 3. Quilting is commonly used to consolidate the warmth and sequestration of a textile. It allows the chance to apply aesthetic properties by the designer.

Figure 3: Mixed Media Textile
Source: Makinde, (2018)

What are the elements of design?

Elements of design are keys to the planning and actualization of any textile design, which include line, shape, form, colour, texture and space. They are the framework of any successful textile design. Elements of design are the building blocks that every artist uses to create or make a successful composition Makinde (2016). Available information refers to elements as basic and structural pillars of any design. The organization of these elements by the artist produces a textile design which could be classified as good or bad by the professionals. There are five elements of design, these elements are line, shape, form, texture, space and colour.

Line as element of design

Every design starts with a line or a mark made by a tool or drawing instrument. They come in all shapes, sizes and colours as shown in figure 4. They are the most basic elements of design that is used by the designer. It is a distance between two points. Lines have direction and they can be visible or invisible. A line can be any continuous mark that causes the eye to follow along its path. The viewer's eye travels along the path of a line because a line is longer than it is width. There are curved lines and straight lines which can be long or short, thick or thin, ragged, sharp, light, dark, simple or complex. Lines can be broken, textured and coloured. Textile designers use lines to create form that gives birth to depth. It can be carefully controlled to create optical sensations to project feelings of sensitivity and strength. Skillful artists and designers play with this tendency to create more familiar forms in their designs.

Figure 4: Lines (Straight, diagonal and wavy)
Source: Makinde, (2018)

Shape as element of design
A shape is an important element that is achieved when a line is enclosed to form a boundary. When a line turns and meets up with its start point, a shape is created. Shapes are two-dimensional which can be described as geometric, organic and abstract There are a great variety of shapes to be found in nature. Shapes can be solid or opaque, linear, textured, coloured and outlined. Shapes can be transparent, revealing other shapes behind them. Some shapes will command more attention than others, depending on their size, colour, value, texture, detail or their location in relation to other shapes. Designers use shapes as motifs in a design work to solve the problem of identity.

Type of shapes
Textile designers select and use different types of shapes in responding to any design brief which are found in:
1. Geometric shapes are mathematical and precise like squares, circles, and triangles.
2. Organic shapes lack well-defined edges and often feel natural and smooth. They add emphasis to a layout.
3. Abstract shapes are figural or linear representation of images in a design. Abstract designs are commonly
used in fabric designs.

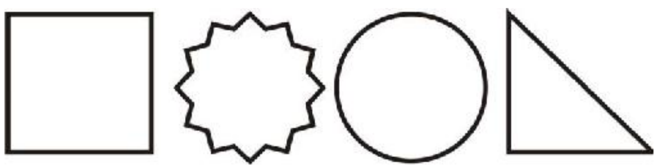


Figure 5: Geometric Shapes: Square, Abstract, Circle and Rectangle
Source: Oyeniyi, (2023)

Form as element of design
Form and shapes are mutually dependent because changing one would affect the other. In art and design, form helps to create an illusion of three-dimensional volume or mass seen in two dimensions. Careful observation of the forms around reveals that, in nature and in man-made

objects, many forms can be described as combinations of the basic geometric structures; spheres, cylinders, cones, cubes and pyramids. There are several methods that can be used to give an illusion of three-dimensional. For instance, the use of perspective in drawing or the use of receding colour in design.

Space as element of design

Space is another important element of design that is used by the designer to create an organization and maturity in a design. It is the area that surrounds a shape. It is the area in, around and between forms or shapes as shown in figure 6. A flat surface has only two-dimensional space. This means that it has length and width but no depth. It is impossible to create actual depth or space on a flat surface but an illusion of space, distance or depth is possible. Artists and designers use many methods to create a sense of space, and also to convince the observer that there is space and depth when, in fact, there is none but mere type of visual deception.

Figure 6: Space
Source: Oyeniyi (2023)

Colour as element of design

A world of colour is a world of varieties and sensation. Colours can be applied to any of the elements to create moods and pass messages in a design as shown in figure7. Professionals use this unique advantage to create fascinating and marketable designs for industries. Some colours are associated with cold (blues and greys) and some with warmth (reds and oranges). Colour can convey the time of day, weather conditions and temperature, and even the time of the year. In design, colour grabs the attention span because memory recall from colour is quite pronounced. Colour is used to promote corporate identity. For instance, blue is used by many banks to give the suggestion of reliability, while the colours of red and yellow are used by many fast-food vendors. Green is also frequently used to denote environmental friendliness while more subtle greens convey a feeling of upmarket status.

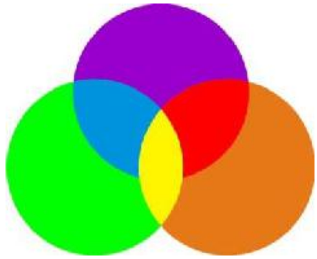


Figure 7: Colour chart
Source: Ogunduyile (2018)

Value (tone) as element of design

Values refers to the degree of lightness and darkness of a specific hue or colour. Between the whitest white and the blackest black there are countless degrees of light and dark values as shown in figure8. Value is important to the designer because of its significant role in designing; Wisbrun, (2011). Shapes that are close in value or tone appear to merge together in a design. Visually dark values appear to come forward and light values tend to recede, but the reverse can occur. Sharply contrasting values attract attention and the use of light against dark or dark against light can create the illusion of size difference. Value is probably the most elusive of all the design elements. The success or failure of a design may rely on the use of values within it.

Figure 8: Value (tone)
Source: Oyeniyi, (2023)

Texture as element of design

Most fabrics are valued because of their texture which could come in form of accessories (Sequim), extra weft in woven fabric or rugs and stone layouts in lace fabrics. Texture is an element that determines the surface quality in any textile design as perceived by touch. Running a hand over a surface may find it to be smooth, rough, dull, glossy, hairy, sandy or bumpy. Texture is very important in textiles, and how fabric feels is an important consideration in product choice. Texture can be seen as well as touched and artists and designers can use a variety of techniques to convey textures when none is actually there. Repetition of design

Figure 9: Textures
Source: Ajiboye, (2023)

elements can often create a visual illusion of texture. Experience have shown that many textiles enjoy good patronage because of their surface appearances which is found in their texture. More importantly, any fabrics without any evidence of principles always appear incomplete and therefore cannot satisfy the emotions of the designer, consumer and the marketer.

What are the principles of textile design?

The principles of textile design are important visual tool that enhances the value of any textile design. They are a set of rules that designers must follow to produce an acceptable textile design. Interestingly, these Principle of designs is mutually dependent on the elements that forms the foundation of any textile design production (Gale and Kaur, 2004). As such, textile designer or other professionals have the responsibility to understand all the basic elements to be able to apply the principles professionally to make a successful and acceptable design. Available scholarly works on textile design production have shown that every textile design work confirms the relationship between the principles and the elements of design. In some or all of the design elements—varieties of line, positive and negative shape, three-dimensional form, occupied and unoccupied, space, colour, value and texture are evident. The manner in which these elements are used and combined determines the quality of a piece of work. Thoughtfully balancing, moving, repeating, emphasizing and contrasting the design elements can achieve a unified piece of artwork or design.

Types of principle of design

Balance

Balance is an important principle of design that designers use or apply to achieve stability in design. It provides a sense of stability when apply to opposing visual attractions or forces as shown in figure10.

There is a natural desire for balance in every design, and in nature balance is ever-present. Three types of balance exist; formal and informal and radial.

Formal balance: The design elements are almost equally distributed on the page. A design or composition that is divided in half so that one side is the mirror image of the other is said to have symmetrical balance.

Radial balance: The design elements radiate from a central point as the spokes of a wheel or the natural form of a daisy.

Informal balance: A center line or point is ignored, with the design elements being balanced visually, rather than in a symmetrical manner. Designers have observed that he/she positions any particular shape in a composition contributes to its strength as shown in figure10. When a shape is in the exact center of a picture plane it is said to be at perfect equilibrium. However, moving the same shape off-center can increase or decrease its importance. In any textile design, each shape affects everything else. Perfect balance can be achieved when the designer arranges, rearrange till he/she is satisfied.

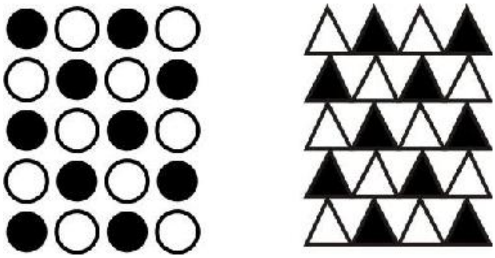


Figure 10: Balance
Source: Jiboku (2023)

Movement

Movement and the portrayal of movement have always fascinated artists and designers. By careful arrangement of the design elements, the illusion of movement can be created as shown in figure11. In optical art and designs the sensation of movement may deeply affect the viewer's responses. Some paintings can provoke dizziness by making it difficult for the eyes to focus on a central point. Associated with movement is time. Pictures and patterns are capable of holding our attention for varying amounts of time. Some designs may be so subtle that these are barely noticed, if at all, by the viewer, while others can hold attention for much longer periods.

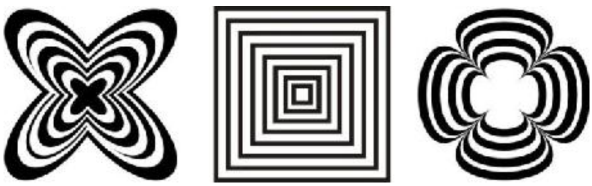


Figure 11: Movement
Source: Jiboku (2023)

Repetition

Repetition occurs when elements that have something in common are repeated. It is a process of repetition a single element through the design. When a design consists of shapes that are exactly alike, repeated in a uniform and regular manner, then that design tends to seem more formal. By varying the shapes and the spaces between them, a more informal interest is created as shown in figure12. The repetition of some of the elements within a design repeat can hold designs together. Repeated shapes make patterns. Many textile designs, because of the method of manufacture, will automatically repeat.

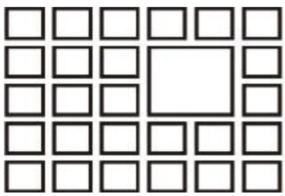
Figure 12: Repetition
Source: Ogunduyile, (2018)

Emphasis

It is a strategy to get the viewers' attention to a specific design element. As long as one can create contrast, either with elements or colour, one will be creating emphasis. Some authors classified the two (contrast and emphasis) together.

Contrast

Contrast refers to the level of difference between design elements in order to create visual hierarchies. It calls attention to important areas of design and subdues everything else on the picture plane as shown in figures13a and b. By placing emphasis on certain areas, artists and designers create centres of interest that cause our eyes to return there again and again. Bold details, unusual textures and bright colours are more prominent than more subdued features. Often the left side and the upper part of a picture attract our attention first; this is particularly so for those whose language is written from left to right. Similarity of elements in a design often leads to monotony. Contrasting elements tend to stand out. Elements that contrast strongly stand in opposition to one another light against dark, large against small, round against square or smooth against rough. Contrast can be used to also create balance and harmony.



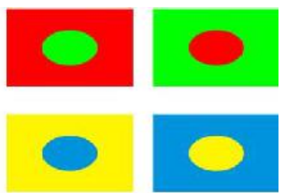


Figure 13a: Emphasis Figure 13b: Contrast
Source: Jiboku (2023)

Unity

Unity is the harmony produced by all the elements in a design. It exists when all the elements in a design work together harmoniously. In a unified design, each element plays an equally important part. Lack of unity in a design will make the work cluttered and confusing by influencing viewers to be attracted to wrong elements.

Processes and application of principles of design

For a successful textile design, the designer needs inspiration that can be drawn in many ways which include: natural or man-made objects, copying, self-creativity among others. Inspiration for textile designs can come from a variety of sources. It is possible to create textile design work by going straight to the process being used. However, a good textile designer will act based on the following steps:

1. Conceptualization of design (inspirational, copying, through commissioning and simulation)
2. Planning the design
3. Choosing the elements of the design and
4. Application of the principles of design.

However, experience has shown that such a method of designing often results in fairly mundane design. Innovative, exciting textile design starts with much more fundamental paperwork; drawings and paintings exploring colours, textures, shapes and patterns Edwards (2009). Drawing from objects in an imaginative and open way will inspire new colour combinations, textural, ideas, shapes and arrangements of these. Inspiration for such paperwork, and ultimately for textile designs, can come from many things. Both natural and man-made objects can inspire. Whether the source material is natural or man-made, abstract or tangible, how themes and source material are used is a matter for debate Textiles can be created from products of other discipline or fine artists using tapestries and silk scarves. Source books for designers often consist of designs from the past or from other cultures. Whatever the inspiration or source for a textile design, the textile designer needs to have a good understanding of colour and aesthetics. A textile designer must be able to draw. They must understand and be able to use colour and pattern.

Pattern

Any textile designer needs to have a good idea of how a design is going to look like as a finished fabric. In principles of design: pattern is the repetition of more than one design element. One piece of paperwork could be worked through to become many different finished designs, woven, knitted or printed. All designers need to understand how designs can repeat. While many designs work as straight repeats, where the design element is repeated again and again, one on top of another, side by side, among others.

Repeat patterns

Textile repeat patterns include the following; full repeat, half-drop and half slide repeats and tile repeats. Mirror, diamond, orgee and scaly repeats. Where elements are reflected about either x or both, x and y axes, is another common way of repeating elements (Makinde, 2018). Fabrics may have sections within one complete repeat that show other repeat patterns, while some fabrics such as border designs will employ repeated designs only within certain sections of the fabric; It is important to consider the repeat structure from an early stage in the design development, and various sketch plans of possible repeat structures should be evolved. Very often, trying to interpret paperwork too literally can be a problem, particularly for a print designer. By its very nature, weaving and knitting design requires elements to be extracted from the initial inspirational paperwork. For print designers, this decision-making process of what to include and what to discard is equally important. The designer selects the most appropriate repeat patter to produce his designs. Simplicity is a guiding principle in design. Textile designers require to have a good understanding of aesthetics.

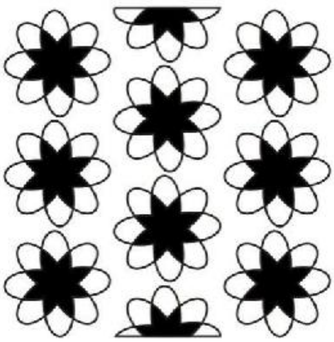
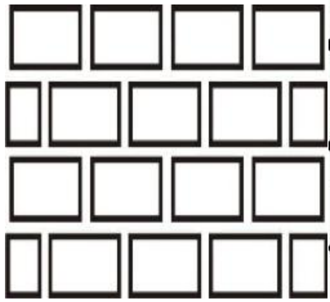
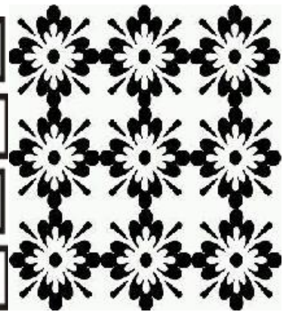




Figure 14a: Straight repeat Figure 14b: Half drop Figure 14c: Tile (or brick) repeat

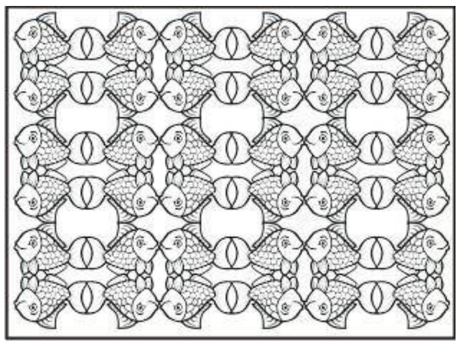



Figure 14d: Diamond repeat Figure 14e: Mirror repeat

Source: Makinde, (2016)

Summary

Principles are rules that a textile designer needs to follow in creating a design. It is a language of design that all designers must understand. The principle is mutually connected with the element of design. Hence, the two are separable and complimentary. Textile designers require to have a good understanding of aesthetics. Design elements can be classified as line, shape, form, space, colour, value and texture while the principles are classified as balance, movement, repetition, emphasis/contrast and unity. Every design or work of art has some or all of the design elements, while some or all of the design principles are evident in the way elements are used. Inspiration for textile designs comes from many sources. Pattern and repetition are an integral part of most textile design, and how repeat is created in textile is very important to the textile designer. The most common repeats are half-drop, full repeat, mirror, orgee, diamond and half-slide among others. The elements of design are foundation for genuine textile design. Like a building project, a successful foundation will lead to a reliable building structure. The elements are basic elements that are required in the formation of a good design while the principles compliment the emotional and psychological aspects of textile use. The elements produce the structure or framework for the design while the principle promotes its value. While the elements help to build the structure, principle of design satisfy consumers' taste and promote its marketability.

Exercise

1. Write and explain your own original definition of textile design.
2. List and explain three types of textile design
3. Explain the 'term' principle of design.
4. Identify and explain five principles of design.
5. Who is a textile designer?
6. List and explain the guiding principle of a textile designer.
7. Explain the relationship between the principles and elements of design.
8. List four properties of a good textile design.
9. Explain the factors that determines choice and marketing of textile design.
10. What is conceptualization in design?

References

Ajiboye, O. J. (2022). Unpublished PG. Seminar Series, Department of Fine Art, O.A.U., Ile-Ife.

Edwards, C. (2009). How to Read Pattern: A Crash Course in Textile Design, Herbert Press.

Gale, C. and Kaur, J. (2004). Fashion and Textiles, Berg, Oxford.

Jackson, L., (2002). 20th Century Pattern Design, Princeton, Architectural Press, New York.

Makinde, D. O. (2016). Unpublished Lecture Notes on Fabric Design

Makinde, D. O. (2017). Unpublished Lecture Notes on Resist Technique

Makinde, D. O. (2018). Unpublished Lecture Notes on Fashion Design

Makinde, D. O. (2021). Unpublished Lecture Notes on Fabric Printing

Makinde, D. O. (2022). Yoruba patterned Dyed fabrics. Unpublished Keynote paper delivered in Kano.

Oyeniyi, W. (2023). Unpublished PG. Seminar Series, Department of Fine Art, O.A.U., Ile-Ife.

Ogunduyile, S. R. (2018). Unpublished Lecture Notes on Textile Technology.

Ojo, E. B. (2016). Unpublished PG. Seminar Series Department of Fine Art, O.A.U., Ile-Ife.

Quinn, B. (2009). Textile Designers at the Cutting Edge, Laurence King.

Jiboku, S. (2023). Unpublished PG. Seminar Series Department of Fine Art, O.A.U., Ile-Ife.

Schoeser, M. (2003). World Textiles, Thames and Hudson, London.

Wisbrun, L. (2011). The Complete Guide to Designing and Printing Fabric, A andC Black, London.

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CHAPTER 38

Creative Fabrics and Fashion Accessories

By

ADEBISI Taibat Tunrayo

Overview

Textiles can be seen as the production of fabrics from raw materials. It can also be viewed as any woven, plaited, braided, knitted or bonded fabrics that are used to sew various styles of garments or articles. In Nigeria and Africa, textiles are used by gender regardless of the age for many years. Ankara (Veritable wax print/ Hollandis), Adire (“resist dyed fabrics: Tie and dye, Batik) and Aso-oke (Yoruba woven fabrics),

Guinea brocade and lace fabrics are used by Yorubas, Ibos and Hausas to promote individual personality and culture. Various designs are available in textile design. It is important to design good and purposeful articles to suit different people for various occasions. Designing plays very important role in the production of textiles, fashion accessories and household articles. It is also making it possible for ideas of the articles to be transformed into picture forms and should be visible. Aesthetic utilization of principles and elements of designs in making attractive and useful textile items with fashion accessories will have effect to outside world.

Objectives

At the end of this chapter, the students should be able to:

1. discuss the conception of textiles design as an art;
2. explain importance of using fabric creatively;
3. enumerate theoretical application of principles and elements of design in construction of: applique, patchwork, tapestries, rugs, embroidery design, stitchery, lacework, soft toys and cushion, macramé, yarns and beads on boards;
4. design and create fashion accessories such as bags using fabrics, beads, and buttons;
5. produce outing accessories such as earrings, bangles, bags, hats, belts, shoes for different outfits; and
6. design and produce costume jewelries.

Concept of textile designs as an art

Textiles can be constructed in various ways. In the visual art, the designs work with principles and elements of arts are selected and arranged to suit the purpose. This is to create something purely functional, ornamental or both functional and beautiful. Designs are important to people for aesthetics values.

Yarns: Yarn may be referred to as a strand. They are made of fibres or filament twisted or laid together. They may also be seen as long continuous length of interlocked fibres used in different fabric construction methods and for sewing. Value can be added to yarns through twisting and dyeing. Combination of fibres/yarns can be used to produce textiles.

Textiles: Textiles are cloths or fabrics used for the production of apparels such as blouse, skirt, skirt and blouse, gown, shirt, buba (blouse) and iro (wrapper), trousers etc. while fashion accessories are bag, shoe, earring, bangle, hat, bracelet, brooches, and belt etc. Textiles are made of fibres. These fibres are the building units of textiles. The characteristics of these textiles depend on those of the fibres. The various kinds of textiles that Nigerians are using for their apparels, costumes, or attires for different occasions and all ages are: Ankara (veritable wax), Aso oke (woven fabrics), the Yoruba call it Aso ofi, Igbira – kente, Northern Nigeria call it Kinchibi Obora and Eastern Nigeria call itAkwete, Guinea brocade, Adire (resist fabrics such as batik, tie and dye). Nigeria veritable wax (printed fabrics) have multitudes of names: such as: Dutch wax print, Peal English wax, Veritable Java print, Guaranteed Dutch Java veritable Dutch Hollandaise. Different innovations were carried out with designs and motifs in order to cater for the taste of everyone in the country. Nigeria veritable wax prints are easily available and affordable depending on one's personality and motives. Also, the woven fabrics culturally reflect the living indigenous nature that are derived from; culture, physical and spiritual features that characterized African society.

Designs: The term designs are used in many ways:

1. These imply selections and organizations for some specific purposes or intentions.
2. The process of constructing descriptions of procedures whether diagrammatically or products specification including aesthetic and performance satisfaction.
3. Plan composition that consist of steps which guides in the proper execution of products and
4. Graphic representation of the language in an industry in contemporary society which communicate ideas and plans from creative designs stage through the finished product.

Designs and production of textiles are primary human activities. In the process of designs, the artist selects the visual quality of the things we use. This selection has a wide and sustained impact on all parts of our lives. In a sense, where entire environment is the work of art. Therefore, design process of making things look pleasing and work properly.

Textile designs: These are the arts of producing textile using principles and elements of designs.

They are the decorative marks or art works made on textiles. There are two types of textile designs; these are structured design and applied design. The two types of designs can be achieved through:

1.) Combining yarns to make particular design.
2.) Introducing novelty – type yarns.
3.) Combining coloured yarns to create a particular effect.
4.) Making woven designs through the use of special looms such as the dobby and Jacquard.
5.) Using yarns with special properties.
6.) Introducing extra yarn to form a design on the background weave.

Figure 1a: Small set of yarns
Source: www.indiamart.com

Figure 2a: Textile – Lace. (Source: Adebisi, 2023)

Figure 1b: Big set of yarns
Source: www.indiamart.com

Figure 2b: Textile – Ankara and Adire
Source: Adebisi & Muhammad (2022)

Figure 2c: Textile – Aso Oke
Source: Adebi

Creative Fabrics

These are fabrics items designed and produced in innovative and imaginative ways to play aesthetic values. These fabrics often incorporate unconventional materials, techniques and designs to create unique textures, patterns, and finishes. Creative fabrics are used in various applications such as fashion, interior design, art, and craft.

Fabrics: fabrics are cloths or textiles. They are the actual materials woven from varieties of yarns and are made from either natural or artificial sources. They undergo certain process before they are finally made into consumable textiles. Natural fibres comprise of plant and animal fibres but with the knowledge of science, and its application to textiles, man- made synthetic fibres were produced to meet individual demands.

Creativity: this is marked by the ability to create, bring into existence, invent into new form, produce through imaginative skill and make to bring into existence something new. It is a special case of problem solving in which originality is emphasized. Creativity can also be seen as the ability and power to develop new ideas and innovation. Fabrics can be creatively utilised.

Creative fabrics: these are the arts of using cloths to bring into existence new, latest, modified or current attractive articles. Natural or artificial materials can be added to fabrics to design and produce nice and pleasing items that can be fascinating to anyone. Creative fabrics are very important in fashion designs and production. Examples of items that fabrics can be used creatively on include shoes, bags and belts.

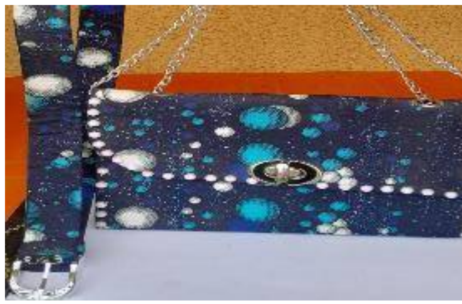

Figure 3: Ankara Shoes and Hat Figure 4: Ankara Belt Source: Adebisi and Isiaq (2022)

Source: Adebisi & Isiaq (2022)

Figure 5: Aso-Oke and Adire Male Shoes
Source: Adebisi and Adedayo (2023)

Figure 6: Aso-Oke Female Bag and Slipper
Source: Adebisi (2023)

Importance of utilizing creative fabrics

1. Productive use of leisure time: Utilizing one's leisure time to make good use of fabric scraps to produce clothing and household furnishings. They can be used for oneself, families, friends and acquaintances.

2. **Improve creativity:** When one imagines and plan to design any article and finally comes out in a way people around you admire it. This will motivate the designers. The urge to be more focused on the vision will improve utilization of fabric wastes; fabric scraps from sewing projects which might otherwise be thrown away or burnt can be used to produce useful articles. This prevents wastage and littering extra / excess fabrics.

3. Self-fulfillment: For one to produce a unique, attractive and useful item from pieces of fabrics might be satisfying to oneself. This brings self-fulfillment if I made / produce this article.

4. Saves money: Articles produced by oneself save ones from giving other people to produce. The amount to be spent on making the article can be used form other needs. This brings more joy.

5. Capacity building/wealth creation: Acquire new skill of producing a particular article that fetch the designer's money. It competence is acquired on that skill, more can be realized.

6. **Enhance marketer's skill**: as one designs and produce article using fabric items, the skills improve, people around the environment get to know the person more and attach the skills to him/ her. This might enhance the sales of the articles.

7. **Utilization of fabric wastes**: fabric scraps from sewing projects which might otherwise be thrown away or burnt can be used to produce useful articles. This prevent wastes and littering of excess fabrics.

Principles and elements of designs

Principles of designs are rules which guide the organization of the elements into designs. They are also the guidelines that are used in combining the elements to produce a design that is unique with aesthetic value. In organising the elements of design, the principles to follow in apperception are; harmony, balance, rhythm, proportion, emphasis and centre of interest.

Harmony: this unifies the parts of the design. It stresses consonance. Among the parts such as lines, forms, textures and spaces. Harmony can be accomplished by:

1. Emphasizing a single motivating idea like simplicity, modernity, sophistication etc.
2. Making use of similarity and repetition.

Balance: this portrays the dissemination of physical components. It is extremely fundamental and unavoidable when one settles on a basic design. Feeling of balance is achieved when the base of the design suggests stability. There are four kinds of balance. These are:

1) Symmetric 2) Asymmetric 3) Radical 4) Crystallographic

Rhythm: It is an organized movement in a design. It is applied in repeating units of a given pattern on a surface. It is also applied through a progression of sizes, shapes, lines, colours and direction.

Proportion: proportion is one of the principles of design that deals with the managing of divisions of space. The same units of space give monotony and the ones that have same/ similar in distribution portray more pleasing effect. Equal/ similar equal unit of space establishes relationships and could be monotonous. The uneven distribution of space turns out to be all the more intriguer.

Emphasis: this gives significance to designs in clothing articles. The eye is lead first to the important part of the designs before the other subordinating areas in the order of importance.

Centre of interest: this is the part of designs in any clothing articles that immediately catches the eye. It is possible to have several centers of interest. Emphasis in principles of designs can also be referred to as the dominance and subordination.

Element of designs

These are the fundamental building blocks of any composition. They are the basic things necessary to all the visual factors common to all that we see in any clothing articles. They are put together in different ways to form the design, they also contribute to the overall design. Application of elements of design on any of the clothing items should be pleasing to the eye and make the wearer looks his/her best. The apperception of elements of design are: dot, colour, texture, shape or form, line and space.

Apperception of principle of design

1. **Dot:** This is the first element of design. Dot may be single and of varieties of direction. A single dot in isolation tends to draw the eye to it. It has a magnetic like power. The dot gains force as it becomes larger.
2. **Colour:** This is what first catches the eye of onlookers. It enables us to express ourselves and affect how we feel. Colour is the most exciting element of design. To be able to make the right choice and combine colour adequately, designer should take note of the following:
   Basic colour, Colour wheel, Colour harmony, Colour triangle characteristics of colour- Hue, Tint and value.

Basic colour is also known as primary colour. These are colour: red, yellow and blue. Colour wheel is an arrangement of colours in a circle life the face of a round clock to show how they are related. Colour wheel consists of primary, secondary and intermediate or tertiary colours. Primary colours include blue, yellow and red, secondary colours are obtained by mixing equal proportion of primary colours together, this include orange (yellow+red), green (yellow+blue) and purple/violet (red+blue), while intermediate or tertiary colours are obtained by mixing both primary and secondary colours together. This include Red-orange, Yellow-orange, Yellow-green, Blue-green, Blue-violet and Red-violet.

Colour harmony

Colour triangle: Black and white colours (neutral colours) are two important colours that do not appear anywhere on the colour wheel, they form colour triangle. Colour triangle has a colour at one angle, black at another and white at the third. Hue, Tint and value.

a. **Texture:** This is the surface appearance or feel of any clothing articles. Texture affect the
   way colours look. The look might be: rough, smooth, dull, fussy, soft, shiny or stiff.
b. **Line:** It is a long narrow mark traced on a surface of any clothing article. Line has direction

(length and width). There are different types of lines, including straight lines and curved lines. Straight lines can be vertical, horizontal or diagonal. Vertical lines are lines that goes up and down. Horizontal lines are those that move from side to side (i.e. left to right) while diagonal lines slantingly move from up to down which connects opposite corners. Curved lines are those which is straight but bent.

c. **Form or Shape:** It is an enclosed area of any clothing items. The shape of any of these items are the outline when seen from a distance or in a shadow. Shape can also appear in a form of motifs which may not be a design in any clothing items. Form or shape might be used interchangeably. Form may be two or three- dimension depending on whether they are drawn on a paper or fabric. They connect parts and can emphasis or create height: they can conceal height or focus attention to certain area especially the best feature or hide the less attractive ones.

d. **Space:** it is the entire area of any clothing items. This is seen between designs when motifs are spaced, too wide, it loses its beauty but when evenly spaced, it has its own pleasing effect.

Element of designs can be used in meaningful ways to produce different items such as: rugs, throw pillows, soft toys etc.

Figure 7: Rug
Source: Adebisi, (2023)

Figure 8: Printed Patterned Rug
Source: Adebisi, (2023)

Figure 9: Throw pillows
Source: Adebisi, (2023)

Figure 10: Soft toy
Source: Adebisi, (2023)

Fashion accessories

Fashion accessories are essential components of any outfits, contributing to the finishing touches that improve the look. Fashion accessories serve as means of self-expression, allowing individuals to express their style and showcase their unique taste. They include: beads, jewelries, bags, hats, and scarves etc.

Importance of fashion

1. Fashions dictate the latest styles in vogue in a particular place and time.
2. They are global business since they are dynamic, exciting and creative.
3. They reflect and push cultural and social boundaries.
4. Fashions can be special and fascinating.

Accessories: these are all the items that individual puts on with clothes. They are used to complement one's dressing. These include: hairdo, make-ups, hats, scarves, belts, jewelries, shoes, handbags, etc.

Fashion accessories: These are decorative items that supplement ones garment/apparel/dress. They can be loosely classified into general areas as accessories carried and those worn. Traditional carried accessories that are worn may include; jackets, boots, watches, shoes, bags, ties, hats, belts, gloves, stocks, shawls, stockings, necklaces and hear rings. These can be made from natural and artificial materials such as: beads, fabrics and beads. They have series of unique characteristics like:

1.) Subject to change
2.) Obsolescence
3.) Eventual replacement of newer items based on fashion in vogue. Nigeria indigenous fabrics (Ankara, Adire, Aso oke and Kente can be used to produce fashion accessories.

Importance of fashion accessories

Fashion accessories give fashion its finishing touch, which ultimately conveys flair and uniqueness. They are often used to complement dressing. Some of the importance of fashion accessories include:

1. Fashion accessories add colour, style and class to outfits.
2. They create certain look but they have practical functions.
3. Help in expressing personality

Materials and procedures in the production of fashion accessories

Production of outing accessories

Outing accessories are those special additional items (shoes, hats, gloves, stockings, jewelries, cuff-links, ties, pins, handkerchiefs, scarves etc.) worn for outings in order to supplement the garment. These could also be called special accessories for unique occasions. Different materials can also be used to produce these items. Beads will be used to explain the detailed materials and quantities of designed necklace, earring, belt, bracelet, shoe and bag. Some of these accessories can also be made with fabric scraps to show unique features through combination of different colours and fabrics. This add some touches of style to outfits. This includes buttoned bag, Ankara scrap bag etc.

Table 1. Details of materials and quantities for beaded Jewelry (necklace and earring)

Materials	**Quantities**
Glass beads	1kg

Fishing line	0.2 m
Earring hooks	0.5
Pliers/Scissors	1 pc

Procedures for the production of beaded jewelry (necklace)

1. Cut out the fishing line and side one bead.
2. Put three beads inside and cross with one bead.
3. Temporarily close off one end of the beading wire
4. String the entire measured bead.
5. Run the wire back through the bead in the opposite direction.
6. Add hook and stopper.
7. Ready for use.

Procedures for the production of beaded jewelry (earring)

1. Insert bead inside fishing line.
2. Insert another one bead inside the left-hand side.
3. Insert three beads inside the right-hand side.
4. Interlock with one bead.
5. Repeat the above steps four times.
6. Pass one glass bead and bead underneath.
7. Interlock and pass the fishing line and tie.
8. Add the hook and stopper, ready for use.

Table 2. Details of materials and quantities for beaded jewelry (belt)
Materials Quantities

Beads	1kg
Fishing line	0.5cm
Cutter	1pcs
Buckles	2pcs

Procedures for the production of beaded jewelry (belt)

1. Cut fishing line.
2. Insert three beads.
3. Interlock using one bead to form a circle of three balls.
4. Insert two beads on the right side, one bead on the left side, interlock with one bead out of the two.
5. Repeat steps.
6. Insert three beads and interlock with one.

7. Pass the fishing line in the next available bead.
8. Repeat the process to form its width and fix the buckle.
9. Insert the fishing line tightly.

Table 3. Details of materials and quantities for beaded jewelry (bag)

Materials	Quantities
Sound bead	500 g
Plastic bead	1.5 kg
Fishing line	0.5 cm
Cutter	1 pc

Procedures for the production of a beaded bag

1. Cut fishing line.
2. Cross the fishing line repeatedly on six pearls.
3. Repeat the process for nine lines.
4. Repeat until you arrived at the desired length.
5. Prepare the handle to the desired length follows procedures 1 to 2.
6. Join together and attach the zip.
7. Attach handles.

Table 4. Detail of materials used and quantities of beaded jewelry (sandal)

Materials	Quantities
Soles	1pair
Bead	1 kg
Fishing line	0.6 cm
Insoles material	36 cm
Buckles	1 pair
Scissors	1 piece
Shoe glue and brush	1 piece

Procedures for the production of beaded jewelry (sandals)

1. Start by making a bead string.
2. Pass three beads inside the fishnet and interlock with one bead.
3. Pair the fishing line into two and put two beads at one side and one bead at the other side.
4. Continue the procedures until you get the length of the desired foot.

5. Shaping the sole and the inner.
6. Cut the insole to the desired size and shape.
7. Apply glue to both and allow to dry little.
8. Mark where you want to place the head you have done on the sole.
9. Glue it on the sole, punch a small hole and join the buckle to it.
10. Clean and ready to use.

Table 5. Details of materials and quantities for Fabric (Ankara) scrap bag

Materials	Quantities
Ankara scarps	1/
Lining	1/
¼" foam/fibre	1/
Sewing machine	1
Thread	1
Zipper	1

Procedures

1. Sketch and draft bag pattern.
2. Transfer pattern pieces.
3. Add ½" to 1" seam allowance to the *Ankara*, fibre and lining.
4. Place the three materials (Ankara, fibre and lining) together.
5. Machine stitch them together.
6. Finish the raw edges with strips
7. Attach zipper and display.

Figure 11a: Materials Used for Bead Making (including fishing line, scissors)
Source: (Adebisi, Bashorun, Abdulkadir and Adepoju, 2021)

Figure 11b: Bead material
Source: (Adebisi, Bashorun, Abdulkadir and Adepoju 2021)

Figure: 11c A set of beaded items (a pair of sandal, earring, necklace, bag and belt)
Source: (Adebisi, Bashorun, Abdulkadir & Adepoju 2021)

Figure 12: Designed Beaded Hand Bags
Source: (Ajibade, 2023)

Figure 13. Fabric (Ankara) scrap bag
Source: (Adebisi, Abdulkadir and Isiaq, 2023)

Costume jewelries

Costumes are different from everyday clothing. These are used as form of symbolic expressions of one's self as well as communicative tools that interpret sociological efforts at any given time. Costumes gives expressive and explanatory information of the wearers, aid characterization, speak volume even before the character begins to speak or express themselves. The culture of the people is identifiable by the kind of costume they put on as first call of attention not only for the external covering of the body. They are unique identities particularly to the people which identifies them in any gathering. Also, costumes are seen as clothes worn by actors or performers to cover their nakedness but beyond that, they give life to the character actors portray whether on screen or on stage. Costumes give information on the tones and styles of play. They may look just like what we wear today or they may look like what people readily wore at the time in which they are set. They also give information on individual character in the relationships among characters and group characters. In today's world, celebrities and stars have become fashion icons as such television shows, films and music beyond serving as outlet for creativities have become fashion outlet. In addition, costumes are always been the major element in theoretical experience and are the vehicles for dressing up. Costume jewelries often incorporate the non-precious metals such as brass, plated bras and other alloys. The non-metals are leathers, textile, natural mud and coconut chops dyed or engraved or cracked shells and non-or-precious stores include: crystals and cubic.

Jewelries

Jewelries are luxurious items that are worn for personal adornment. They can be small decorative item attached to the body. They can also be reformed to accessories that include; earrings, necklace, rings, bangles bracelets, watches and bronches. They are designed for men, women and children and can be made from varieties of different materials like: beads, wires, metals etc. The wearing of jewelries are of the first human means of expression transcending the necessities of everyday life and have been constant features in mankind existence. All over the world, jewelries have been worn for the same reason and at the same place in the body. Jewelries add meaning to the wearers. They establish relations between public and private realms such as:

1. Personal expression: allowing individuals to communicate their identity, values and style to the public.
2. Social interaction: Wearing a unique and beautiful piece of jewelry can spark conversations.
3. Cultural traditions: In many cultures, jewelry play a crucial role in ceremonies, rituals and celebrations
   representing cultural heritage, values and identities.
4. Status and social class: Wearing luxury or expensive jewelry can signal the public of one's social class,
   privilege or status and may impact how individuals are perceived and treated.

Figure 14: Nigerian Costumes
Source: Adebisi, (2023)

Figure 15: Lace with beaded jewelries costume jewelries costume
Source: www.tmlinson.top/products

Figure 16: Aso-Oke with beaded
www.pinterest.com

Summary

This chapter has presented the concept of textile, design and accessories. The creativity of designing and producing various items with fabrics, beads, and buttons are interesting when competency is acquired. Textiles can be constructed in various ways. It can be made from combination of yarns. When they are used creatively to make different items with combination of elements of designs, desired aesthetic look will be obtained. Creative fabrics are fabric items designed and produced for various purposes. The fabrics scraps can be used to make different types of items including shoes, bags, belt, and hat. This ensures saving of money, prevent wastage and also in turn helps to use leisure creatively. The principles of design are guides to application and combination of principles and elements of design. They affect the ways they are organized. Fashion accessories are essential to give finishing touches that aids in improving the look of an individual outfit. They can also be used for self-expression and sometimes shows the status or class individual belongs. These fashion accessories are made from varieties of materials including: beads, buttons, fabric scraps etc. The procedure for making beaded accessories are highlighted in this chapter. Costumes are used as a symbolic expression of one's

self and it communicates extensively to the onlookers about the status or gathering one belongs. They are worn by actors or artists. They can be made from metals (brass, plated bras and other alloys) or non-metals (leathers, textile and natural mud). Jewelries are luxurious items that are worn for personal adornment. They can be small and be used as decorative items. In addition, they can be reformed to accessories that include; earrings, necklace, rings, bangles, bracelets, and watches.

Exercise

1. Explain textiles and designs.
2. State four importance of using creative fabrics.
3. Explain five principles of design
4. Enumerate the elements of design
5. Design and produce any accessories using beads and fabrics.
6. Discuss two apperceptions of principles of designs.
7. Enumerate materials and procedures in making beaded necklace and earring.
8. Design and produce any Nigerian costume jewelry.
9. Mount exhibition on items produced.

References

Adebisi, T. T., Bashorun, O. E., Abdulkadir, S. O. and Adepoju, B. A. (2021). Perception on Acceptability of Nigeria female on Beads Jewelries Empowerment for Entrepreneurship Development. Journal of Consumer Scieince. 6 (1):20-39.

Adebisi, T. T., Oduneye, F. E. and Ogunniyi, W. T. (2017). A survey on Safety Precaution Utilized by Indigenous Resist Fabric Dyers in Ilorin, Kwara State. Nigerian Journal of Textiles, 3(1): 68-75. Published by Textile Researchers Association of Nigeria.

Adebisi, T. T. and Abdulsalam A. O. (2017). Factors Influencing Colours in Clothing Selection. The Journal of Asian Regional Association for Home Economics 24(2): 56-63.

Adebisi, T. T. and Abdulkadir, S. O. (2015). Determinant Factors Influencing Utilization of Nigerian Veritable Wax and Indigenous Woven Fabrics among Homemakers in Southwest, Nigeria. Nigeria Journal of Education, Health and Technology Research (NJEHETR). 7(1): 214-222.

Adelaja, O., Salusso, C. J. and Black, C. (2016). Design and Development of Western-style Nigeria Apparel. International Journal of Fashion Design, Technology and Education

http//:exdoi.org110.108017543266.2016.11411237. 9(3): 169-175.
Adiji, B. O. (2018). Use of Beads in Contemporary Fashion Industry of South-western Nigeria. International Journal of African Society Culture and Traditions 6 (1). 7-14.
Akankasha, A. (2020). Elements of Design. International Peer Review Journal and Book (IPRJB) Doi.10.13140/RG.2.2.34459.28966.
Al-Ababneh, N. (2020). The Concept of Creativity: Definition and Theories. International Journal of Tourism and Hotel Business Management (IJTHBM) 2 (1) 245-246.
Anyawu, C., Chuckueggu, C. and Orubu, S. (2022). Textile Design and Traditional Cultural Properties in Nigeria: A Batik exploration. Journal of African History, Culture and Arts, 2 (2) 104-109.
Beadwork. (2020). Fabulous Leather and Lace Jewelry Making Projects Digital Edition.
Retrieved from: https://www.intweweave.com/product/beadwork feruary-march-2020-digitaledition/.
Forster, P. (2014). Clothing and Textile, Ghana Winmat Publishes. 460-466.
Nguru, M. and Mains, S. (2020). Socio-cultured Impact of Beadwork in East Africa. The nexux between the Dinka Samburu and Maseai ethnicities. International Journal of Innovative Research and Development. 9(7): 87-54. Doi: 10.24940/ ijird/2020/v9/7/jw.
Ohaka, R., Lemchi, S. and Iloeye, C. (2017). Consequence of Fashion Preferences on Students Perceived well-being in Tertiary Institution in Imo-State Nigeria. Journal of Home Economics 6 (1): 212-226.
Pinterest (2023). 660 Aso Oke Ideas, Explore Adeoye Omolara’s Board, https//www.pinterest
Tekena, M. G. and Ochuba, P. (2022). Fashion at Creative Art, Communication and Media Studies, Kenya School of Creative and Performance Art Film and Media Studies. ISSN 2958-1737 (Print) ISSN- 2958-1745 (online).

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CHAPTER 39
Introduction to Weaving Techniques
By
OGUNDUYILE Sunday Roberts and MAKINDE David Olajide

Overview

The word ‘textile’ was coined out from the Latin word “texere’’ The term was used initially when referring to woven fabrics that involved various fiber-based materials. Today the word ‘textile’ is used to embrace threads, yarns and fabrics that are used in cloth production. However, the scope of textile has been extended to embrace woven and non-woven materials. The non-woven textile materials could be produced using knitting, crocheting, felting, braiding, plaiting and bonding techniques. The importance of textiles to humanity cannot be overemphasized. It has been a major component aspect of material culture in many civilizations from time immemorial. Textile production was a form of activity that enhances human existence. Early textiles, prior to industrialization, apart from covering human nakedness, were used to display power, wealth and status in the society. Today the scope of textile has been expanded to cover many aspects of human needs. Textiles are used for physical protection against unfavorable weather conditions, adornment, modesty, status, among others. Textile is also used in geotextiles, filtration, rugs and carpets and in furnishing. Weaving is the most popular way of fabric manufacturing. It is a technique in textile production which involves the interlacing of warp and weft yarns at right angle in a regular and recurring pattern. The weaving of yarns into fabrics is often done on a loom.

Objectives

At the end of this chapter, students should be able to:
1. explain basic textile terms;
2. describe basic techniques of weaving
3. identify the types and parts of a loom; and
4. distinguish the differences between the weave patterns; and
5. perform weaving operation and produce samples of woven fabric

Basic terms in textile

Textile also refers to a flexible material comprising of a network of natural or artificial fibres, known as yarn. It is a generic term for all fibre materials used in fabric making. This includes fibre, yarn, thread, whether made by weaving or other processes. Fibre: has been described as a basic unit of raw material used in the making of yarns and fabrics. Silk, cotton, nylon, wool and linen fall into this category. Fibre is a long and narrow hair-like component that could be extracted from plant or animal tissue. Such plants as jute, flax, cotton, hemp or from silkworms, and other man-made materials such as acrylic, nylon are sources of getting fibres. Fabric is defined as any thin, flexible material made from yarn, directly from fibers, polymeric film, foam, or any combination of these techniques. Fabric is mainly constructed with yarns by weaving, knitting, felting, crocheting, etc. The warp is the thread or yarn that runs lengthwise in a woven fabric.

Cloth: This is a piece of fabric that has been woven or knitted. Any material referred to as cloth is expected to be pliable, soft, absorbent, easy to handle, durable and can be sewn among others. Cloth and fabric: can be used interchangeably. They are materials made from fibres, such as cotton, wool, silk, or synthetic. Cloth is a finished product such as a piece of clothing while fabric could be referred to as the raw material for cloth making.

Plain weave: It is the most basic of three fundamental types of textile weaves. The warp and weft threads filling over and under each warp yarn with each alternating with a high number of intersections cross at right angles and so aligned to form a simple criss cross pattern. Twill weave is one of the three types of weaves used for textiles. Twill weave often resulted into patterns that are diagonal in nature. Satin is when some weft yarn pass over three warp yarns and under one warp yarn and the circle is repeated. Satin weave often produces a glossy and smooth surface.

Embroidery: This has to do with the decoration of fabrics by the use of needles to stich designs into some selected portions of a fabric. Decorative materials such as variety of threads, needle types are used in the process.

Felt: described as a material made from condensed textile fibers. The process involves shrinking, melting and pressing together through a mechanical means to make flat the surface of the steamed and shrank materials. Shedding is the process of creating a passage for the shuttle or a weft yarn carrying devise to interlace with the warp through the lifting of the heddles

Filament: A filament is a very thin piece or thread of something. *Filament* yarn is yarns made from long continuous fibers or strands by either twisting them or grouping them. The performance of any fabric is dependent on the fibres or filaments.

Knitting: It is the process of knotting some loops of continuous thread to form a usable material. The process of interloping of continuous yarns can be done by hand or machine.

Loom: A manual or mechanical device for making warp and weft to interlace thereby resulting into a woven material.

Brief history of loom and weaving

Weaving is a process of interlacing the length wise yarns with the filling yarns at a position where the yarns are perpendicular to each other. Warp and weft yarns can be interlaced through many techniques. Weaving is a critical process that turns a raw material such s cotton, silk, flax polyester fibres into useful products.

The art of weaving has been in existence from time immemorial and has contributed immensely to the survival of mankind. It was embraced worldwide because of its peculiarities and its usefulness in the provision of clothing and a way to exhibit cultural attainments in many civilizations. Through the art of weaving, many civilizations were able to showcase their symbols and identities. Synthesis of literature reviews indicate that the emergence of weaving was traced back to the Neolithic era, about 12000 years ago. Before this time the principle of interlacing had started with the use of bark of trees, flax, jutes and grasses. In Africa, art of weaving had been traced to 500BC in Ancient Egypt. The importance of weaving and textile tradition was supported by the discovery of a terracotta plate which indicated the existence of a horizontal loom about 4400 B.C. According to Viegas (2011) humans began to wear clothing 170,000 years ago when they realized that being in nude was not comfortable. In Africa, the art of weaving became resilient artefacts that carry the history and memories of ethnic groups, nations and individuals. The art of weaving has been one of the important ways to make ends meet in Africa. The art of weaving has long been an integrated part of the African culture. The *Aso Oke* of the Yorubas, the *Akwete* of the Igbos and the *Okene* cloth of the Ebiras lend visual splendor, social prestige and cultural identity to the wearer. Tootal (2020) noted that looms are devises used in weaving cloth and that it began in ancient Egypt around 3400 B.C. Oelz (2018) observed that spinning preceded weaving around 600BC and that the use of looms did not evolve until the Middle Ages. He added that weaving preceded wearing and that the art of wearing clothing materials must have commenced after Adam and Eve had made their clothing from the fig leaf (Ogunduyile, 2005). At this time, the use of narrow band similar to finger knotting came up in many civilizations. This led to the invention of simple weaving looms and the production of textile began to be practiced in the home environment.

The traditional shuttles (Moncrief, 2020)

The Reed

https://en.wikipedia.org/wiki noted that the word loom was derived from old English, 'geloma' which was a generic name of a utensil meant for fixing threads on cloth in the 1830s. Loom was from then invented to make weaving possible through the interlacing of the lengthwise yarns and the filling yarns,

The interlacing continues to be on a narrow band types which had been embraced in many civilizations. The early loom as described by Merriam-webminister.com (2023) consisted of bars fixed in a place to form parallel threads in two sets alternating with each other. More refined hand looms came up before the industrial revolution and were mostly for small scale production. The period of industrial revolution brought in machines and new techniques of doing things. This time, the hand loom gave way to faster machine. The weaving that was previously done in the home environment for local consumption could now be produced through mechanization. A British Engineer known as John Kay invented the flying shuttle weaving machine in 1733. The outcome of his effort made weaving more dynamic and the new invention was acknowledged for its dominance for more than two centuries. Various inventions came up during the period of industrial revolution. In 1785 the first mechanized loom came into existence and was invented by Edmund Cartwright. The mechanized loom with large shaft and reeds was invented to produce wider cloths in large quantities at a faster speed. Unlike the hand looms which have the disadvantages of slowness, narrow width fabrics, manually operated shuttles and production at high cost. Another inventor, Joseph Marie Jacquard, a French man, developed an attachment for powered loom in 1804. The machine was made of an automatic selective shedding device and operated by a treadle controlled by the weaver and punched cards with holes. The cards made it possible to determine what cord of the fabric warp should be raised for each pass of the shuttle. The Jacquard loom is capable of producing intricate designs of applicable to damask, brocade and tapestries. With the inventions, textile could be produced cheaply in larger quantities as mechanically driven looms become available to meet the demands of the growing population. The Jacquard loom was invented at a time where there were higher demands for fabrics and the ease with which the machine could produce faster made its usage to spread to many countries. The discovery of synthetic fibres and polyester in the 19th and 20th centuries made the art of weaving more intricate with various weaving patterns. At this period, the first power loom using steam came up in 1786. The emergence of electricity in the 20th century also brought in lots of innovations. The steam weaving looms were replaced by the flying shuttle and jet types. The development in technology continued up till 1945 when the projectile technology by Sulzer was introduced.

A loom

A loom is a weaving machine that contains various functional parts such as the frame, beam, heddles, a lifting system among others. Through the lifting of the sheds, yarns are interlaced under tension. All looms have some basic features that make them perform the function of looms. All looms have the warp beam, harnesses, heddles, shuttles, take up and a means of shedding, picking, battening and taking off operations. Looms can be classified into manual and powered looms. They all have to maintain tensions while weaving.

The hand loom is a simple device with a wooden vertical shaft and are often used at cottage level or in the rural communities. Hand looms are manually operated and these include the vertical, the rigid heddle loom and the horizontal types. The uses of manual operated looms to weave various traditional fabrics have helped in providing employment for many people in Africa.



Inkle loom Rigid Heddle loom Horizontal loom

(Photo by Boe) (George Boe)

Source: (Nwaohuocha and Sophie, 2018)


Vertical loom Benjamin Umuteme (2022) Table Loom

https://www.camillavalleyfarm.com/weave/dorothy.htm


Sulzer Weaving loom Sulzer loom, springerlink.com

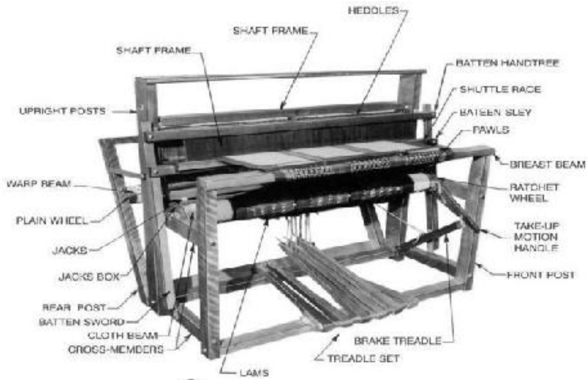
All the manually operated looms are in various categories such as the foot powered loom, vertical loom, horizontal loom, rigid heddle loom, narrow band loom, back strap loom among others. We also have the mechanically powered looms with various shuttle devices such as the automatic loom: a loom on which the shuttles are discharged automatically; in a circular Loom: the shuttles travel simultaneously on a circular path through a wave shed; Shuttle less Loom: A loom in which the weft is drawn from a stationary supply and is inserted by means other than a shuttle. Weft is carried by projectiles, in case of shuttle-less looms. The production rate is much higher and the quality of the product is also better and the product range much broader compared to that of shuttleless looms based on the product range. In an air jet weaving, the shuttle is not necessary as the weft yarn is being through in the shed by the means of air jets. This consists of a main and auxiliary nozzle as well as a profile reed. The air jet weaves faster than the shuttle loom. In a rapier loom the means of carrying the weft thread through the shed is fixed in the end of a rigid rod or of a flexible ribbon that is positively driven. A brief comparison between the looms will provide more insights into the various features of the looms.

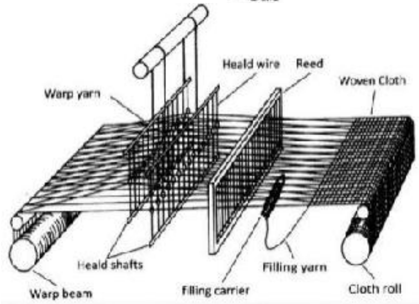
Table 1: Comparison between Hand Loom, Power Loom and Modern Loom

SN	Different Matters	Handloom	Power loom	Modern Loom
1	Types of Loom	It is Shuttle loom	It is also shuttle loom	It is shuttles loom
2	Driving Method	Driven by manual method	Driven by electric power or steam	It is driven by electric power
3	No of warp shed	Higher warp shed needed	Lower shed needed	Lower shed needed
4	Production Capacity	Lower production	Higher production than hand loom	Higher capacity than power loom5
5	Quality of produced design	Simple design can be produced	Complex design can be produced	Complex design
6	Running speed	Slow speed	High speed	High speed
7	Variety of design	Less number of design varieties can be produced	More number of design variety than handloom	More number of design variety than power loom can be produced
8.	Initial investment	Investment is lower	Higher investment	Investment higher
9	Shedding method	Shuttle is done by pedal	Shedding is done automatically	Automatically
	Picking and beating method	Done manually	Automatically	Done Automatically

Source: Oelz, (2017). http://www.finderzkeeperz.co.za

Parts of loom





Source: https://www.the-sustainable-fashion-collective.co

Heald-Shaft

This part is related to the shedding mechanism. According to https://textiletutorials.com/ Heald shaft carries a number of heald wires through which the ends of the warp sheet pass. The heald shafts are also termed as 'heald staves' or 'heald-frames'. The total no. of heald shafts varies according to the warp repeat of the weave. The shedding mechanism separates the warp threads into two sheets (layers) by lifting some of the heald shafts up whilst lowering others. Since each warp yarn from the weaver's beam passes through an eye of the heald shaft, when some of the heald shafts are lifted and lowered by a shedding mechanism, the corresponding warp ends are raised or lowered thus forming an opening.

The heddle https://wikidiff.com/heald/heddle The reed https://www.handweavers.co.uk/rigid-heddle-reed-

Heddle

Merriam Webster defines heddle as one of the sets of parallel cords or wires that with their mounting compose the harness used to guide warp threads in a loom. It is *one of the sets of vertical cords or wires in a loom, forming the principal part of the harness that guides the warp threads*.

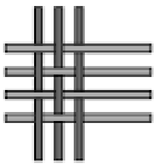
Reed: https://en.wikipedia.org/wiki noted that a reed is part of a weaving loom, and resembles a comb or a frame with many vertical slits. It is used to separate and space the warp threads, to guide the shuttle's motion across the loom, and to push the weft threads into place. In most floor looms with, the reed is securely held by the beater. Floor looms and mechanized looms both use a beater with a reed, whereas Inkle weaving and tablet weaving do not use reeds.

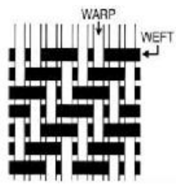
The methods of weaving

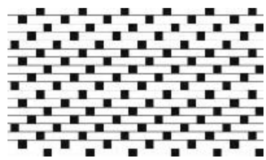
Weaving is a technique of fabric production. It consists of intertwining of two separate yarns called warp and weft. Before embarking on weaving, it is important to warp the loom with yarns and tie the end of a length of cotton string to the top left corner of the loom. During the weaving process, the warp yarns runs from one end of the frame to the other end while the filling yarns are rolled in a holder that goes into the shuttle. The shuttle is thrown forth and back as it unwinds the weft yarns across the opening shed for interlacing and beating. The lengthwise yarns are usually under tension when the shedding process is on so as to maintain the firmness of the fabric after weaving.

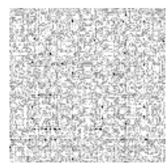
Types of weaves

The four main important weaves are the plain weave, the twill weave, the satin and basket weave.



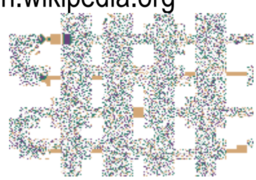






Plain weave Twill weave Satin weave Basket weave

https://en.wikipedia.org https://blog.treasurie.com/satin-weave/



Basic Leno Weave. https://en.wikipedia.org/wiki/Leno_weave

The plain weave simply refers to a process whereby the warp yarns and the filling yarns pass over and under each other at the same rate to produce a draught board effect. Based on the 50/50 level of interlacing, the plain weave is considered to have some qualities above other weave designs. It is considered more durable, easy to sew and looks identical on both sides.

Twill weave
A twill weave is often identified by its diagonal rib lines which were the results of the offset in the warp yarns. Unlike the plain weave, the twill allows the filling yarns to go over and under one or more warp yarns. The twill weave produces distinct front side different from the back side; this means that the front side and the backs sides are easily identifiable. Twill weave has more thread count which makes the end product to be thicker and durable. Twill is popular because the filling and warp yarns do not interlace as many times as they do in a plain weave.

The Satin weave
This is regarded as the third basic weave and requires at least five shafts to weave. In this structure, the weft yarns are predominant on the face of the cloth, and the warp yarns that bind the weft floats should be scattered as widely as possible. Satin weaves are smoother and reflect more glossy finish on the surface but show a matte flat finish on the other side.

Basket weave
It is closer to plain weave because two or more weft and warp can be alternated with two or more filling yarns, resembling a plaited basket. Basket weave is considered to be stronger and pliable than a plain weave. This weave is more pliable and stronger than a plain weave. Although is more loose than and not as stable as the plain weave.

Slit weave
This is a common weaving technique in tapestry and woven carpets or rugs. Slit weave comes out with open slit between colours that are adjacent to the other www.colan.com.au/compositereinforcement

Leno weave is defined as a weave in which two warp yarns are woven around the weft yarns to provide a strong yet sheer fabric. Yarns are put in position by crossing two or more yarns over each other and interlacing with the one or more of the weft yarns. There other types of weaves that are derivatives of the four basic types, they are: Honeycomb Weave, Huck a Back Weave, Crepe Weave, Jacquard weave, among others.

Characteristics of the weaves

Plain weave	Twill weave	Satin Weave	Leno Weave
No wrong side Versatile Creases easily Flexible Less Absorbent	Have and front surface More pliable' More durable with high counts Recovers from wrinkles easily	Shiny front side Aesthetically pleasing Versatile and more goods come out of it More durable Sewing is a bit difficult	Warp yarns wraps around the filling yarns more effectively Good for bags, nets more porous

Strong and Hard Frays easily Limited Stretch	Good texture and good looking Higher warp and weft densities Glossier and soft Low abrasion resistance	Snags easily Resistant to wrinkles	Staple Gauze lime and Durable

Basic weaving materials.

There are some basic materials needed for weaving after the possession of a loom. The materials include the following: Warp thread, weaving needle, Weaving comb, Yarn, Shuttle sticks, scissors, wool roving and threads.

Motions of loom

The loom undergoes different basic motions for fabric production. These are the primary motion, secondary motion and auxiliary motion. These are essential for weaving of fabric. Shedding, Picking and Beat-up are the essential feature of the primary motions. Take up and let off are known as the secondary motions. The third one which is the auxiliary motions is set to improve the quality of the fabric. The secondary motion also provides the let off necessary for quality of tension in the weaving area and at the expected rate. Shedding which is the process of separating the warp yarn into two layers to form a shed is a basic motion while picking, the method of passing the weft threads across through warp yarn is another and the beat-up process allows yarns that are sent to the weft to settle at the fell of the cloth.

The auxiliary motions are used in the efforts to improve the quality and productivity of the fabrics. The auxiliary motions are:

Warp stop motion: This motion helps to stop the loom in case of warp yarn breakage or extensively loosened warp yarn.

Warp protector motion: This motion protects the warp yarns by stopping the loom when shuttle fails to reach the other end of the loom.

Weft stop motion: This motion helps to stop the loom in case of Weft yarn breakage or run-out of the pirn (Weft Package).

Weft mixing motion: This helps to insert various colored weft yarn into the same fabric for check and stripe effect.

Feeler motion: This motion helps to identify the presence of weft yarn on pirn.

Break motion: This is a mechanism to stop the loom when weft yarn breaks.

Weft Replacement Motion: This motion helps to provide uninterrupted filling insertion by changing the depleted to a full package.

Sequence of Operation in Weaving

Winding and clearing are considered very importance in a weaving sequence. Winding is the process of transferring yarn or thread from one type of package to another to type of package. It is done in the spinning mill. Rewinding is also an important operation in the fabric manufacturing factory. The clearing aspect has to do with the process of removing faults from the yarn. The process improves the quality of the spun yarn so that weaving operation could be attained with the required skill on the weaving machine. Other sequence includes weft winding, sizing, usually a synthetic coating, is applied to the yarn as **an** intermediate protective process. It prepares the yarn for the weaving against friction, stretching, wounds from the healds and reeds etc. The types and parts of a loom

Defects in woven fabrics

There are various types of defects in fabrics which may be created during weaving of fabrics. These defects can be eliminated with adequate care and attention paid to the various stages of cloth production. Some of these defects are:

Broken picks: During weaving, if the weft yarn is broken and it is not rectified, then fabric defect happens in width of the fabric.

Reed Marks: This becomes visible when marks are created in warp yarns during weaving or if the denting is not properly done or beam setting is wrongly done.

Broken pattern: During weaving of design fabrics, if the warp yarn is broken and not rectified then in any designs like dobby, jacquard or in ordinary looms, the patterns are broken. In order to avoid such defects, care should be taken for lifting, peg plan or jacquard card.

Thick and thin places: If the yarns in fabric are thick in some places and thin in other places, then thick-thin places are created in fabrics. These defects are more visible after finishing of fabrics. Also if the fabric is woven with uneven warp yarn weft or yarn, then this type of problem may appear.

Mixed weft: For any reason if different types of weft yarns are used, then visible stains are created in fabrics which become more visible after finishing. Generally, such type of defect happens due to weaver's mistake.

Missing End: This occurs when a space is created in the fabric as a result of a partial or total missing of yarn from the woven fabric

Shuttle marks: Sometimes stains are found in the warp yarns parallel to the weft yarns which are caused due to the friction of warp yarn with the shuttle. This type of defects may happen due to the alignment fault of shuttle box, the uneven tension on warp yarn or for any other reasons. In order to have an aesthetically pleasing woven fabric, it is important to consider those elements of design that affect the piece. We have elements of design applicable to all artistic works, so elements such as colour, texture and pattern cannot be pushed aside when casting an overall look at a woven fabric. The development of striking patterns and textures could be enhanced by the use of coloured warp and weft yarns combined with the weave structures. Consumers will always want to consider the colour and the feel of the woven fabric with regards to its depth and dimension.

Summary

In this chapter, the authors introduced the topic and defined textile. The important basic terms in the field are covered. The chapter identifies the types of looms and their parts as well as the sequence of operations in weaving. Various weaves such as the plain, twill, satin, leno weaves and their characteristics are discussed. The motion in weaving and the defects that affect woven fabrics are also stated. However, a course of this nature requires that students are exposed to the practical aspect of weaving in the studio where their experiences could be concretized.

Exercise

1. What is textile and what are factors that make good textile?
2. Define fibre and filament and what is their importance to the art of weaving.
3. Heald and heddle are synonymous, discuss.
4. What are the techniques involved in the production of a plain weave fabric?
5. Mention five important parts of a table loom and discuss each
6. What are the advantages and disadvantages associated with power loom?
7. Briefly trace the history of traditional loom and its use in Africa
8. With an inkle loom, table loom vertical or horizontal loom produce a two feet plain fabric.
9. Discuss various manual looms and their contributions to fashion in Nigeria.

References

Avoca Handweavers. https://www.pinterest.com/pin

Bharathi, K. D. (2020). Traditional Textiles of Nigeria, Value Chain. http://textilvaluechain.in

Cordoni, C. (2020). Brief History of Weaving. Arte Morbida Textile Arts.

Gonsalves, A. S. (1974). Weaving: Techniques & Projects, (A Sunset Hobby & Craft Books) Paperback

Magnavita, S. (2020) The Early History of Weaving in West Africa: A Review of Evidence, Cambridge University Press

Makinde, D. O. (2018). Unpublished Lecture Notes on Fashion Design.

Moncrief, L. (2020). Choosing and Using Shuttles, Stick Shuttles, Flat Shuttles, and Rag Shuttles, handwovenmasgazine.com

Nwaohuocha, O. and Sophie (2018). Fashion designer reinvents ancient technique, Inside Africa Magazine

Oelz, L. (2017). http:/www.finderzkeeperz.co.za.

Ogunduyile, S. R. (2005). Cottage Textile Production: A Step out of Poverty, 41 Inaugural Lecture

Series, Federal University of Technology, Akure, Nigeria.
Ogunduyile, S. R. (2016). Unpublished Lecture Notes on Weaving Techniques.
Perry, T. (2022). The History of Weaving and Women from ecoist.world/blogs/ecobliss/
Shiyu Hu (2013). A Typological Theory of Weaving and Its Applications in Computer Graphics Unpublished PhD Dissertation, Graduate and Professional Studies of Texas A and M University
Tootal Fabrics (2020). The History of Woven Textiles (https://www.tootal.nl/en/homePublic)
Umuteme, B. (2022). 100 looms weaving Competition will attract Investment into Ebira Land, Blueprint. https://www.blueprint.ng › 100-looms-weaving-comp.
Leno Weave: https://en.wikipedia.org/wiki/Leno weave (2021).

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Professor Makinde, David Olajide is an indigene of Ogbomoso in Oyo state. He was born in Kumasi in 1962 where his parents (Mr. and Mrs. Olawale Makinde) have gone to trade in Ghana. He had early elementary education in Ghana before returning back to Nigeria to complete his primary education in Ogbomoso. Makinde obtained his first-degree certificate in Fine and Applied Art with specialization in Textile design from the University of Ife, Adeyemi College of Education, Ondo. In 1997, professor Makinde obtained a master degree (M.A. Art History) and Master of Fine Arts (Textile Design) degree in 2006 from Obafemi Awolowo University, Ile-Ife. Makinde in 2014 obtained his Ph.D in Art History and Criticism from the University of Nigeria, Nsukka. Makinde rose through the ranks to become professor of Textile and Art History in 2017 in the Department of Fine and Applied Arts, Obafemi Awolowo University, Ile-Ife. Professor Makinde has served in many administrative and academic positions including; Head of department, Vice-dean among others

CHAPTER 40
Patterns Drafting and Cutting Room Practice
By
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Overview

To make clothes, there is need to make pieces that will be joined together to give a three-dimensional form that will conform to the body shape. The pieces are first made on paper to ensure that the measurements, style and fit are right. In clothing construction and fashion design, a pattern is the template from which the parts of a garment are traced onto woven or knitted fabric before being cut out and assembled. While pattern drafting is a pattern making process using the measurements of different body areas to create basic patterns - or blue prints of essential pattern blocks - which is often referred to as a pattern set: such as Bodice Front, Bodice Back, Sleeves, Skirt Front, Skirt Back, Trouser Front and Trouser Back. However, it is a known fact that in most developing countries like Nigeria, patterns are not available and where they are available, they are expensive. On the other, hand making patterns for sewing becomes expensive since most of our garments are made for individuals. In most African countries therefore, garment construction is started by cutting straight from the fabric.

Objectives

At the end of this chapter, students should be able to:

1. acquire the practical skills for making patterns;
2. describe ways of making patterns;
3. explain the importance of pattern;
4. describe different types of patterns;
5. describe basic blocks using standard measurements;
6. demonstrate how body measurements are taken;
7. draft basic block patterns;
8. adapt basic block patterns for different styles;
9. explain freehand cutting;
10. understand the principles for freehand cutting to produce maximum results;
11. cut out simple garments using freehand; and
12. compare the advantages and disadvantages of freehand cutting with patterns.

Tools and equipment for making patterns

(i) Working Surface: A flat working surface is required.

(ii) Paper: Strong brown or white paper is used for patterns, Parchment or thin card should be used for blocks that are used frequently.
(iii) Pencils: use hard pencils for drafting patterns (2H), coloured pencils are useful for outlining complicated areas.
(iv) Fibre Pens: these are required for writing clear instructions on patterns.
(v) Rubber: As an eraser
(vi) Metric Ruler: For measurement.
(vii) Curved Rules: these are used for drawing long curves.
(viii) Metre Stick: is a ruler used to measure length
(ix) Set Square: a large set square with a 45^0 angle is very useful; metric grading squares can be obtained.
(x) Metric Tape Measure: this is used to take body measurement.
(xi) Tracing Wheel: is used to transfer markings from patterns onto fabric with or without tracing paper.
(xii) Shears: use separate shears for cutting cloth and papers as cutting paper will blunt the blades.
(xiii) Cello tape: is used to bond patterns together.
(xiv) Pins: pins secure pattern pieces to the fabric for easy cutting.
(xv) One-quarter and One-fifth scale squares: these are essentials for students to record pattern blocks and adaptations in their notebooks.
(xvi) Stanley Knife: this is use to cut out narrow channels in patterns.
(xvii) Tailors Chalk: these is used for marking out the final pattern onto the cloth and for marking alterations on the garment when it is being pitted.
(xviii) Toile Fabrics: Calico is used for making toiles for design on woven fabrics. Make sure the weight of the calico is as cloth to the weight of the cloth as possible. Knitted fabrics must be used for making toiles for design in jersey fabrics; the toile fabric must have the same stretch quality.
(xix) Metric Square: this does not have to be the more expensive graduated tailor's square based on the chest scale. The system in this book is based on a range of standard body measurements so the graduated square is of limited use.
(xx) Calculator: the calculator is now a common tool in all areas of skill; it eliminates the hard work of calculating proportions and is accurate. If a calculator is not available use the table of aliquot parts (page 36).
(xxi) French Curves: plastic shapes and curves are available in a range of sizes; they are useful for drawing good curves. A flexicurve which allows a shape to be manipulated is also available.
(xxii) Pattern Notcher: this is tool which marks balance points by snipping out a section of pattern paper.
(xxiii) Pattern Punch: this is used to punch holes in the pattern.
(xxiv) Pattern Hooks

(xxv) Pattern Weights: these keep pieces of pattern in position on paper or cloth.

(xxvi) Model Stands: Although not essential for beginner, they are invaluable to the serious student for developing design.

(xxvii) Computer Equipment

Pattern making, symbols and the importance

Meaning of pattern making

A pattern is a blueprint that is used to cut the fabric pieces and the garment is made. It is the draft or technical drawing of a garment. Measurements are taken using standard charts, dress forms or the human body; these measurements are plotted/drafted into two-dimensional (2-D) patterns form which clothing is created. For students, pattern making is both fascinating and crucial because it enables them to interpret designs and comprehend. There are numerous ways to create patterns, the most popular ones are the ones to be discussed. Pattern-making is an art. Thus, it is an art formed to manipulate and mould a flat piece of fabrics to fit one or more human figures. Making patterns serves as a link between design and production. A pattern that translates the design into the shape of the garment components can turn a sketch into a finished item of clothing. The body is not flat, although the pattern is: body dimensions include height, breadth, and depth. The pattern maker therefore, is concerned with the task of moulding to conform to a number of secondary curves and bulges that are present inside this generally cylindrically framework. The pattern maker transforms the flat piece of fabric into three-dimensional fashion form that contours of the body's curves. Usually, a flat sketch with measurements or two-dimensional fashion illustration is used as the basis for a pattern by a pattern maker. The fundamental pattern is the cornerstone on which pattern creation, fit and design are built. The fundamental pattern therefore, serves as the foundation for creating flat patterns. Thus, it has a straight forward design and fits the body with just enough ease to allow for comfort and movement.

Ways or methods of making patterns

(i) Drafting

Pattern drafting is one of the ways by which patterns are made. Drafting is a method in pattern making that involves the measurement taken directly from a person or a dress and so basic design patterns are created using the process. It involves the use of body measurements to draw out the outline of the garment piece on paper, before the various body measurements are used. Pattern drafting needs the skill of an artist and the precision of a scientist. Since garment come in different styles and designs, the standard body measurements sometime need to be divided up to obtain dimensions for the different styles, as such simple mathematical skill is needed.

(ii) **Flat paper pattern making**

Flat pattern making is another method of making patterns. It involves the development of a fitted basic pattern with a comfort to fit a person. In this method, a basic pattern is made through the method of drafting. These basic patterns are made to have all the body fittings. These basic blocks are patterns in a very simple design that provides all the fittings needed for the body. These blocks, which are not patterns because they have the darts cut out, are manipulated using principles in flat pattern making to come up with various designs or styles. A sloper is the standing point in a flat pattern method. In a nutshell, if a designer wants to develop a standard pattern, flat pattern is the fastest and the most efficient method.

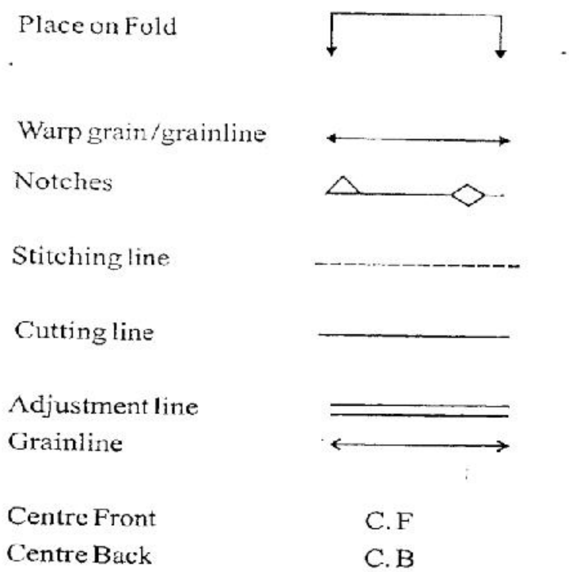
(iii) Draping

Draping is another method of coming up with patterns for use in garment construction. Draping is a method which involves a two-dimensional piece of fabrics around a form because of which a three-dimensional fabric pattern is created. Thus, it involves wrapping fabric around a dress form while creating the desired style. As the fabric is wrapped around the dress form, it is pinned in place and cut along proposed seam lines. Once this process is completed, the fabric is taken off and used as the pattern or transformed into a paper pattern. The fabric used in the original draping is not the fashion fabric. It is worth noting that the fabric is a test fabric which is usually called muslin. It is advisable therefore, that the muslin should have weight and structure similar to the final fashion fabric that will be used to make a meaningful garment.

Pattern symbols and labelling in garment construction

Symbols and labels are used on patterns to provide directions to the user of the pattern. Symbols on patterns give a variety of information including cutting lines, alternation lines, button/button-hole placement, fold lines. dots and notches, which help match the piece during construction. Standard international markings/labels are used on patterns and provide information on cutting and joining of cut pieces. The international symbols make it possible for the patterns to be used all over the world since they represent the same meaning in every language.

The common pattern markings are as follows:



Pattern piece should also be labeled to indicate:

- A particular pattern piece number.
- The various parts of the garment like bodice front, front yokes etc.
- The name of manufacturer.
- Pattern catalogue number.
- The number of pieces that can be cut.

Types of patterns

There are basically two sources of pattern for use to the home sewer. They are commercial patterns that are brought on the market and then home-made- patterns.

(i) Commercial patterns

Commercial patterns are full-scale tissue paper clothing patterns used by the home-sewer to create garments and accessories. Commercial patterns are prepared by companies and sold in the market. There are various commercial patterns in the market. These are designed and made by experts to fit standard figure types using specific body measurements. In Africa however, they are not very common, however, ready-to-wear garments are based on these patterns. In the selection of commercial patterns, it should be noted that patterns are made to fit various sizes or figure types. They are not designed for age or any specific person. In selecting a pattern therefore, one may not get one that will fit his/her body measurements exactly.

There are generally two types of commercial patterns. These are printed and perforated. The type is determined by the markings on the type of markings on the commercial pattern.

(ii) Drafted Patterns

Drafted pattern is made to fit a particular person. A person's body measurements are first taken, then the pattern is drafted to fit his/her size. Home-made patterns are usually drafted or adapted at home using body measurements. Drafting a design from scratch at home is very challenging and requires a lot of skills. It is therefore advisable to acquire basic blocks and adapt to selected designs.

Importance of accurate body measurements in garment construction

Taking correct measurements is one of the most important steps in making a custom-made dress. Tailors need to pay a lot of attention to every small detail while taking measurement to garment creation. Despite being an obvious necessity, there are many reasons why it is an important task for the tailor to take accurate body measurement. Typically, body measurements are done to ensure that garment fits perfectly, neither loosely nor tightly. Thus, a well fitted garment can enhance not only the look of the person but also the personality. The importance includes:

(i) Style

Taking measurements in garment construction

Ideally, all body measurements should be taken over an undergarment to be worn with the garment. Body measurements should be taken by someone other than the person whose measurement is being taken to make sure it is taken properly and accurately. Measurements are taken from different areas of the body, depending on the style of garment that is being constructed. As one takes the body measurements, it is advisable to create a record book for the clients It is not advisable to use measurement taken of a particular person or client over and over again. It is advisable, as much as possible, to take a person's body measurements anytime a fashion designer is going to make a new set of clothes for customers.

There are six measurements that are the key reference points that most sewing pattern company size charts use:

(i) Neck and Bust: To measure your neck, pull the tape around the middle, coming from the back to the front.
(ii) Waist: It is measurement of the area right above the belly button, the smaller circumference
(iii) Hip: measuring the lower Hip's widest part would give the perfect hip measurements.
(iv) Length: To measure the overall length of a dress, the model needs and stand straight. By then, the measuring tape should be placed at the top of the shoulder, falling to the floor or the required length.
(v) Cross Shoulder: While getting an outfit stitched that must be worn on the upper body, one must get their cross-shoulder measurement done. In this, measurement from one shoulder to another shoulder is noted down.
(vi) Arm Length: One must put the measuring tape from the armpit to the wrist to measure the arm's length.

The diagrams that follow show the various points of the body where measurements are usually taken.

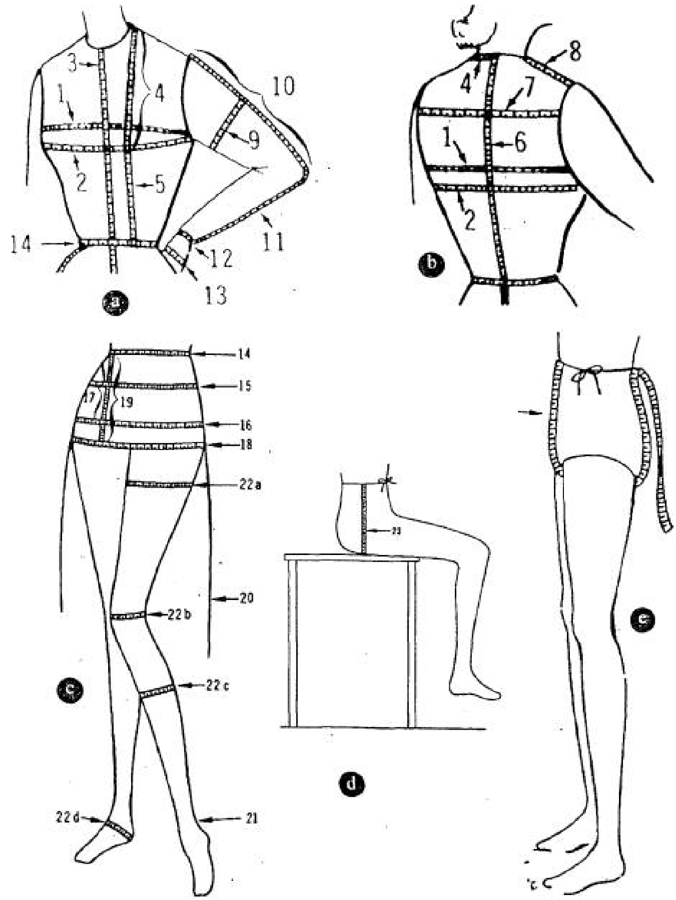


Figure 1: Body Measurements for Females

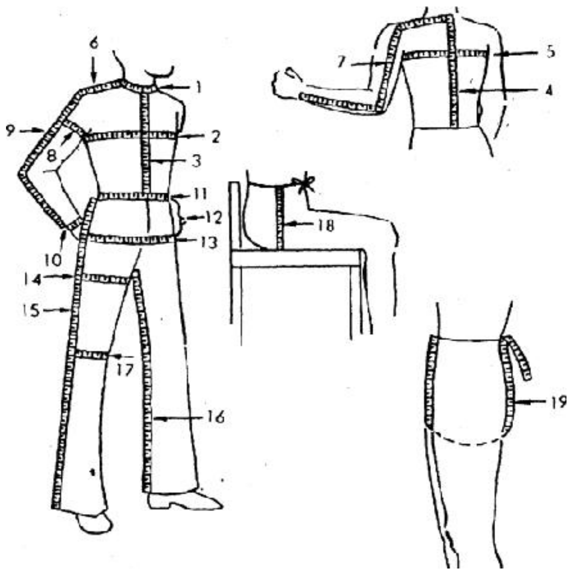


Figure 2: Body Measurements for Males (Nigerian)

(i) Taking vertical measurements

Vertical measurements are those taken along the length of the body. When a fashion designer is about to take body measurements, it is advisable to tie a cord around the waist of the person and leave it in position until all the measurements is completed. The accuracy of many of the longitudinal measurements that are taken depends on this exact waistline location. The table that follows shows the vertical measurements a fashion designer will need in garment construction and how to take them.

(ii) Taking horizontal measurements

Body measurements should be snug but not tight. Putting two fingers in the tape helps in making sure the tape can be moved around and also provides a good indication of the snugness of the measurement.

Personal Body Measurements for Women (Nigerian)			
	Body Measurement	Ease to be added in cm	Minimum required = column 2-H
BODICE 1. High bust 2. Bust 3. Centre front bodice length 4. Length from nape to tip		 7-5-12.5 0.6-1.3 1.3-2.5	

of bust 5. Length from centre front over bust to waist 6. Centre back bodice length 7. Across back width 8. Shoulder, length, (neck to arm socket)		 0.6-1.3 1.3	
SLEEVE 9. Upper arm circumference 10. Arm length, shoulder to elbow 11. Arm length, shoulder to wrist 12. Wrist circumference 1 3 . Hand circumference		 5-7.5 1.3-2.5 1.3	

SKIRT 14. Waistline 15. High hips, 7.5cm below the waist 16. Hips at the fullest part, parallel to floor 17. Waist to fullest part of hips 18. Thighs parallel to floor 19. Waist to thighs, centre front 20. Skirt length – waist to floor		1.3 – 2.5 1.3 – 2.5 5 – 7.5 5 – 7.5 Hem allowance needed	
PANTS 21. Pants length 22. Leg circumference a. Thigh b. Knee c. Calf d. Instep 23. Crotch depth 24. Crotch length		5 or more 1.3 – 2.5 2.5 - 5	

Personal Body Measurements for Men

	Body Measurement	Ease to be added In cm	Minimum required = column 2+3
UPPER BODY 1. Neck 2. Chest 3. Centre front to waist length 4. Centre back to waist length 5. Back width 6. Shoulder length		 1.3 2.5 – 12.5 0.6 – 1.3 0.6 – 1.3 2.5 – 3.2	

SLEEVES 7. Shirt sleeve length 8. Upper arm circumference 9. Arm length 1 0. Wrist circumference		5-7.5 1.3-2.5	
Le4x\sOWER BODY 11. Waist 12. Waist to fullest part of hips 13. Hips (seat). 14. Thigh 15. Trouser out seam (side Length) 16. Trouser in seam 17. Knee. 18. Crotch depth 19 Crotch Length		1.3-2.5 2.5-5 2.5-5 1.3-1.9 5 - 7.5	

Drafting basic blocks using standard measurements

(i) Bodice blocks

Measurements needed for drafting the basic bodice blocks.

To draft the bodice blocks, one needs to look at the waistline to the neckline which is the area occupied by the bodice block. Measurements for this area together with the needed ease are what is required to come up with the front and back bodice blocks. These measurements are as follows:

1 . Total bust measurement, i.e. bust measurement plus ease of 10cm.
2. Across back measurement plus ease.
3. Nape to waist.
4. Neck base
5. . Total waist measurement.
6. Shoulder measurement
7. Total chest measurement
8. Bust separation.

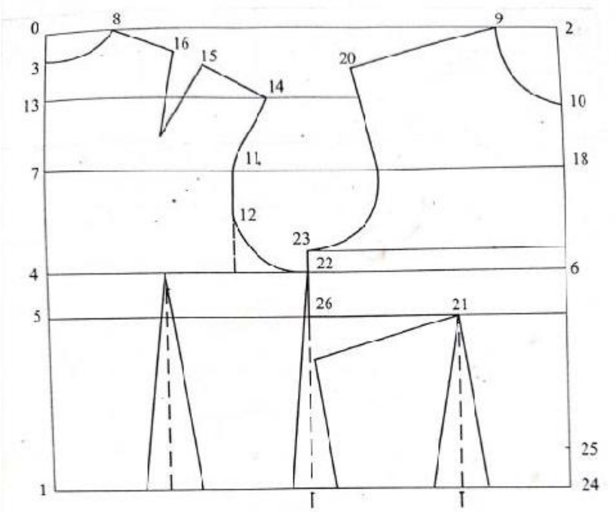


Figure 3: Basic bodice block

Drafting the fitted bodice block.

0-1 = Nape to waist plus 2cm. Square both points across.

0-2 = $^1/_2$Totalbustplus0.5.Square down to24.

0-3 0-3 = 2cm.

3-4 = ½ 3-1. Square across to 6 for underarm line.

4-5 = 4cm. Square across for bust line.

4-7 = ½ 4 -3. Square across for across back line.

0.-8 = ½ neck base circumference. Join 8 -3 with a smooth curve for the back neckline.

2-9 = 1/5 neck base circumference minus 1.5cm. Square down.

2-10 = 1/5 neck base circumference plus 0.2cm. Square across and curve the front neckline about 2.5cm diagonally from the corner.

7-11 = ½ total back width. Square down to underarm line and mark midway 12.

Extent the 7-11 line to cut C.F. at 18.

3-13 = 1/3 3-7 minus 0.5cm square across. 13-14 = 7-11 plus 2.4cm.

Extend the 13 -14-line outwards

8-14 = Shoulder length plus 1.5cm.

14-15 = ½ Shoulder length. Square 15 to 17,2cm from across back line

15-16 = 1.5cm for dart. Close the dart and complete the shoulder line

10-18 = ½ 10-6 plus 2cm. Square across.

18-19 = ½ total chest width. Square from 19 to underarm line.

9-20 = Shoulder measurement with 20 being 1.5cmfrom 13-14 line.

21 = ½ bust separation from C.F.

22 = Midway 4-6. Square down for provisional side seam.
Connect 20 through 19 to 23(23 is 1.5cm above 22) for front armhole and 14 through 11,12 to 22 for back armhole.
24-25 = 1.5cm for extra length to cater for bust prominence.
Join 24 to 1 for provisional waistline.
Mark 26 on bust line at side seam
27 = 2.5 cm below 26.
Join 26 and 27 to 21 for underarm dart

Waistline shaping

The waistline as drafted so far has no shaping. It has the same fit as the bustline. It has to be shaped to fit the waistline and make the bodice conform to the curves of the body.
This shaping is achieved as follows:
Square 17 and 21 down for the midline of waistline darts.
Back Dart = 4cm
Front Dart = 5.5cm.
Side seam = 4cm to be divided between back and front
Draw in the back side seam.
Close side dart and draw in the front side seam to be same length as back side seam

Measurements needed for drafting the basic skirt blocks.

To draft the skirt blocks we again need to look at the area of the waist down, where the skirt is used for and then determine the measurements needed for making a pattern to fit that part of the body. Once again we will add ease to the needed measurements.
The measurements needed to draft the basic fitted block are as follows:

1. Total waist measurement-i.e. waist measurement plus ease.
2. Total hip measurement-i.e. the waist measurement plus ease.
3. Skirt length.

Drafting the basic skirt block

Draw a rectangle 0,1,3,2.
0-1 = Skirt length plus lcm for C.F.
0-2 = Half the total hip measurement.
4 = Mid way between C.F. and C.B. at hip level

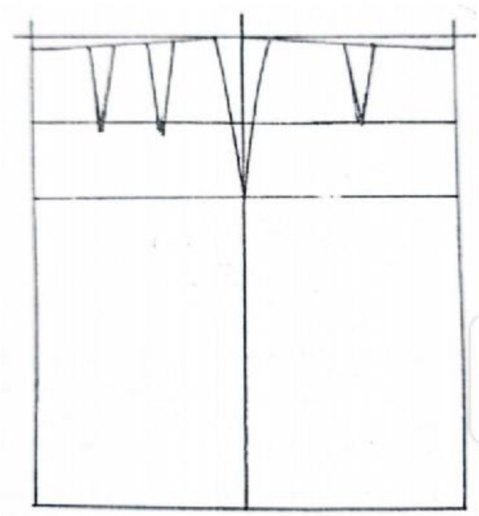


Figure 4: Straight Skirt block

Sleeve block

Measurements needed for the fitted sleeve block are as follows:

1.Armhole measurement of bodice block

2.Sleeve length

3.Upper arm measurement plus 5cm ease.

4.Wrist measurement plus 6.5 cm ease.

Drafting the basic fitted Sleeve block

Square lines from 0 out

0-1= one third the armhole circumference of bodice block

1-2= sleeve length.

0 -3 = 0-4 = half total top arm measurement. Mark underarm line and join 1 -3 and) 4 with straight lines.

0-7 = lcm which is the front waist drop.

0-8 = One quarter total waist measurement plus 4cm.

2-9 = 1.5cm which is the back waist drop.

2-10 = One quarter total waist measurement plus 5cm.

5-6 = Mid way between 0-2 and hip level.

To complete the side seam draw smooth curves from 8 through 11 to 4 for front *unA* 10 through 12 to 4 for the back, with 11 and 12 being lcm and 0.5cm respective^ from the straight line that separates the front and back.

Dart placement.

To locate the darts divide the total waist measurement by nine and place tbs fW darts, that distance from C.F. or C.B. on waistline. The front dart has a width of 4ca. The dart allowance for the back is 5cm and is divided equally among two dam 2.5cm apart. Note that the front dart can also be divided into two.
To complete the waistline, close the dart and draw a smooth curve from 7 to % and 9 to 10 with the lines meeting C.F. and C.B. at right angles.

Back:
3-5 = one third 3-1
6 = midway 3-5 and 0.5 cm in from guide line.
7 = 2 cm out from guideline and midway 5-1.
Connect 3-6-5-7-1

Front:
4-8=halfway 4 -1 minus 1.8cm
9= midway 8-1 and 2cm from straight guideline.
10= midway 4-8 and 1.5 cm in from guide line
Connect 4-10-8,ll-l
Elbow level from 0=25 - 26 on bodice draft

Wrist shaping
The standard measurement for wrist is 2-10 = total wrist measurement plus 5.5 cm dart allowance divided by 2. Elbow point is (2-14) midway underarm seam (3-13) and center grain line {1-2) 10-15= half 10 -2 plus 0.8 cm. connect to elbow point. This line forms the center of a 5.5 cm wrist dart.

To complete wrist:
Midway 2-10 drop 0.5 cm. Midway 2-14 raise 0.5 cm. Fold in sleeve dart and connect wrist curve through all these points.

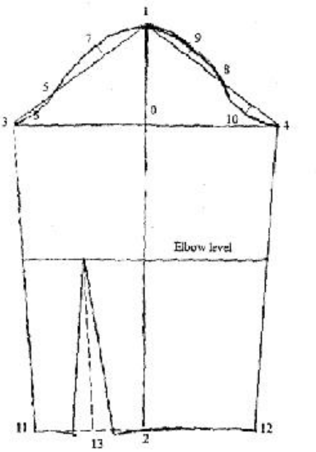


Figure 5: Sleeve (Wrist Shaping)

Adaptation of basic patterns

The basic block is the basic pattern in which all other designs are built. Before one goes on to change the basic block to other patterns, it is important to discuss the basic structure of the blocks.

The structure of the basic blocks and their use in pattern adaptation

The five basic blocks are made to fit closely to the shape of the body, for this to happen there are darts to do the fitting. The diagram that follows shows what a garment made from patterns of the basic blocks will look like. Since the designs shown below are not the only design in the fashion world, the basic block which is simple and easy to make is used as a basis for creating other designs.

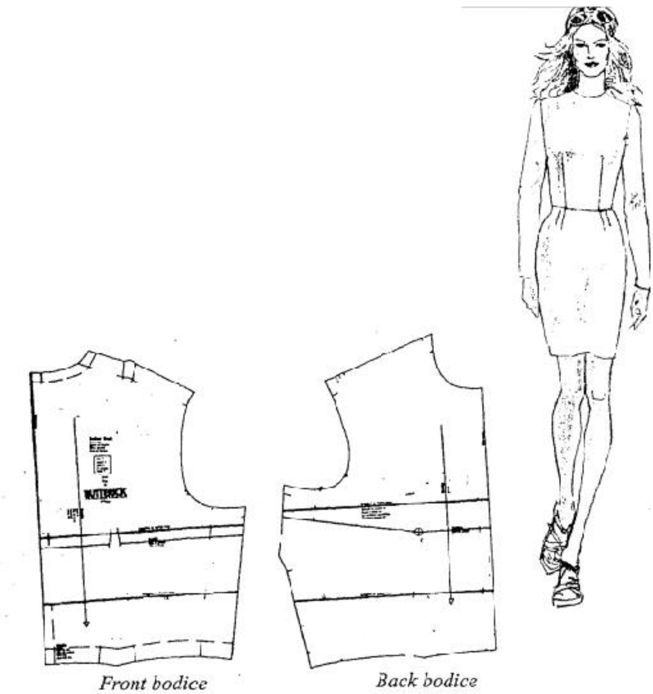


Figure 6: Front and Back bodice and Female style being adapted from the bodice.

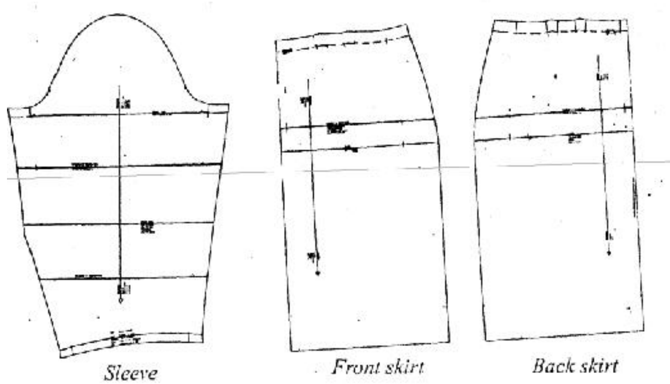


Figure 7: Sleeve, Front and Back Skirt

Darts in patterns

Pattern adaptation has its basis in the structure of darts and their use therefore understanding darts is very important to pattern adaptation. Darts are triangular folds in a garment to allow a fitted garment to accommodate the bulges or curves of the body. There are "Wedge" and "Oval" darts but the basic block darts are basically "wedge" darts. It should however be noted that oval darts are a result of the base of two wedge darts meeting at a common seam line with the common seam line eliminated. Darts are generally named after the seams they emerge from. There are waistline darts, underarm darts, shoulder darts, etc. Fitting darts point to the bulges for which they cater. Since they create a three-dimensional effect to accommodate bulges, their tips should not cross the tip of the bulge they are catering for or the bulge gets flattened. Dart tips should also not be too far away from the bulge or they create unsightly pockets outside the bulge. The tips of the bulges the darts cater for are what we call pivot points of the darts. That is the darts revolve round these points. It is an indication that no matter the seam line a dart is moved to, in creating a new design it should still point to its pivot point.

Determining pivots points of darts

In all the diagrams shown for the blocks, the darts do not converge at a point. To determine the pivot point of the front bodice, you bisect the underarm and waistline darts beyond their tips. Where the two bisecting lines cross is the pivot point of the darts and for the front bodice increases the nipple. For the back bodice it is the bisecting point of the waistline and shoulder darts. The pivot point for the skirt blocks is located halfway between the tip of the dart and the hipline. For the sleeve it is the elbow point.

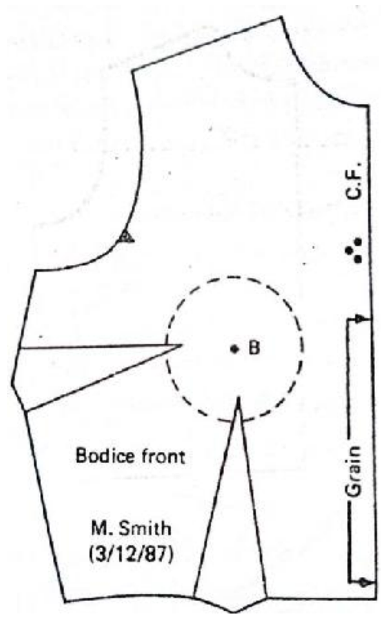


Figure 8: Pivots points of dart (Bodice)

Folding darts

Darts in patterns are either horizontal or vertical. In pattern making, darts are folded to lie in the position they will take when the garment is constructed. The convention in folding darts is that vertical darts have their fold towards the center front whilst horizontal darts have their folds towards the waistline.

Perfecting darts and seam lines

When new designs are made from the basic blocks, the position of darts may be changed. These new positions should fit into the new seam lines they emerge from as they would during sewing. The wide end of the dart should therefore be perfected so that during construction they would align with their seam lines. Dart perfecting is achieved by folding the dart in position and cutting or tracing along the seam line from which the dart emerges.

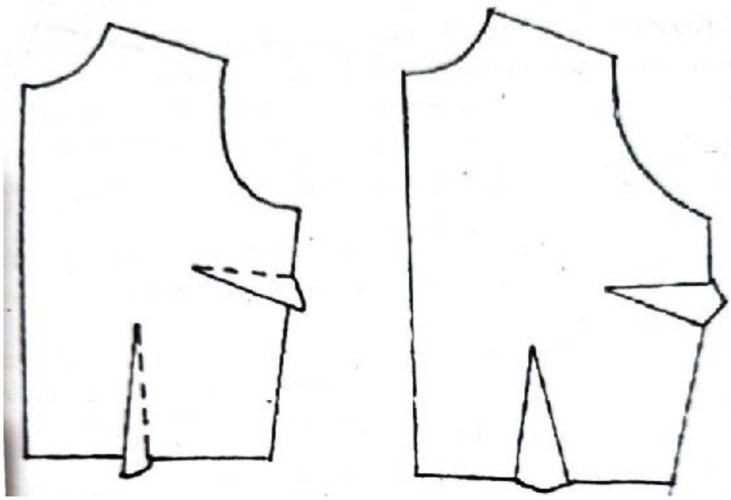


Figure 9: Dart and Seam line (Bodice)

When a change is made in any area of a seam, the seam line should be redrawn to be smooth and follow the shape of the original seam. This is called perfecting or truing a seam line. For example, if a dart is in a seam line, the dart should be folded the way it will lie in the seam during construction and the seam line in that area redrawn before opening the pattern flat again. The folded darts have some parts protruding beyond the seam lines. After truing the seam lines, these protrusions will be eliminated and when the pattern is opened out flat the end of the darts will take the final shapes they will have in the garment.

Dart length, width and size

The basis for the use of darts in pattern adaptation lies mainly in the size of the dart. The size of a dart cannot however be discussed without looking at the dart length and width. The arm of a dart determines the length of a dart whilst the distance of the dart tip from the seam the dart emerges determines the width of a dart at the base. The darts of the front bodice for example can be moved to any seam line in the front bodice so long as they still point to the bust. The further away the tip of a particular dart is from a seam line, the longer it is and the wider the dart is at the base. In the fig. 9 the underarm dart has been moved to mid-shoulder.

The size of a dart is determined by the angle at the tip of the dart. The bigger the angle the larger the dart and the more curve it produces. It should be noted that the size of the dart has nothing to do with its length or width. Anytime the position of a dart is changed, the length and width of the dart may change. The size should however always remain the same.

Dart transfer, combination and dividing bodice designing with darts

Darts can be used in different ways in the basic design to come up with new styles **re**designs. Darts can be 'transferred', 'combined', 'divided', 'released', or 'transformed'. Transferring a dart means moving a dart from one position to another in the pattern. Combining darts means that two darts are put together to form one dart. In dividing darts one dart is spilt into two or more darts. Releasing a dart simply means that the dart is not drawn in as a dart in the pattern therefore it is not stitched in as a dart, during sewing whilst transforming darts involves changing the form of the dart that is, the dart is not stitched in its regular form as a triangle.

With these principles in mind, no matter what is done with a dart, it should still point to the highest point of the bulge it is catering for, it should come from a seam line and it should maintain its original size. Generally, darts are made through slashing and lapping patterns.

Skirts patterns

Skirts come in a variety of designs. Some of which one knows how to sew already but there are others in the market that present a challenge. This is therefore, an opportunity to be introduced to making pattern for skirts.

The basic fitted skirt

The basic is usually a straight fitted skirt. It may however have a littler flare at the side seam. It has two or four darts in front and four at the back. Although some skirts may have two darts each at back and front, the four darts give a better fit especially in firm fabrics and people with prominent behinds and/or abdomen.

The style and length of a skirt.

The style of a skirt is a name by which it is normally or commonly called. A skirt could therefore be referred as one gathered, flared, straight or pegged. The length of a skirt is however determined by its distance from the floor. A skirt could therefore be maxi, midi, knee length, mini or micro-mini.

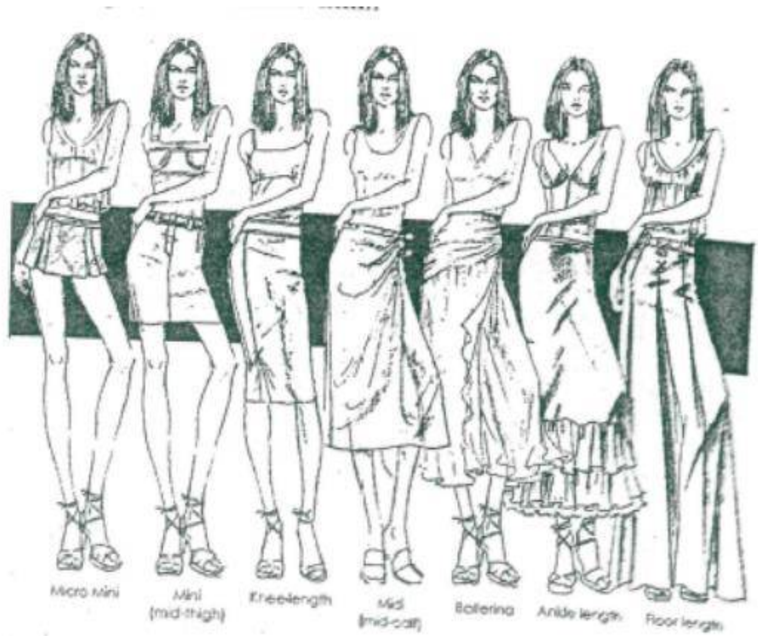


Figure 10: Showing Different Length of Skirts

Using darts in skirt designing
As in bodices, the darts of a skirt can be transferred, combined, released or converted to dart equivalents. The front darts cater for the abdominal bulge and the back darts cater for the buttocks. The pivot point for each dart is located halfway between the tip of the dart and the hip line on the bisecting line for the dart. The common pivot point for two darts is located midway between the two darts and midway between the tip of the darts and the hipline. Where the two dart are not of the same length, the longer dart is used as reference point. The dots in the skirt patterns below, represent the pivot points of the individual darts while the crosses represent the common pivots point for the two darts.

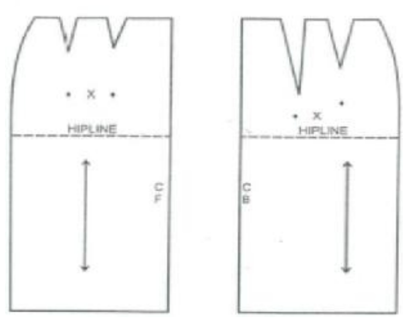
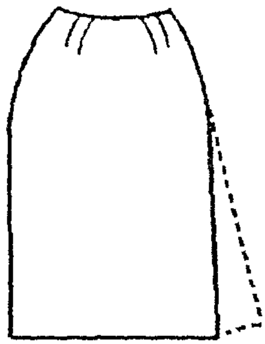


Figure 11: Skirt Pattern with Pivot Points of Individual Darts.

Making skirt designs (Few practical exercise)



There are numerous skirt designs.

Skirts with yokes

The principles of darts as applied in bodice yokes also apply in skirt yokes. Remember that a dart can be incorporated into a yoke line; it can stem from a yoke line resulting in a dart which is still of the same size but has a shorter length and the yoke can also be an ordinary seam line only.

Making the pattern design

Make a copy of the skirt front and locate the common pivot point for the two darts.

Draw lines from the tip of the dart to this pivot point and draw in your yoke-line to pass through the pivot point.

Slash along the dart arm of each dart to the pivot point but not through. Also slash along yoke line from side

seam line to pivot point but not through. Close and tape down the darts and then cut along the rest of the

yoke line to separate the yoke from the main skirt. Transfer your patterns onto a new pattern paper and add

seam allowances mar and label to complete the pattern.

A-line skirt

An A-line skirt is a type of skirt that hugs the hips but widens below the hip. It is probably called A-line because when the side seamlines are projected upward it will come to a tip and form the shape of the letter A.

To make an A-line skirt:

1. Make a copy of the basic skirt.
2. Slash from hemline to the hipline.
3. Spread the slash to form a tangent with the side seam through the hemline.
4. Complete the pattern as usual.

Freehand cutting

The termed free hand cutting

Freehand cutting means cutting out fabric straight into the various places that are needed for sewing a particular garment without using paper patterns. This method employs body measurement and other standard measurement to cut out straight from the fabric. It is like drafting but it is not as complicated as drafting. Freehand cutting is acquired with practice but once perfected, it is very useful and convenient where individual garment construction is the norm. Before trying to cut out any garment, it is advisable to first all take the body measurement. Make a copy of the chart that has been outlined earlier on in pattern making on personal measurements. After the measurement have been taken, the next step is the cutting out.

Advantages and disadvantage of freehand cutting

Advantages

1. It is a simple and fast method
2. Although body measurements are used, they are not many therefore the method is not as complicated as drafting.
3. It is inexpensive since one does not have to buy paper and can cut directly front the fabric.
4. It is convenient in countries where custom sewing is the norm but patterns are non-existent in the styles of that country such as Nigeria.

Disadvantages

1. Fabric may be wasted since the pieces are cut one at a time and one does not have3 the chance to arrange all the patterns to save fabric.
2. Mistake made in cutting are almost impossible to correct since cutting is done directly from the fabrics
3. There is no pattern left for future use
4. Takes some time to master.

Measurement taking and cutting procedure

Taking measurements for freehand cutting

Earlier, we learnt how to take body measurements for drafting patterns and for determining our sizes. We are going to apply the same principle here. In freehand cutting however, we use fewer measurements. As one personally perfect the art, he/she can add more professional look. From experience, it is advisable to take close but not tight measurement for freehand cutting. After we have taken the measurements then we will add the ease to allow for comfort and movement before cutting out the fabric. Adding the ease to allow for comfort and measurements can be a bit of a problem since it becomes difficult to maintain the amount of ease from person to person and also for the same person on different occasions.

Practical Work on Freehand Cutting (Trousers)

INSTRUCTIONS FOR CUTTING OUT A PAIR OF TROUSERS

INSTRUCTIONS	DIAGRAM

FRONT

AB = Trouser length - 1"

AD = Crotch depth = 9" – 12" (Standard)

AC = Hip depth = 7"- 9"

DE = ¼ Total Hip measurement +1"

Square up to H'.

H'I = ¼ waist measurement + (2" – 3") for darts and seams

EF = 1½"- 2½"

EJ = 1½" - 2½"

Join F to J with a smooth curve

BN = 1" - 2"

NO =Finished hem width. Join DN and FO with dotted lines.

Locate Knee level LM to be ½ DB -2" from crotch line.

Draw in the inseam and side seam as shown with LL" = MQ = 1".

Add a hem allowance of 1½" and fold back on hemline before cutting.

BACK

Place the front piece on another folded fabric, match side seams and proceed as follows:

Front waistline to R = 1½" -2"

AR = ¼ Waist measurement + 3½".

FG = 3"- 4½". Drop G ½" below the crotchline to G

Join RG with a smooth line for the back crotch.

MQ" = 2" – 2½"

OO" = 1" -2"

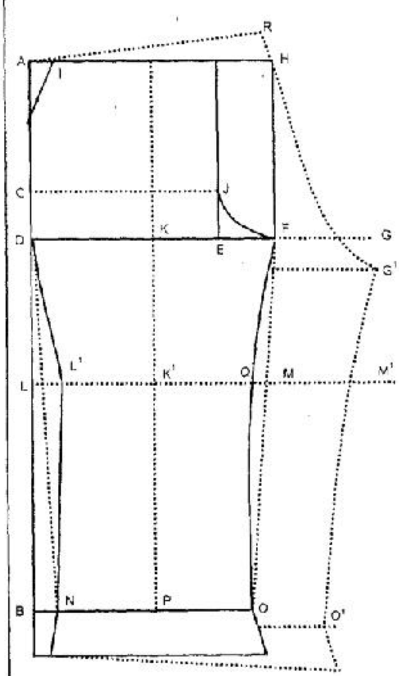


Figure13: Cutting Steps (Pair of Trousers)

Drop M' and O' and hemline on the inside seam $^1/_2$" below the front lines. Draw a smooth line from G' through M' to O' and hemline to get the back.

NOTE:

The instructions have a V" seam allowance included all round except for the back crotch which has an allowance of about 1 Vi" at the waistline but tappers to 'A" at the crotchline.

Finish the waist with a band that has a finished width of $1^1/_2$"

Cutting Shirts

INSTRUCTIONS FOR CUTTING OUT A SIMPLE SHIRT – Body

INSTRUCTIONS	DIAGRAM

FRONT

0-1 = Shirt length
0-2 = 2½"- 3½"
0-3 = 2½"- 3½"
Join 2 to 3 with a smooth curve
0-4 = Across shoulder plus 1"
4-5 = 2"
Join 2 to 5 with a straight line
5-6 = Around arm divided by 2 plus 1"
7-8 = ¼ total chest (Total chest = Chest plus 6"-10")
Join 5 to 8 to go in ½" at mid point for an armhole.
1-9 = 7-8

Note: This shirt front is without a buttonhole closure.
For a buttonhole closure, provide an extension of 2 to 2½" in front. This extension includes a buttonhole extension of ½" with the rest being an extended facing

BACK

–Place the front another piece as shown.
–Draw a shoulder line 2" above the front shoulder line.
0-A = 2"
A"- = 1½"
A-B = ½" longer than 0-2 of front neckline.
B-C = Front shoulder.
Join the back shoulder point to underarm point for back armhole as shown in the diagram. Note that the back does not go in like the front.

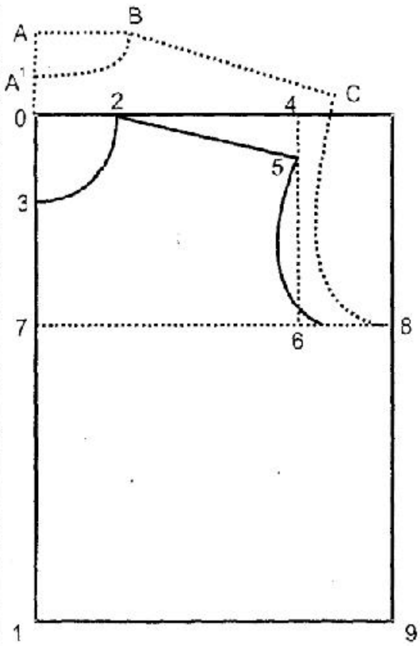


Figure 14: Cutting Steps (Shirt)

Note: before cutting out armhole fold the back extended shoulder in position on the front to be parallel to the front shoulder to make sure the neckline and shoulder points match and make adjustments where necessary.

INSTRUCTIONS FOR CUTTING OUT A SIMPLE SHIRT – Sleeve

INSTRUCTIONS	DIAGRAM

SLEEVE

Fold a fabric with width = half around arm plus 3".

1-2 = sleeve length minus 1".

1-3 = ½ around arm plus 3"
Square 3 to 6 at sleeve length level.

1-4 = Armhole depth on shirt front minus 3"
Square 4 to 5.

- Draw a straight line from 1 to 5 and divide it into three then draw in the sleeve head curve as shown.
- Pick the front layer and deepen the curve by ½" as shown.

6-7 = 1/3 the measurement 2-6
Join 5 to 7 for underarm seam.

- Locate 8 halfway between 7 and 6 on the back sleeve only.
- Square 8 to 9 4"-5".

CUFF

Note: the standard dimensions for a cuff are given below.
Cuff size/width = Close wrist measurement plus 2 1/4"
Cuff depth = 2½"

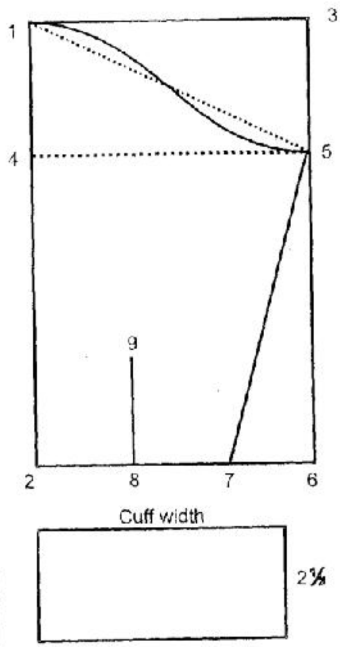


Figure 15: Cutting Steps (Shirt-Sleeve)

Now to cut the cuff.
Cuff width = Finished Cuff width plus 1".
Cuff depth = 3 $^1/_2$".
- Shape the cuff according one's wish.

INSTRUCTIONS FOR CUTTING OUT A SIMPLE SHIRT- Collar

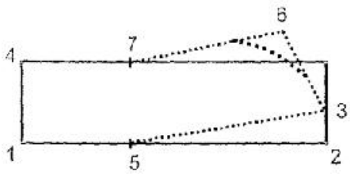
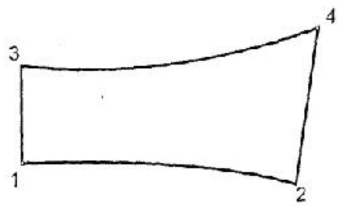
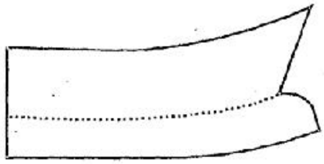
INSTRUCTIONS	DIAGRAM
Note: the collar is usually cut out on an interfacing and then put on the fashion fabric. Remember that the interfacing goes on the undercollar.	
TWO-PIECE COLLAR	
STAND 1-2 = ½ Neckline length after stitching shoulder and folding the front facing in place. 2-3 = ½ - ¾ " 1-4 = Collar stand width = 1" = 4 - 7 1-5 = ½ back neckline plus 1". – Draw a line from 4 to 6 to be parallel to 1,5,3 – Shape the end of the stand as shown in the diagram. Note: The shape at the end of the stand varies.	
FALL – Trace out the fall edge of the stand, turned upside down, as shown 1 - 2. 1-2 = Fall edge of stand – 1" 1-3 = 1½ - 2 ½. – Square a line from 3 outwards. – Shape the end of the collar as desired. – Note: The shape of the collar end / tip is influenced by fashion.	

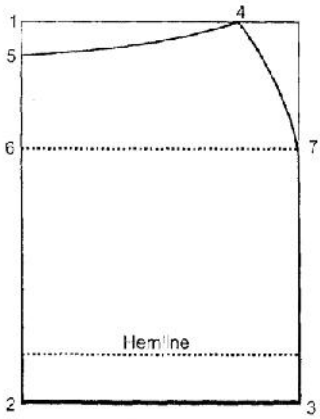
Figure 16: Cutting Steps (Shirt-Collar)

ONE-PIECE COLLAR

- Draw out stand as in the two piece collar.
- Draw the fall but this time directly onto the stand without tracing out the fall seamline of the stand.
- Note: after stitching the design line of the one piece collar and attaching it to the neckline. Finish the collar by stitching in the line that separates the stand and the fall.



INSTRUCTIONS FOR CUTTING OUT A SIMPLE FITTED SKIRT

INSTRUCTIONS		DIAGRAM
STRAIGHT FITTED SKIRT		
1-2	= Finished skirt length + 2½ - 3"	
1-3	= ¼ of Total Hip measurement + 1½"	
1-4	= ¼ waist measurement + Dart allowance (1 – 2) + 1½"	
1-5	= ½" – Join 5 to 4 with a smooth curve as shown.	
1-6	= 8-9" (Square across to 7) – Join 4 to 7 with a smooth curve.	

SHAPED FITTED SKIRT

1-2 – Finished skirt length + 2½ - 3"

2-3 = ¼ of Total Hip measurement + 1½"

1-3 – ¼ waist measurement + Dart allowance (2") + 1½"

1-5 = ½"

– Join 5 to 4 with a smooth curve as shown.

1-6 – 6 - 7" (Square across to 7)

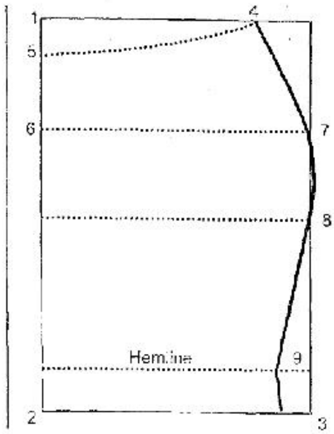
– Join 4 to 7 with a smooth curve.

7-8 – 4-6"

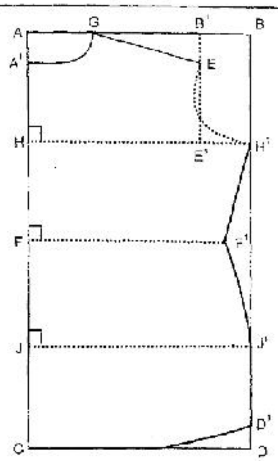
– Make a 2" - 2½" fold at edge of the skirt for hem line

– Point 9 is 1½ - 3" from side seam.

– Join 8 to 9 with a straight line.



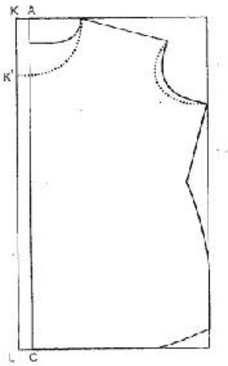
INSTRUCTIONS FOR CUTTING OUT A SIMPLE BLOUSE- Torso

INSTRUCTIONS	DIAGRAM
Back AB = CD = ¼ HIP – 1½ AC = BD = blouse length + 2 ½" AA' = Back neckline Depth = 1 ½" Note ½" if collar is attached AG = 2 ½ - 3" Join A'G with smooth curve A'F = Nape to Waist AB' = ½ Across shoulder + ½ B'E = 1 – 1 ½" Join G to E for shoulder line EE' = ½ around arm + 1" HH' = ½ Bust Join E to H' with a smooth curve coming in about ½" of mid-arm hole	

Figures 17: Cutting Steps for (i) One-piece Collar (Shirt) (ii) Simple Fitted Skirt (iii) Shaped Fitted Skirt (iv) Simple Blouse- Torso.

HE' = ¼ total Waist + 1 - 2" (For Dart allowance)
+ 1½" (Seam allowance) = ¼ total Waist + 2½" - 3½"
EJ = 5 – 7"
DD' = ½ - 1"
Join H' E' J' D' for the side seam
Join CD' for the hem
Note :- Dart separation from C.F= Waist/8
or waist/8 – ½"

FRONT BLOUSE
Place back on folded fabric 1" wider
KA =LC = 1" = Button/Hole extension
KK' = 4"



INSTRUCTIONS FOR CUTTING OUT A SIMPLE BLOUSE - SLEEVE

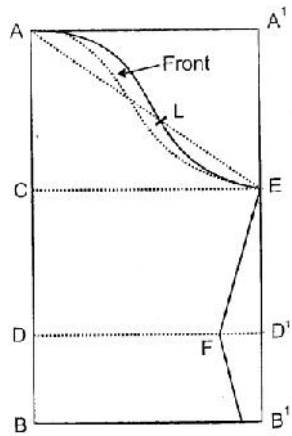
INSTRUCTIONS	DIAGRAM
SLEEVE AA' = BB' = ½ Round arm + 1½" to 2" AB = A'B' = Sleeve length – 2" AC = A'E' = Garment armhole depth – (2"- 2 ½") AC = ½ AE AC = 3 = 5"Join AC'E' with a smooth curve as shown to give you the crown of the sleeve. BD =1 ½" FD = 1" Join E' D' B' to give you underarm seam with DD' as sleeve hemline. Fold hemline DD' under before cutting to get the D'B' shaping correct. FOR FRONT SLEEVE Open sleeve out and go inside the crown ½" as C' Then draw front sleeve as shown with dotted line.	

Figure 18: Cutting Steps for (i) Simple Front-Blouse (ii) Simple Blouse-Sleeve

Summary

Accurate body measurements mark the beginning to the making of well-made garments. The beauty of a garment on the body is not determined only by the fabric or style but mainly by how the garment conforms to the curves of the body showing the proportions of the body into consideration in the cut out. Whether one is going to make a pattern or purchase it, body measurements are needed in making a pattern of the correct size or buying the correct patterns. Patterns that people buy are made according to standard body sizes and not to fit any particular figure. It is therefore important that when patterns are bought, the pattern pieces should be measured and compared with the body measurements of the person going to use the pattern, to determine any alterations to be made on the pattern. Freehand cutting is the most common means of cutting out used in Nigeria. It is not an easy skill to acquire but once perfected can become a very useful tool for students use and teaching. In cutting out using free hand, it is important to look at the part of the body the garment is being made for and determine the measurements that will give a good fit.

Exercise

a) Explain the importance of measurements in garment construction
b) Explain the marks/ labels and symbols of a commercial pattern piece
c) Give 3 advantages and disadvantages of freehand cutting
d) Cut and make a simple skirt and blouse or trousers and shirt

References

Kumar, M. (2023). Pattern Making. Tutorialpoint.com Retrieved on 13th February, 2023

Ojo, C. M. (2017). Basic Textiles for Home Economics for Students in Tertiary Institutions.Concepts Design and Prints.

Sewing Plums (2013). Opinion on Sewing Pattern. 2013sewingplums.com.

Winifred Aldrich: Metric Pattern Cutting.

Helen Armstrong: Pattern Making for Fashion Design.

Connie Amaden-Crawford: Pattern Making Made Easy. 3rd Edition.

Keenneth King: e-books on CD.

Aldrirh, W. (1997). Metric Pattern Cutting for Men, Blackwell Science Ltd, Osney Mead Oxford OX2 0EL

Biodata of Author

Gwari Williams Bako (PhD) is a renowned Professor of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) in African Traditional Clothing, Textile and Fashion Design, has both BA, and MA (Industrial Design (ABU, 1986 & 1990 respectively). In his PhD, Gwari was opportune to go for one-year PhD Bench Space at Department of Textile & Paper, School of Material Sciences. University of Manchester, UK to complete his PhD data analyses which was funded by the USA Carnegie Foundation Scholarship. He then returned to ABU. Zaria, Nigeria, and successfully, defended his PhD. Textile & Fashion Design in 2008. Gwari rose through the ranks to the position of Professor in 2014 and has held many administrative, academic and professional responsibilities, such as Head of Textile & Fashion Design Section, Head of Department as well as currently the National President, Textile Researchers Association of Nigeria (TRAN).

CHAPTER 41

Introduction to Pattern Drafting and Design

By

IGBO Chinyere Anne

Overview

Pattern drafting is an engineering approach to pattern production. Patterns are like blue prints used for dress design. Patterns are produced in different ways and there are different types of patterns. Patterns may be drafted or commercially produced. The chapter also provides exercises to test learners grasp of concepts in the cognitive, affective and psychomotor domains of learning.

Objective

At the end the chapter the students should be able to:

1. Identify pattern drafting equipment and tools;
2. Draft basic blocks;
3. Differentiate between drafted and commercial patterns; and
4. Adapt different styles using the basic blocks.

Meaning of pattern drafting

Pattern drafting is an engineering approach to pattern production using a set of measurements and guiding instructions. Pattern drafting utilize body measurements to create basic patterns. The basic patterns produced act like a blue print and is to the fashion designer what house plan is to the architect. The process of pattern drafting is used to create pattern block also known as pattern set made up of the following: Bodice front, Bodice back, Sleeve, Skirt front, Skirt back, Trouser front and Trouser back.

These seven basic patterns, as shown in figures 1-7, are needed to create patterns for all the different types of clothes. The different types of clothes include tops, shirts, skirts, shorts, trousers dresses, jackets and coats.

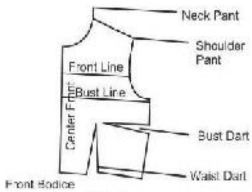
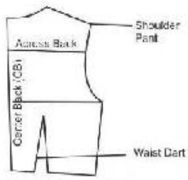
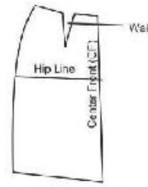


Fig 1



Back Bodice Fig 2



Front Skirt Fig 3

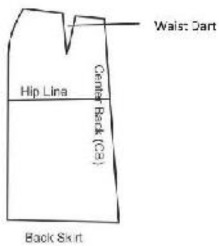


Fig 4

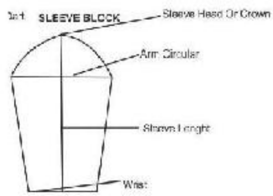


Fig 5

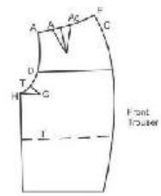


Fig 6

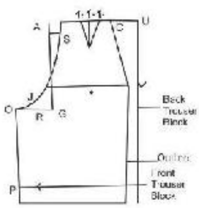


Fig 7

These blocks are also known as foundation pattern or master plan. They can be made on papers or cardboard sheets. The block patterns are simply plain and do not have seams, hems or extra fullness. They are constructed to fit a particular size or standard figure. The result of pattern drafting is the production of patterns.

Techniques used in pattern drafting

There are various techniques used in pattern drafting. These are:

1. Sketching: This involves a sketch of the style;
2. Drawing: This is done following a set of instructions and body measurements;
3. Labeling and addition of pattern symbols e g CF, CB etc.;
4. Tracing: This involves the transfer of pattern marks to another paper. This can be achieved using dress makers carbon and tracing wheel; and
5. Creating a sloper: This is a slightly complex method in pattern drafting. A sloper is the building block from which a designer can make as many patterns as possible.

To achieve a sloper:

a. Find ample free sloper patterns online;

b. Creating from the scratch. This requires a good knowledge of mathematics. However, this can be created by software like pattern master, design sew, Gerber Accumark etc.;
c. Drawing: This is a very important technique in pattern making. It requires the pattern maker to be skillful in sizing and shaping;
d. Sketching: This goes hand in hand with drawing. The pattern maker must be good at the use of pencil and must be imaginative; and
e. Cutting: The pattern maker must be skillful and be a very careful person. The person must be good at observing details and must know how to handle the scissors or rotary cutter.

Tools and equipment used for pattern drafting

List of pattern-making tools include:

1. Straight pins: These are used for draping, fitting and closing of darts during manipulation;
2. Straight pin holder: These can be pin cushions or magnet. They are used for holding pins while at work. They can be made to fit on the wrist or kept on the table;
3. Scissors: There are different types of scissors used in pattern drafting. However, the pattern maker must not use the same scissors for making patterns to cut out fabrics. The rotary cutter can be used for pattern cutting too;
4. 18” C- Thru Ruler: This will help to see lines especially when drawing perpendicular lines;
5. Tapes: These are used for measurement and changing the design of pattern or adding pleats;
6. Tracing wheel: This is very important in pattern making. It is used for transfer of pattern marks; It helps the pattern maker not to destroy an original pattern during transfer of pattern marks;
7. Pencils: These can come in various colours but the most valuable being red and blue colours;
8. French Curve: This can be made of wood or metal. They are usually calibrated. French curve can be: French curve 12, curve rule 24”, hip curve 24”. They are used to shape armholes and necklines;
9. Marking Awl: This is another important pattern drafting tool used in marking;
10. L-square Big 24”/14” and L-Square small. This has two sides. These are used to mark fabric corners, grain lines, align edges of fabric. They are also called Tailor square;
11. Quilting Ruler: This is a clear ruler that has a square shape, used for cutting fabric squares accurately. It is used for squaring half square triangle blocks and used for patch work and quilting;

12. Hip curve ruler: They are hip-shaped and used for shaping the hip sideline in seam, in pants, arm-curve, the open edge of the sleeve. Hip curve can help in giving a natural look to the hipline for pants and skirts;
13. Straight Rulers: This must be a clear plastic. It can be 18” by 2”. Small plastic rulers are also needed for small measurements;
14. Sewing Gauge: This is a tool you can use to mark hems and seams accurately;
15. Compass: This is used to make small circle during marking for embroidery;
16. Protractor: This is used to mark angles especially when carrying out patch work; and
17. Cutting Mat: It is used for measuring surface and protect work surfaces as one cuts with the rotary cutter. It is also used for accurate measuring and marking.

Basic pattern terms and symbols

There are many basic terms and symbols that can be used to understand pattern alterations, fitting and flat pattern making. These are:

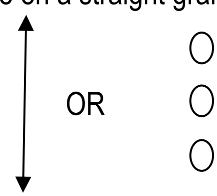
1. Armscye: This is armhole measurement;
2. Balance points: Mark that refer to all to notches and dots that help align fabric pieces when constructing a garment;
3. Blocks: This refers to the foundation pattern or a master plan. They can be made on paper or cardboard sheets. Blocks do not have seam allowances hem, facings or extra fullness. It is made up of the following; bodice front, bodice back, skirt front skirt back, sleeve, trouser front and trouser back;
4. Bust Point: The further protruding point of the breast;
5. Center back: usually abbreviated CB;
6. Center front: Abbreviated as CF;
7. Dart: This is a wedge of fabric that is used to control fullness. It allows for shaping and removal of excess fullness in a garment;
8. Dart intake: This is the distance between dart legs, measured at the seam line. The dart legs are the lines on each side of a dart. It is the stitching line for a dart;
9. Dress form: This is also called a mannequin or dummy. It is used to display clothes in a shop window. It is also used by artists, tailors, dressmakers, window dressers to display or fit clothing and show off different fabrics and textiles. Additionally, it is used to represent the human figure. There are different types of mannequins: female full mannequins, seated male mannequin, child full body mannequins, bust mannequins, materials skin or realistic mannequins, abstract mannequins, headless mannequins and animal mannequins. They are used for exhibitions, trade shows, pop-up shops and product launch events;
10. Flat pattern making: This is a two-dimensional approach in pattern making based on the use of the basic blocks;
11. Ease: This is the difference between body measurements and garment measurement. It allows for comfort and movement;

12. Fold line: This is the part of a pattern that shows where fabric is to be folded when cutting;
13. Grading: This is the process of increasing or decreasing a pattern to fit a particular size. It involves altering a pattern;
14. Grain line: This is the direction of the thread in a woven fabric. The grainline can be straight or lengthwise showing the warp thread parallel to the selvedges. The grain line can also be crosswise or diagonal, along the weft thread running perpendicular to the straight grain. The lengthwise grain has minimal stretch unlike the diagonal grain;
15. Interfacing: This is a material used on the wrong side of a fabric to strengthen it. It can be in the form of a fusible or ordinary fabric;
16. Muslin: This is an inexpensive undyed fabric used when truing patterns. It can be used to test out a garment before using a permanent fabric;
17. Notches: it can be used to match edges. They are usually triangular in shape and are used to match corresponding pieces of a garment;
18. Pleat lines: These are lines on patterns indicating details like pockets, flaps front plackets and where they should be;
19. Princess seam: This is usually a curved seam from the armhole to the hemline. The seam can also start from the shoulder passing through the bust tip to the hemline of blouses;
20. Seam allowance: The area between the sewing line and cutting line;
21. Slash and spread: This is a technique used in pattern drafting for adding fullness or flare to a pattern by cutting apart and spreading to increase width;
22. Sleeve cap: This is also known as sleeve head. It is the upper part of the sleeve that fit into the shoulder;
23. Sloper: This is a basic pattern without seam allowance. It is used for creating different styles;
24. Sweep: This is the measurement for hem circumference on a skirt;
25. Tailors Tack: This is a temporary stitch used for transferring pattern marks in very fine fabrics that can be easily destroyed using tracing wheel or where tailors chalk or pencil can leave a permanent mark on such fine fabrics.

Pattern symbols

These are marks that help to identify each pattern piece and points of importance on each pattern. They are similar but vary according to manufacturers as shown in figures 1 - 20.

1. Place on a straight grain



- These are long black arrows or three evenly spaced holes
- They mean place on straight grain of fabric

Figure 8

2. Place on diagonal grain

These are diagonally shaped
They are placed on the diagonal grain of fabrics

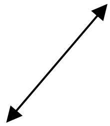
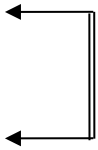


Figure 9

3. Place on fold

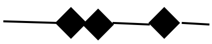
This is an arrow with squared ends. It indicates place on fold. It can also be represented by two small holes.



OR

Figure 10

4. Notches



These are called notches or matching edges. They are represented by black diamonds along cutting line

OR

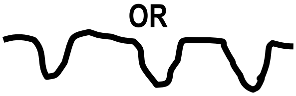


Figure 11

5. Seam Allowance

This represents hem or seam allowance.
They are made up a row of small broken lines or small evenly spaced holes.
About 1.5cm or 5/8" from the cutting line

OR

Figure 12

6. Dart

This shows the dart. The center line indicates the dart line fold.
The dart is shown by holes in a triangular shape with connecting lines. It can also be represented by five, seven or nine holes arranged in a triangular shape.

```
  O
 /|\
 /|\            O
O|O

 /|\   OR    O      O
O|O           O     O
```

Figure 13

7. Gathering line

═ ═ ═ ═ ═ ═

OR

≈ ≈ ≈≈≈≈≈

Figure 14

It is represented by double wavy lines showing The area to be gathered

8. Trued Pattern

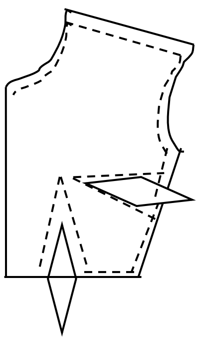


Figure 15

This is the pattern obtained after corrections have been effected after fitting the basic pattern. The broken lines show the seam lines in the basic pattern while the continuous lines show the trued pattern.

9. Seam allowance

This the extra measurement of about 1.5cm or 5/8” added around the pattern in desired areas to allow for sewing

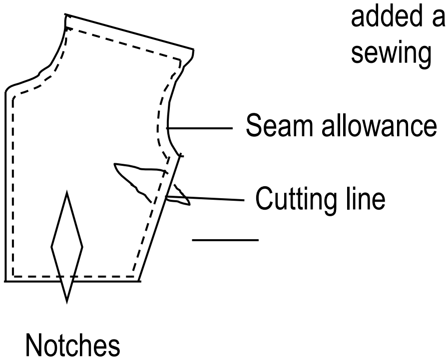


Figure 16

10. Selvedges

A selvedge is a narrow-woven edge of a fabric parallel to the warp. It is often made with stronger yarns and tighter weave than the rest of the fabric. This prevents fraying or raveling and supports tension in weaving fold line

Selvedge

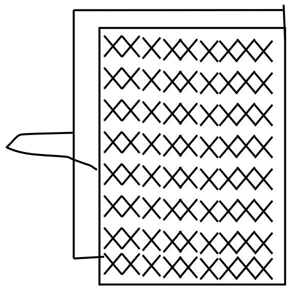
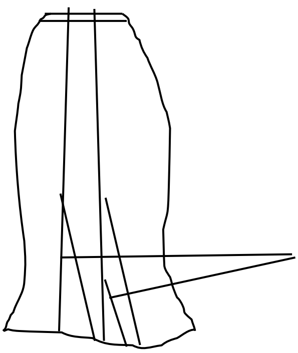


Figure 17

11. Godet

The godet is a pie-shaped semi-circular or rectangular pleated piece of fabric set into a seam, dart, cut-out or slash to give extra width to the hem. It can also be used to add flounce to sleeve or swing to a skirt. It aids mobility and comfort.



Godets

Figure 18

12. Slash and spread

Slash lines are marked at equal intervals

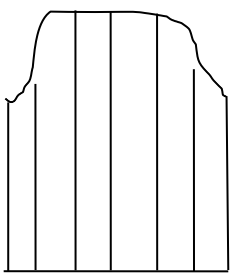


Figure 19

13. Lines Slashed and Spread

The lines are slashed and spread to desired width and retraced

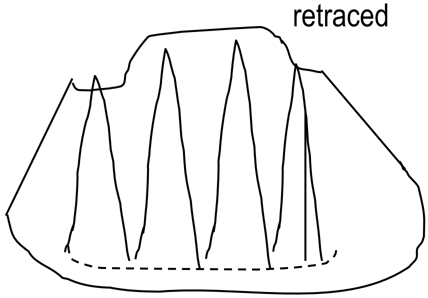


Figure 20

Types and methods of obtaining patterns

The methods of drafting patterns include:

1. Modeling or draping method;
2. The knock-off design method;
3. Modifying from a set of patterns (Grading method);
4. The computer-aided design; and
5. The flat pattern method

Modeling or draping method: This is a method which involves the manipulation of a cheap fabric such as calico or muslin cloth on a figure or dress form to create a style.

Advantages of modelling or draping method

1. It can be very satisfying to a dress maker with creative ability; and
2. It is the only suitable method for draped styles as it enables the exact position and amount of fullness to be controlled.

Disadvantages of modelling or draping method

1. It is an expensive method since the use of fabric is involved and fabrics are not cheap;
2. It is time consuming; and
3. Cutting out is done on double fabric and the dress stand must be padded.

Knock-off design method

The knock–off design is used in large scale production of a best-selling clothing items. It involves ripping off the seams of a cloth and copying the styles. This is a legal process because there is no copyright law in clothing.

Advantages of the knock-off design

1. It helps to duplicate the look and fit of a popular garment;
2. Home sewers can easily use it to make professional looking garments;
3. Help to replace the look of worn-out loved old garments;
4. Used by small scale companies to mass produce garments; and
5. The pattern pieces produced are accurate and gives good fit.

Disadvantages of knock-off design

1. It is time consuming;
2. It is expensive because one has to buy a garment and take it apart;
3. The original garment may not be able to be assembled again if it shows signs of wear; and
4. Inexperienced dressmaker, home sewer or designer may not be able to put the garment exactly the way it was.

Methods of producing patterns using knock-off design

1. Take garment apart at seam line;
2. Loosen all seams, darts, tucks and other fullness methods. All garment pieces must be flat;
3. Press all garment pieces to original shapes;
4. Check to see any seam and hems which could be modified; and
5. Trace out pattern pieces on a fresh paper

Rub-off method

The rub off method involves:

1. Cutting out to grain of fabric a rectangular piece approximately same size as garment to be copied;
2. Placing muslin or calico on top of garment to be copied;
3. Aligning grain of fabric carefully;
4. Using a soft lead pencil or tailor's chalk, rub of outline of the exact shape of each pattern piece, button and button hole positions, darts, top stitching lines etc.;
5. Making sure muslin or calico lie tightly against garment to be copied;
6. Pining the two fabric together at seam lines;
7. Removing muslin or calico and use a French curve and a ruler to "true" the pattern edges;
8. Cutting out the shapes in muslin or calico;
9. Rechecking pattern shape on garment for accuracy and make necessary changes especially at curved lines;
10. Adding seam allowances and hem to pattern pieces; and
11. Making sure all pencil marks are on muslin or calico not on garment.

Use of pin

1. Lay the clothing you want to trace on top of a piece of paper;
2. Trace the seams by poking pinholes around edge of that piece;
3. The pinholes should not damage, the cloth but they will mark the paper; and
4. Remember to work on a firm and flat surface.

Use of paper and tracing wheel method

1. Carefully fold garment in asymmetric order and pin securely;
2. Lay the front half flat on a broader sheet of paper;
3. Mark shapes of the different parts of the garment on paper with the help of a tracing wheel with long points, or use a marking tool with a sharp needle;
4. Use cork board as working surface or improvise soft top;
5. Place paper and garment on work top and pin;
6. Use pointed edges of the tracing wheel or needle to pierce garment fabric and paper along seam lines to make perforated lines that outline each pattern piece;
7. Use pencil, ruler and smooth French curve to connect the perforation dots and trace edges of each pattern piece; and
8. Add seam and hem allowance.

Using the tape measure method

1. Measure rectangular shapes like waistband, cuffs, pockets and transfer measurements to paper by drafting;
2. Use ruler to correct pattern; and
3. Add seam allowances.

Modifying from a set of patterns (grading)

This is the process of turning a sample size, sometimes referred to as base size, into a smaller or larger size. It is carried out using a size specification sheet. It does not create a new shape. It only increases or decreases the size of the original shape of a garment.

Grading can be carried out in three ways as:

1. Slash and spread: This is the easiest way. It is carried out by slashing a pattern and spreading the pieces by a certain amount to grade up or down. To carry out this technique, pencil, ruler, scissors and measuring tapes are needed;
2. Pattern shifting: This is done by moving the pattern around at a constant distance after which the designer redraws the outline to produce the same results as slash and spread method;
3. Slash and overlay: This is used for decreasing a pattern size;
4. Slide-and-close: This is used for decreasing patterns; and

5. Computer grading: This can be done with the help of a computer. This is the fastest method of grading. It uses the same process as slash and spread and pattern shifting methods. It is achieved by digitizing the slash, spread and shifting method.

Computer-aided design method: This involves the use of computers to aid in the production of patterns. This requires the use of software which increase the productivity and quality of the work of the designer. In this process, shapes of cardboard pattern pieces are given X and Y coordinates by a digitizer and entered into the computer. This enables pattern shapes to be displayed on a monitor. The pattern produced is then graded.

Flat pattern method

This is the process of obtaining patterns by working from a set of measurements, using a set of instructions and drawing to shape on paper or cardboard.

Advantages of flat pattern method:

i. It is cheap and inexpensive when compared to modeling method;
ii. The blocks provide permanent record of correct fit;
iii. Dart movements, additional seams and fullness are planned on them;
iv. It is faster than any other method of drafting;
v. Fresh patterns can be cut out from the blocks; and
vi. It shows that all styles are related no matter how different they may appear since they are all developed from the same basic block.

Disadvantage of flat pattern method

If the block is not properly or accurately made, any pattern adapted from it will not give a good fit.

Taking body measurements

For a garment to fit perfectly, the designer or dress maker must be able to measure accurately.

Principles of accurate body measurement include:

i. Tape for measurement should be held snugly and tautly but not fitly against the body;
ii. For circumference and width measurements, the tape should be held parallel to the floor;
iii. Use a tape measure that does not stretch;
iv. Do not measure over bulky garments like cardigan;
v. Do not pull the tape measure too tightly;
vi. Do not to take your own measurements;
vii. Tie a ribbon around the natural waistline;
viii. Keep the tape measure parallel to the ground;
ix. Record the numbers obtained;

x. The person being measured should stand relaxed when measurement is being taken;
xi. Wear good foundation garments such as brazier, knickers, tights etc.;
xii. Maintain good posture and stand upright when being measured; and
xiii. Breathe normally.

Basic measurements for drafting patterns and sewing are shown in figures 21 to 25 and table 1.

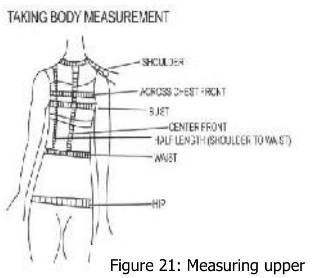


Figure 21: Measuring upper body parts (1)

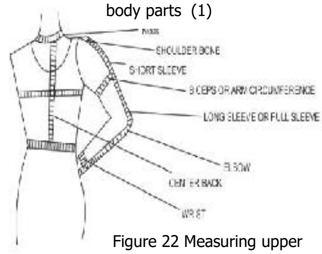


Figure 22 Measuring upper body parts (2)

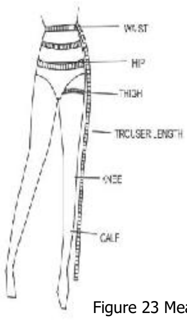


Figure 23 Measuring upper body parts

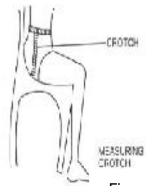


Figure 24

Figure 25

Table 1: Basic measurements for drafting patterns and sewing

Part of the body	Where to measure	Measurement obtained
Neck	Allow the tape to sit at the base of the neck above the collar bone	As Applicable
Bust	Bring the tape around your back and round to the front over the apex or fullest point of the bust	√
Waist	Over the natural waistline curve i.e. the smaller part of the torso, right under the rib near the belly button make sure the tape is even across the front and back and parallel to the floor	√
Hip	Measure round the largest part of the hip area that is 18-20cm or 7 ½ below the waistline over the fullness part of the hip	√

Shoulder to waist (front) or Half length	Measure from side base of neck from the highest point of the shoulder down, passing over the highest point of bust to before the navel	√
Shoulder to waist back or half-length back	Measure from nape of the neck down to the spine to waist	√
Back width	Measure horizontally between underarm	√
Shoulder	From base of the neck along the shoulder to shoulder bone	√
Sleeve length	From the shoulder over the elbow to the wrist with the arm slightly bent	√
Underarm Sleeve	From armpit to wrist bone. this is usually about 5' to 6" less than the sleeve length	√
Across Back	From armhole seam to the other armhole seam	√
Arm circumstance or Bicep	Measure round the fullness part of the arm.	√
Wrist	Measure around the wrist bone	√
Skirt length	From waist over the hip prominence to the desired point on the hem	√
Trouser Length	From Waist to Ankle.	√
Thigh	Over the fullest part of the length; just below the crotch, do not hold the tape so tightly	√
Abdomen	Measured 3-4 inches, below the waist line or the fullest point of the abdomen	√
Crotch	From the waist over the hip prominence to the surface of the stool with the person to be Measured sitting on a firm stool	√
Knee	Round the knee across the Knee cap with knee slightly flexed	√
Ankle	Round the Ankle, observing the width based onthe prevailing Fashion	√

Commercial pattern

A Commercial pattern is a full-scale tissue paper pattern used by home sowers to produce garments and accessories. Leading commercial pattern markers include Butterick, Simplicity, Mac calls, Vogue etc. They include printed guides, designed and used by both professional and home sewers. They provide instructions for sewing which helps the in-experienced home sewer. It can be produced by flat-pattern method. It is made up of the envelope, cutting and construction guide as well as pattern tissue pieces.

Advantages of commercial patterns

a. The patterns are already cut to size;
b. Supplies information on type, quality and quantity of fabrics are needed;
c. It can be used by home sewers to produce professionally looking garments;
d. It can suggest the correct numbers and sizes of notions and accessories to be used;
e. Sewing instructions are provided;
f. The pattern can be used again and graded; and
g. It may be cheaper because you can easily use the pattern for production of new garments.

Disadvantages of commercial patterns

1. Creativity is not encouraged and this pattern pieces may not be easily available;
2. Pattern may need adjustment in some areas;
3. May be time consuming to mark, cut and sew when compared to drafted patterns;
4. It requires proper care because small pattern places may be lost; and
5. The home sewer may not be able to adjust to designs desired.

Differences between commercial and drafted patterns

Drafted patterns, especially blocks, are based on average size which is an ideal size. They are made for a particular person and produced to fit standard figure types using specific measurement. It gives fit unlike commercial patterns which may need to be adjusted or altered.

How to analyze design/style

This can be subjective because criteria can change depending on the type and purpose of design itself. The following are questions to be asked when analyzing a design:

1. Does the design fulfill its purpose? Does it communicate? Has it solved a problem?
2. Is the message on the design easy to understand?
3. Is the design aesthetically pleasing?
4. Is the style appropriate for your audience?
5. Is the design original?
6. Is the design unique/not violating copyright rules?
7. Does the design have quality?

The stages involved in the drafting of basic block front shown in figure 26 are stated below:

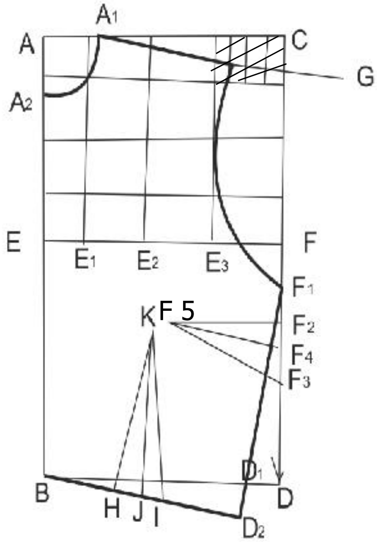
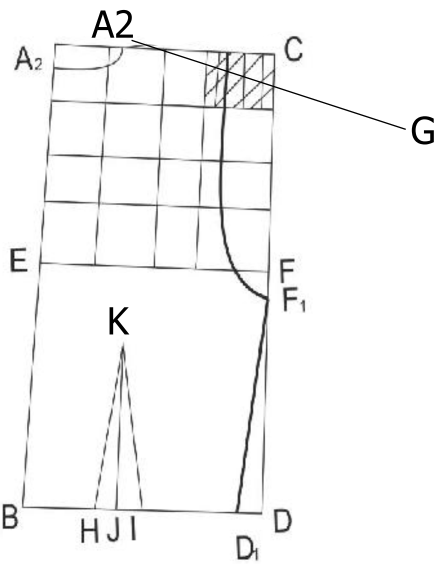


Figure 26

1. Draw a line AB equal to, shoulder to waist line measurement;
2. Draw from A to C horizontally equal to one quarter of burst measurement;
3. Draw the same line from B to D equal to AC;
4. Join C to D;
5. Divide AB and CD into two to obtain E and F;
6. Join E to F;
7. Divide AC and E F into four as shown in figure 26;
8. Join the lines to obtain 16 squares between ACFE;
9. From A_1, the square on the line AC, measure ½" or 1.25cm;
10. From A_2, the first square on line AE, measure ½" or 1.25cm;
11. Join A_1 to A_2 to obtain the front neck line;
12. Divide the 4^{th} square that is shaded in the figure 26 into four;
13. From the top of the first line in the shaded square, measure 1" or 2.5cm to obtain G as shown in figure 26;
14. Join A_1 to G to obtain the shoulder line;
15. From F, measure $1/2^{11}$ or 1.25cm to obtain F_1;
16. Join G to F_1 as shown in figure 26 to obtain the armhole;
17. From D on line BD, measure ½" or 1.25 cm to obtain D_1;
18. Join F_1 to D_1 to obtain side seam;

19. From B on line BD measure 3 ½" or 8cm to obtain BH;
20. From H on line D, locate T. This is the difference between one quarter of the Burst and Waist (HI);
21. Locate J, the center of HI;
22. From J measure 7" or 14.5cm upwards to obtain K;
23. Join J to K, H to K and I to K to obtain Waist Dart (HKI);
24. From F_1 measure 6.25c or 2½" to obtain F_2. From F_2 measure 2.5cm or 1" to obtain F_3;
25. Find the middle of F_2 to F_3 to obtain F_4, draw a slanting line towards K and the line at about 1" or 2.5cm from K to obtain F_5;
26. Join F_2 to F_5, F_3 to F_5 to obtain the Burst dark;
27. Extend D_1 by 2.5cm or 1" downwards to obtain D_2;
28. Join B to D_2 as shown in the figure 26;
29. Thus, the front bodice is completed A_2 A_1GF_1 F_2, F_3 D_2 and B; and
30. The Bust dart is F_2 F_3 F_5 while the waist dart is HKI.

The stages involved in the back-bodice block shown in figure 27 are shown below:



In addition to instructions given in stages 1 to 10 for the front bodice block, the following stages are involved for the back-bodice block:

a. Join A_1 to A_2 to obtain back neck line as shown in figure 27;

b. Divide the shaded last square to four. From the top of the first line, measure ¾" or 1.9cm downwards to locate G;

c. Locate F_1, that is, half an Inch or 1.25cm from F;

d. Join G to F_1 as shown in figure 27;

e. Locate waist dart as in front bodice, that is, B to H equals 3½" or 8.9cm;

f. H to I equals difference between one quarter of bust and waist H to K equals 7 ½" or 18.9. Thus, back bodice dart is HKI; and

g. Back bodice pattern is A_1A_2 GF_1DB.

FIG
1.27

Drafting of Front Skirt

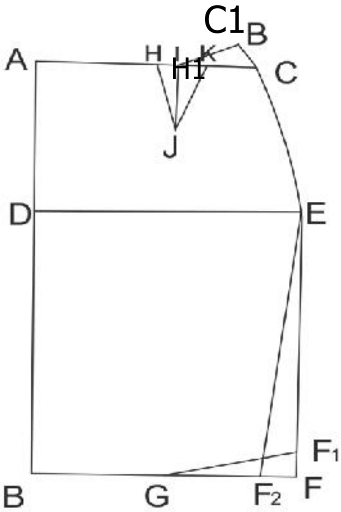


Figure 28

1. Draw a line AB equal to skirt length
2. From a draw a horizontal line AC equal to one quarter of waist measurement
3. From A on line AB measure, $7^{1/2}$ to 8“or 18.8cm to 20cm mark it. D this is the hip depth;
4. From D draw a horizontal line equal to $^{1}/4$ of hip and label it, E;
5. From B, measure a line BF equal to DE;
6. Join E to F with a straight line;
7. From F on line EF, measure $^{1}/2$ “or 1.25cm upwards label it, F_1;
8. Locate the middle of BF label it, G. Then, join G to F with a straight curve;
9. Raise C by $^{1}/2$ “or 1.25cm label it, C_1;
10. Join E to C_1 with a skirt guide;
11. From A on line AC, measure 5” or 12.5cm to locate H;
12. From H, take 2.5cm or 1” to locate H_1. Find center of H and H_1 to locate I;
13. From I measure 4” or 10cm to locate J, the height of dart, join H to J, I to J and H1 to J; and
14. Join C1 to I.

Back skirt block

Carry out instruction 1 to 10

11) From A draw a line measure $3^{1/}2$ “or 8.8cm to locate H

12) From H measure 2.5cm or 1” to locate H1 find center of H and H_1 to locate I

13) From I measure 4’ or 10cm down to locate J. (This is the height of the dart) join H to J, I to J and H1 to J

14) Finally join C_1 to I

The stages involved in sleeve pattern, as shown in figure 30, are shown below:

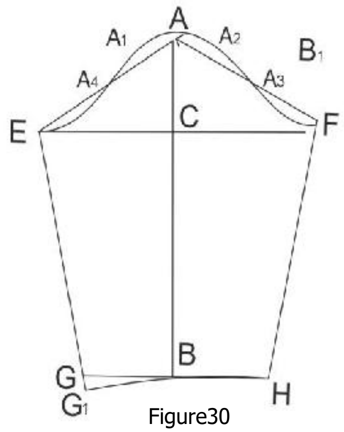


Figure30

1. Draw a line AB equals to sleeve length;
2. From B towards A, measure underarm sleeve measurement to locate C;
3. From C on both side, measure half of arm circumference to locate E and F;
4. On both side of B, locate 1/2 of wrist measurement to obtain G or H respectively;
5. Join E to G and F to H respectively;
6. Lower G by 1/2 "or 1.25cm to obtain G_1. Join G_1 to B with a slight curve;
7. Join A to E and E to F with straight lines;
8. Divide Line AE into three and line F to two to locate A_1, A_2 and A_3 as shown in figure 30;
9. Locate the center of A_1 to E and that of A_3 to F;
10. Raise A to A_1 by 1'or 2.5cm and by A_2 by 3/4 or 1.9cm;
11. To obtain the arm hole, join A through the space between A and A_1 lower the slope at A_1 and at the counter space between A and E lower by 1/2 or 1.25cm to obtain the curve as shown in figure 30;
12. Join A through the raised slope at A_2 lower at A_3 and at the outer space between A_3 and F lower by 1/4 "or 0.65cm to F as shown in figure 30; and
13. The sleeve is thus completed E A1,A,A2,A3,F,H,G1 to E.

The stages involved on front trouser block, as shown in figure 31, are stated below.

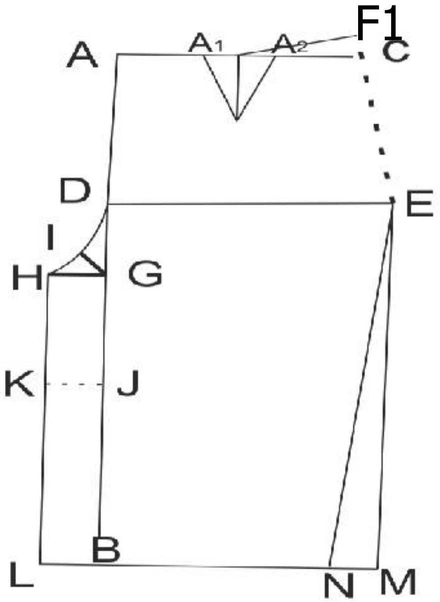


Figure 31

1. Draw a line AB equals to trouser length measurement;
2. From A draw a line AC horizontally equals to $^{1}/_{4}$" waist measurement;
3. From A draw a line AB, measure 18.75cm to 22.5cm ($7^{1}/_{2}$-9") depending on hip position to locate D;
4. From D draw a line equal to $^{1}/_{4}$ hip measurement minus 0.65 ($^{1}/_{4}$) to locate E;
5. Connect E to C with a slight curve and extend to 1.8cm $^{3}/_{4}$ above waist line to locate F;
6. Join F to A with a curve;
7. From A on line AB mark crotch measurement (body rise to locate G);
8. From G draw a line horizontally to H equals to one twelfth ($^{1}/_{12}$) hip measurement plus 1.25cm or $^{1}/_{2}$ so that G1 is half GH;
9. Join H, I, D, A to obtain the correct crotch measurement;
10. To obtain leg seam, locate J (knee length midway on line BG);
11. From J, mark K equal to $^{2}/_{3}$ GH;
12. From B locate L equals to 3.75cm or $1^{1}/_{2}$;
13. Draw inside leg measurement from L through K to H;
14. Draw a vertical line, E down to M from M, measure 6.25 or $2^{11}/_{2}$ to N;
15. Join N to L to complete the ankle;
16. From A, measure 7.5cm or 3" to locate A1 from A2, measure 1.25cm or ½ an inch to obtain the dart;

17. Drop down 7.5cm to 10cm or 3-4 inches from the center of A_1 and A_2 to complete dart; and
18. Trace out front trouser AF1CENLKHIDA.

The stages involved in drafting the back trouser block as shown in figure 32 are stated below.

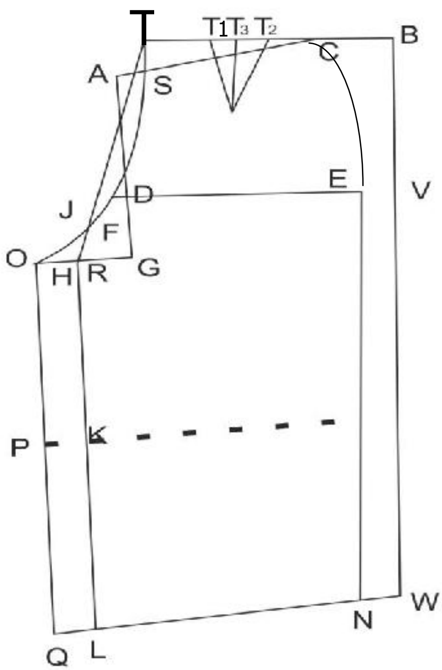


Figure 32

1. Trace out the front trouser back on fresh brown paper, allowing enough margin of about 7.5cm or 3 inches all around;
2. Label as in front pattern AFCENLKHIDA;
3. From H, measure 5cm or 2 horizontally to the left to locate 0;
4. From K, measure 4.38cm or $1^{31}/_4$ to locate P;
5. From L, measure 3.75cm or $1^1/_2$ to locate Q;
6. Join OPQ to obtain inside leg;
7. 1 to J is 1.85cm or $^3/_4$";
8. Midway between G and H locate R;
9. Draw a line from R through I to DS extending 3.75cm or $1^1/_4$ to locate T;
10. Draw the back crotch from O through J, D and S to T;
11. From T, measure one quarter of waist plus 2.5cm or 1" to locate U;
12. From E, measure 2.5 cm or 1 to locate V;
13. From N, measure 3.75cm or $1^1/_2$ to locate N;
14. Join U to W through V;

15. To obtain back waist dart, measure 7.5cm or 3 from T to locate T_1;
16. From T1, measure 2.5cm or 1 to locate T_2;
17. Locate midpoint of T_1 and T_2 to obtain T_3;
18. From T_3, measure down 7.5cm or 3 to complete the dart; and
19. Trace out the trouser pattern as OJSTUVWQPO.

Developing pants from skirt pattern (one-piece trouser pattern)

1. Draw back and front skirt with sides together, as shown in figure 33, and mark the hip lines;
2. Lengthen skirt to desire trouser length;
3. Mark ABDCEFG and H;
4. From A, measure down length of crotch plus 2.5cm or 1 for ease and mark I;
5. From D, measure up the same distance as BI and mark point J.D the same from C and K;
6. From I locate L equal to $^{1}/_{4}$ of IK measurement;
7. From J locate M equal to $^{1}/_{2}$ distance of JK;
8. From J mark $^{1}/_{4}$ of JM to locate N;
9. At center of GF (waist line) locate O;
10. Draw a line from N through E (hip line) at approximately 1.88cm or $^{3}/_{4}$ from waist line to locate P. Join P to Q with a curve;
11. Shape front crotch line from A to L and back crotch line from P through E to M;
12. Draw a line from M parallel to center line equals to the length of JD to locate Q;
13. Draw a line from L, the same distance as MQ and parallel to it to locate R. LR is parallel to center line;
14. Connect QD and RB; and
15. Trace out the pattern ALRBCDQMEPOGHA as shown in figure 33.

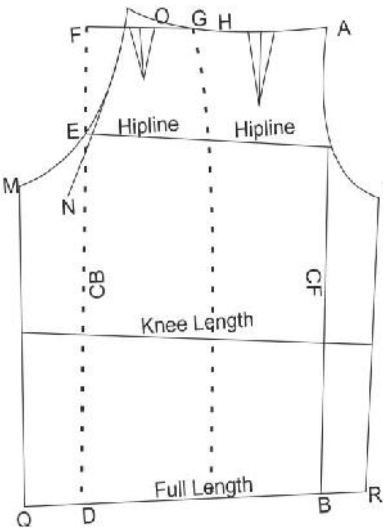


Figure 33

I rousers separately:

1. Trace the trouser pattern ALSBCDTMEPA;
2. Fix a notch at the center line along CKX as shown in figure 33;
3. Slash the patterns into two along the line of CKX; and
4. Trace each pattern piece separately and add seam allowances.

Dart manipulation

Darts are features on a garment used to control fullness. They are dressmakers' punctuation marks, placed on several positions in a garment such as shoulders, neck, center front, center back, waist, bust and armhole as well as several other places, depending on the styles features in vogue. Darts are used to turn 2D+3D shapes. A dart is made up of two parts, the widest part and the point. They can be manipulated to create style features.

Dart Manipulation Techniques

There are three dart manipulation techniques used in flat patterns. These are:

a) Pin and pivotal dart transfer techniques;
b) Slash and spread rotation and overlap techniques; and
c) Dart equivalent technique.

Pin and pivotal dart transfer techniques: Here, pattern designers use pivoting methods to make fashion changes. Darts are moved or fullness created by anchoring the basic pattern with a pin and moving the pattern in, out and around. The pattern swings back and forth like pendulum. No slashing takes place in order to change the original shape into a design. It is rather a transfer method.

Slash and spread rotation and overlap techniques: Here, slides motion is used to change pattern sizes. Patterns are moved up and down and to the side to increase or decrease from one size to the other.

Dart equivalent techniques: Darts are cut and used to create style line like tucks, gathers, pleats, flare and even cowls. The dart or its equivalent will always radiate from the pivot point.

Examples of dart movements

Dart manipulation moving waist and bust dart to shoulder

1. Moving darts to Shoulders

Bust dart is closed in by slashing and pinning and the center of waist dart is slashed and then the bust dart, which has earlier been slashed and pivoted at bust point, is closed with a pin to increase fullness at waist which is then transferred to the shoulder as shown in figure 34.

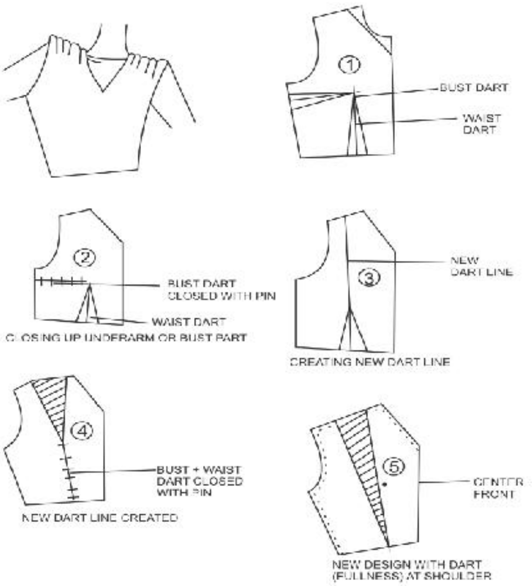


Figure 34

2. Moving waist Dart to Under Arm Dart

The waist dart is closed and transferred to the bust as shown in figure 35.

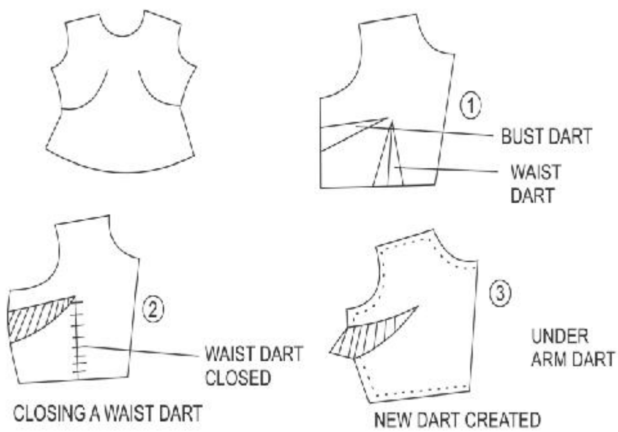


Figure 35

3. Moving bust dart to neckline

The bust dart is transferred to waist dart. This is transferred to the neckline. If more fullness is desired at the neckline, more slashes are made and spread to the desired width as shown in figure 36.

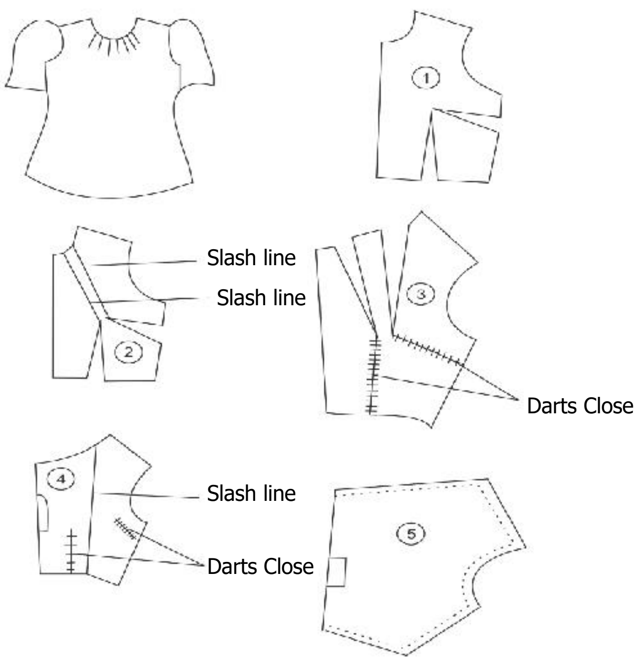


Figure 36

4. Movement of bust dart to armhole

The burst dart is slashed and transferred to the armhole as shown in figure 37.

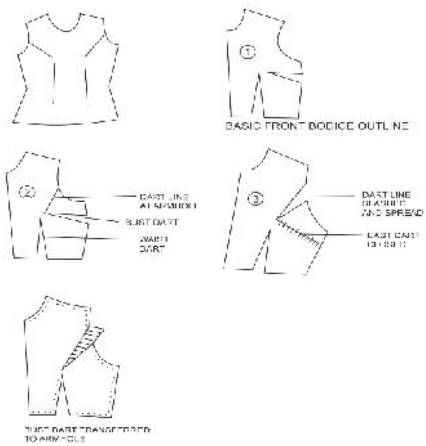


Figure 37

5. Princess line

1. Connect burst dart to armhole;
2. The burst dart is transferred to the armhole;
3. The darts are now slashed out as shown in figure 38, thus producing two patterns. Seam allowances are added to these two patterns

Moving dart to obtain princess dart from armhole

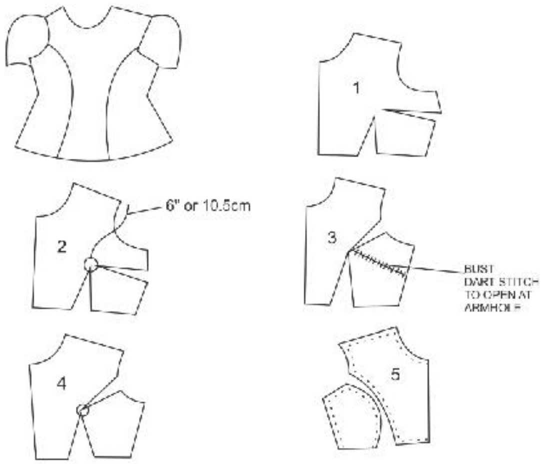


Figure 38

Moving dart to obtain princess line from shoulder

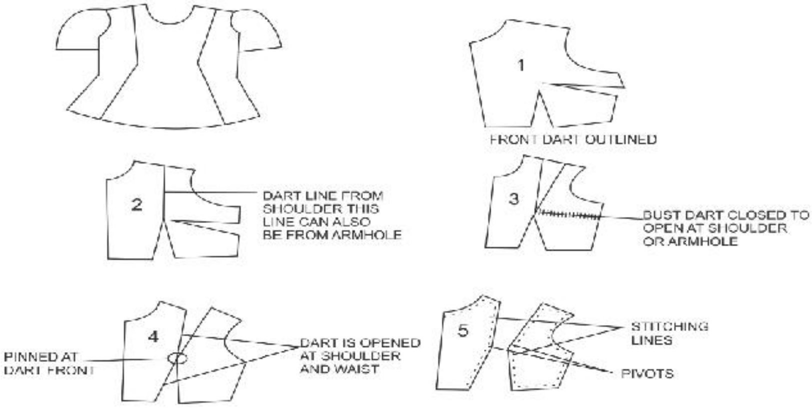


Figure 39

6. Moving dart to yoke to create style

1. Outline the basic block front;
2. Measure and remove yoke;
3. Transfer bust dart to waist dart;
4. Make lines from waist to dart point;
5. Slash through the center of this dart to the top and transfer it to the top of the lower part of the blouse without yoke; and
6. This can now be gathered and sewn to the yoke.

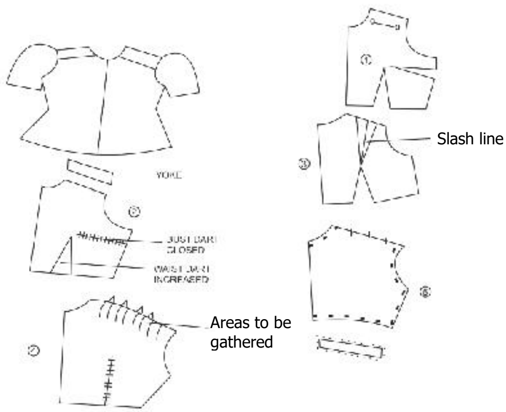


Figure 40

7. Conversion from darts to tucks

The stages for converting darts to tucks as shown in figure 41 are explained below.

a. The burst dart is transferred to waist dart;

b. While keeping the center front constant, lines are made from the edge of the neck through the entire neckline;

c. The lines are slashed through; and

d. The center front is placed at a straight line while the other lines are spread to desired width at equal interval.

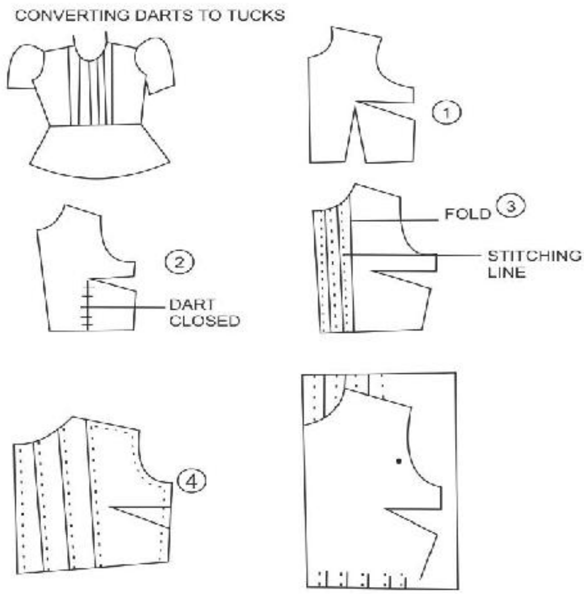


Figure 41

Adaptation of basic block
Skirts adaptation
The basic skirt can be adapted to the following:

1. Four gore
2. Six gore
3. Flare
4. Fish tail

Adaptation of basic skirt to four gore

1. Outline the basic skirt front;
2. Draw a straight line from center of dart to hem;
3. Slash from hem through the dart to skirt waist without slashing through;
4. Close the dart so that the hem spreads as shown in figure 42;
5. Add 3.8cm or 1½" to hem as shown in figure 42;
6. From the hip depth, draw a line to join the 3.8cm or 1 ½";
7. Add the same 3.8cm or 1½" to the base of the center front. Then join the center from front waist dart as shown in the figure to complete the skirt; and
8. Repeat the same process for black skirt.

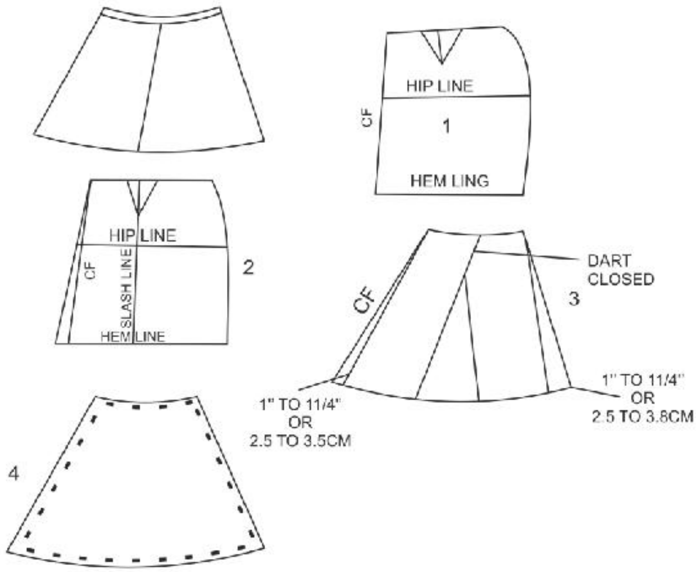


Figure 42

Adaptation of basic skirt to six gore

1. Outline the basic skirt pattern;
2. Measure from the waist through the hip line down to where you desire the gore to start. This depends on the height of the person who the skirt is being made for;
3. Measure between 3 to 3½" or 7.5cm to 8.5cm from center towards the dart on the waist line;
4. From that point, draw a line to the hem of the skirt to obtain A to A_1 and B to B_1 slash through, label the pieces 1 and 2;
5. Close the dart at the waist with a pin;
6. From the hem on the skirt side upwards, measure to where you had earlier marked as where the gore will start. This decides the length of the gore;
7. On a fresh brown paper. Draw the length obtained in 6 as shown in figure 43;
8. Decide the width of the gore which may be 6" or 15cm to obtain the triangle in E;
9. Trace each part of the skirt parents pattern obtained as stated in instruction 4;
10. Place at each panel, the triangular piece to obtain F and G as shown in figure 43;
11. Repeat this process for back skirt, remember that the triangular pieces are the same;
12. Finally, the pattern pieces have been produced; and
13. When cutting out after seam allowances have been added, place CF on fold, Cut 2 of pattern piece No2, place center back on fold, cut 2 of pattern No 4. Remember that the zip opening is placed at the side else it will turn to seven gores.

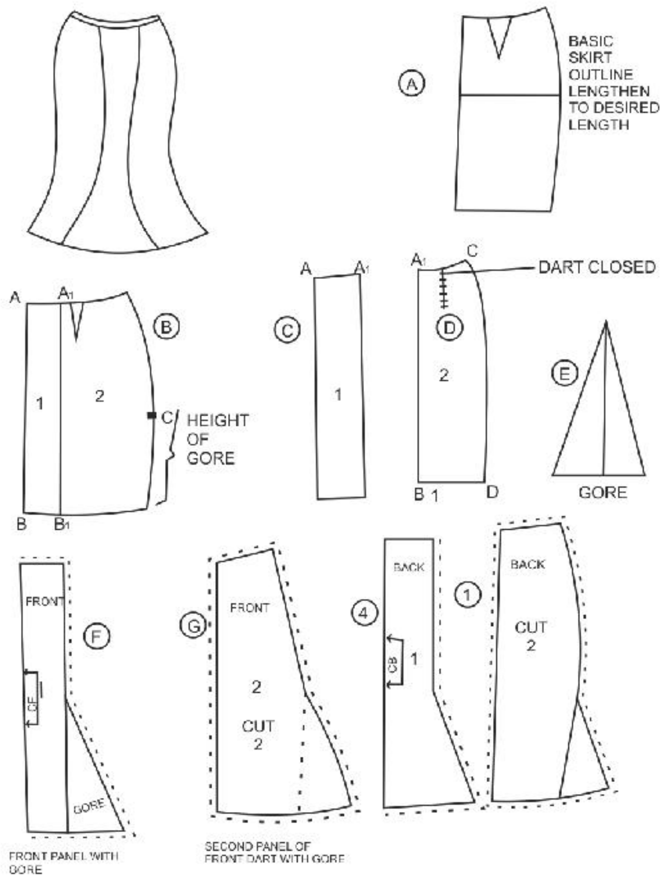


Figure 43

Adaptation of basic skirt to flare

1. Close the dart by drawing a straight line from center of dart to the hem;
2. Slash the dart from the hem so that it opens up outline this figure;
3. Draw lines at equal internals on the figure obtained in No 2;
4. Slash from the hem to the tip of the waist line but don't slash through;
5. Place on fresh brown paper and spread as desired at equal intervals; and
6. At the end of the skirt hem; measure 2.5 to 3.8cm or 1. to 1¼". Join this to the hem. Join this with a straight line to the waist line.

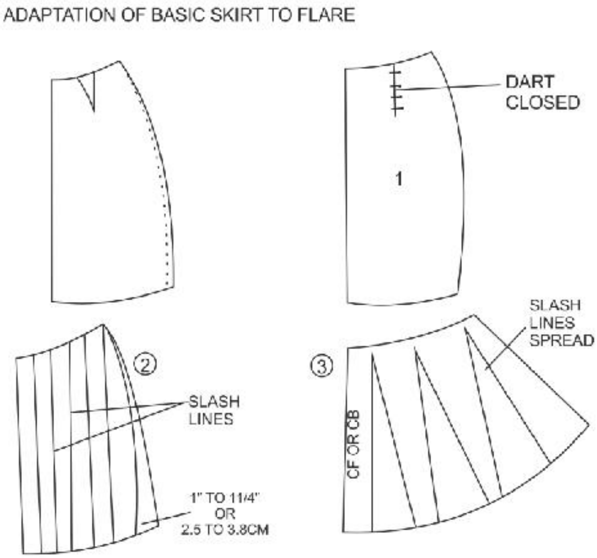


Figure 44

Adaptation of basic skirt to fish tail

1. Outline the basic skirt;
2. Decides the position of the tail by measuring from the waist to where you want the fish fail to start. Mark this point to have two pattern pieces 1 and 2 as shown in figure 45;
3. Draw lines at equal intervals in 2;
4. Slash from hem to the top of this pattern but do not slash through;
5. Spread at equal internal make sure the center front or back is on a straight line while the other pieces are spread at equal intervals;
6. After spreading, add 1 to 1/4” (2.5-3.8 cm) to the end of the hem;
7. Join from the top to this new hem; and
8. Repeat the process for the back.

ADAPTATION OF BASIC SKIRT TO FISH TAIL SKIRT

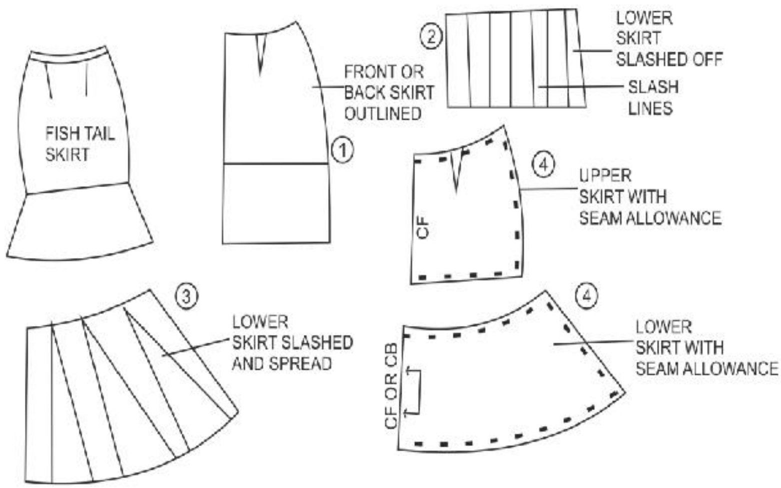


Figure 45

Adaptation of basic block to one sheet dress

1. Trace the front bodice;
2. Place the front skirt under the front bodice;
3. Align properly;
4. Adjust the waist darts if they did not align;
5. Trace the entire diagram to obtain the figure 46; and
6. Repeat instruction 1-5 using back bodice and skirts to obtain back dress.

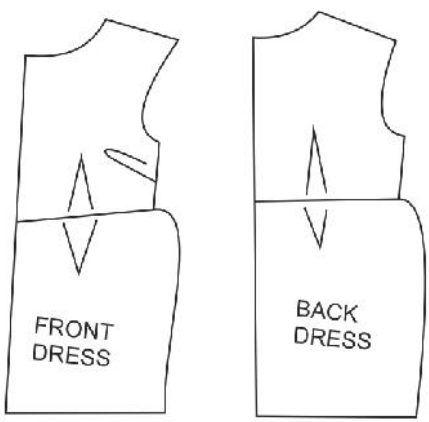


Figure 46

SUMMARY

This chapter stated the meaning of pattern drafting, tools used, terms, symbols and methods of pattern drafting. Also, it described the types of patterns and their differences. Furthermore, it showed how to draft basic blocks, how to use them to adapt styles and how to manipulate darts to obtain styles in garments.

EXERCISE

1. Draft the seven basic blocks
2. Adapt the basic skirt to the following:
    a. Fish tail
    b. Four gore skirt
    c. Six gore shirt
3. Mention 10 tools used in pattern drafting and describe their uses.
4. Describe the procedure for measuring the following parts of the body:
    i. Burst
    ii. Shoulder to waist
    iii. Hip depth
    iv. Skirt length
    v. Crotch measurement
5. Describe, with illustrations, how to adapt the dart to the following styles:
    a. Princess dart from arm hole
    b. Princess dart from shoulder
    c. Gathering at neckline

References

Igbo, C. A. and Iloeje C. I. (2012). The basics of dress pattern drafting. (Nigeria) Iselberg Ltd

Kopp, E, Rolfo, V and Zelin, B. (1972). Designing Apparel Through the Flat Pattern. 4th Edition New York, Fair child publication INC.

Bray, N. (2002). More Dress pattern Designing. Fourth Edition, New York Blackwell Science.

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CHAPTER 42
CLOTHING CONSTRUCTIONS
By
IGBO Chinyere Anne

Overview

Clothing is one of the three basic needs of man. However, the ability to select appropriate clothing depends on a person's knowledge of the figure types, style features and clothing construction skills. This chapter provides information on figure types and style features that flatter or hide different figure faults. Also, It provides exercises to test the learner's knowledge in body measurements, clothing choice and construction methods.

Objectives

At the end of the chapter, students should be able to:

1. identify suitable styles for various figures/ages;
2. construct simple styles of garments for various figures/ages ; and
3. select styles for various figure needs and occasions.

Selection of styles for various figures

In order to dress appropriately, the figure type and shape must be known. This can be determined by measurements.

How to determine body shape or figure using measurements

1. Use a cloth tape instead of a metal tape to take body measurements;
2. The tape must not be too tight or too loose when taking body measurements; and
3. It should be snug as if it will slip.

Measurements to determine body shape or figure

A. Shoulder measurement

1. To take the shoulder measurement, place the tape at the base of the neck and measure round to the other side till it meets where the measurement started at the shoulder; and
2. Measure very close to the shoulder through the widest part of the shoulder.

B. Bust

1. Allow the person to be measured to stand straight;
2. Measure over the fullest part of the bust;

3. Place the end of the tape at the fullest part and wrap around under the bust to bring it to where you started; and
4. The tape should not constrict the bust. It should rather pass through the chest.

C. Waist

1. Do not touch or pull in the stomach, make small conversations while taking the measurement because it will be difficult to slouch or pull in the stomach while talking;
2. Measure from 1” or 2.5cm above the navel or belly button;
3. Measure from below the rib cage along the natural waist line; and
4. The natural waist line can be obtained by bending the point at which you bend is the natural waist line.

D. Hip

Measure 7½ or 8” from the waist to locate the hip depth. At the hip depth, measure from one side of the hip over the fullest part of the other side of the hip and bring the tape to the starting point.

How to dress based on body types/figures

A good understanding of the body shape helps one to choose clothes to flatter the shape. There are five major body shapes.

1. The inverted triangle body shape

The inverted triangle has broad shoulder with a tiny waist line. An individual with an inverted triangle body shape should avoid necklines like boat-neck or bateau, big straps, halter-neck, big shawl collars and large patterns at the upper section of the body. They should wear items like A-line skirts or wide-leg trousers.

2. The rectangular body shape

With the rectangular shape, one can wear the same size both at the top and bottom. The individual does not have a defined waist line but have a straight shoulder line and hips. The individual is athletic looking and should:

a. Wear garments that create an illusion of a waist;
b. Use belts around the waist, mid-waisted trousers, jackets with belts however around;
c. Vertical looking garments like straight jackets and trousers;
d. Use soft fabrics as coarse fabrics give an illusion of weight; and
e. Any type of trousers can fit this individual.

Pear shape or regular triangle

This individual has a wider lower half, wider hips, thighs and narrow top half.

1. Choose soft prints, bright colours at the upper part of the body (bust area);
2. Choose wider necklines like boat necklines and sweet heart necklines as these give an illusion of broad shoulders;

3. Wear frills to add volume to the upper half of the body;
4. Allow shirt and blouse to reach the widest parts of the hip;
5. Avoid extremely long shirts and blouses;
6. Avoid cropped shirts;
7. Use padded bra or push up brazier; and
8. Use dark colours around the hip area as they give an illusion of slimness.

Hourglass body shape

The waist is well defined but the shoulder and hip are same size. The waist is the slimmest part of the body.

1. Scoop neck or boatneck will fit this individual;
2. However avoid high necks, like turtle neck;
3. Do not wear in seam pockets;
4. Wear pants with angled pockets;
5. Wear mini-skirts to show off the legs; and
6. Wear peplums and empire waist dresses

Round body shape

This is also known as the apple body shape. The upper body is larger than the lower body.

1. Wear well fitted, tailored tops and jackets that are not skin tight;
2. Avoid body conscious dresses;
3. Wear slim fit dresses, pencil skirts with loose tops; and
4. Wear straight leg jeans.

Preparation of fabric for cutting out

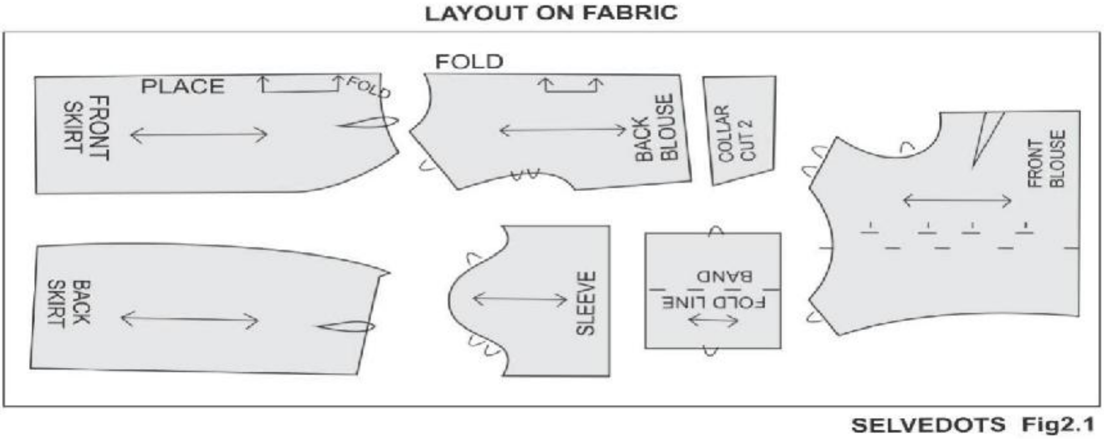
A. Fabric preparation

1. Buy fabrics based on pattern pieces, figure type, notions and fabric design;
2. Test fabric for shrinkage by cutting two pieces of same size of the fabric, wash one in hot water and press then compare the size with the unwashed piece if shrinkage occurred, then the whole fabric must be pre-shrunk before cutting out.

In order to Pre-shrink

1. Dip the fabric into water without creasing, drip dry and press before cutting out;
2. The fabric can be covered with a damp cloth and pressed evenly. However, this method is not suitable for velvet or pile fabrics;
3. Check the grain of the fabric by folding the edges together. If the grain line is okay, the fabric will lie flat but if not, pull the fabric firmly on the cross grain till it lies flat; and
4. Care should be taken when placing patterns on velvet, face cloth and one-way designs, making sure that the pattern pieces face the same direction.

B. Laying pattern on fabrics



Method

1. If you are using a commercial pattern, study the instruction sheet, layout directions of the style, size and fabric width;
2. Fold the fabric on the wrong side, right sides facing and lay pattern pieces as directed;
3. Check the pattern symbols;
4. Pin pattern pieces carefully taking special care of corners and curves; and
5. Cut only after all pattern pieces have been placed on fabric.

C. Cutting out

1. Use sharp scissors, utilizing the whole length of the blade to give a smooth edge;
2. Do not cut in the air. Do not lift up the fabric while cutting;
3. Place the left arm on the fabric while cutting;
4. Remember to cut the balance marks or notches outwards; and
5. Leave cut-out fabrics with their different pattern pieces pinned to them until you are ready to transfer the pattern marks.

D. Transfer of pattern marks

Pattern marks can be transferred to fabrics using the following methods:

1. Tailor’s chalk;
2. Dressmakers carbon paper and tracing wheel; and
3. Tailor’s tacks and thread marking.

Use of tailor’s chalk

a. Use pins to poke through the pattern and fabric on the seam lines; and

b. Mark the seam or construction lines on the fabrics with chalk over the pins.

Dress markers carbon paper/tracing wheel

Dressmakers carbons are not easily found in Nigerian market. However, one can improvise by smearing profusely, on white sheets of paper, crayon of different colors (wax crayon). Do not use regular typing carbon paper as this will discolor the fabric.

How to use dressmakers carbon paper/tracing wheel

1. Fold the carbon paper in half with right side outwards;
2. Place between two larger fabrics to be marked; and
3. Trace over pattern and fabric with tracing wheel.

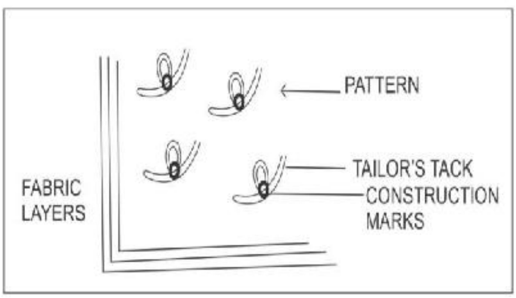
Tailors tack and thread marking

This is usually carried out on fine fabrics that can be easily destroyed by the sharp edges of the tracing wheel. Also, It can be carried out with a fine long needle (straw) and long double thread.

How to use tailors tack and thread marking

1. Thread the needle with long double thread;
2. Make a stitch along the seam line through the pattern piece leaving ends of about 4cm long;
3. Start the stitch with a back stitch, through the stitch form a loop leaving another thread of 4cm and cut thread;
4. Remove pattern gently; and
5. Cut tacks between fabric as shown in figures 2 and 3.

Transferring pattern marks



TAILOR'S TACK 1. Fig 2.2

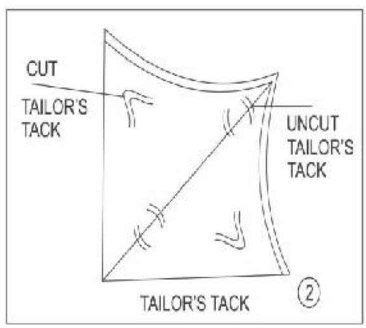


Fig 2.3

Components of a garment

The component of a garment depends on the garment type.

1. **Blouse**

   These have the front and back blouse, the sleeve cuff, placket, yoke, collar and pocket. blouse components also include shoulder pad, buttons, zippers (closures) interfacings, embellishments (beads) wading.

Garment components include

i. **Labels and motifs:** Labels also carry care labels, sizes, fabrics type of fabric, country of origin manufactures trade mark etc.
ii. **Sewing thread:** this is one of the most essential components in a garment. When choosing threads, consider the fabric type, quality of thread, strength of thread, elasticity, shrinkage, size etc.
iii. **Interlining:** This is needed to increase the strength of parts of the garment or to give the desired shapes. They are used in collars, cuffs, facing, front, part of jackets and coats, waist bands etc.
iv. **Lace braid and elastic:** They are used for decorative or functional purposes. They come in different measurements, designs and sizes
v. **Wadding:** These are used for filling and they come in different thicknesses in the form of sheets. They non-woven types are made from synthetic fabrics called, batting. Wadding is used in garments where a raise in weight is needed.

2. **Other components of a garment include closures like**
   - Zippers
   - Hook and eye
   - Buttons
   - Velcro
   - Snaps and fasteners

Methods of garment assembling

This is the method of putting together garment parts into a finished product. e.g sleeves, bodice, skirts. Garment making is an organized activity made up of sequential processes like laying, marking, cutting, stitching, checking, finishing, pressing and packaging. It is the method of converting raw materials into finished goods or products. Garment assembly methods include:

1. The Unit Method

This is the conventional method of production line where a clothing maker assembles a single piece of garment at a time by carrying out all the necessary sewing processes to assemble a garment. This method suggests that the sewer completes as much work as possible on one unit before joining that unit with other parts e.g cuffs and bands are attached to set in sleeves before the sleeve is set into a garment.

Advantages

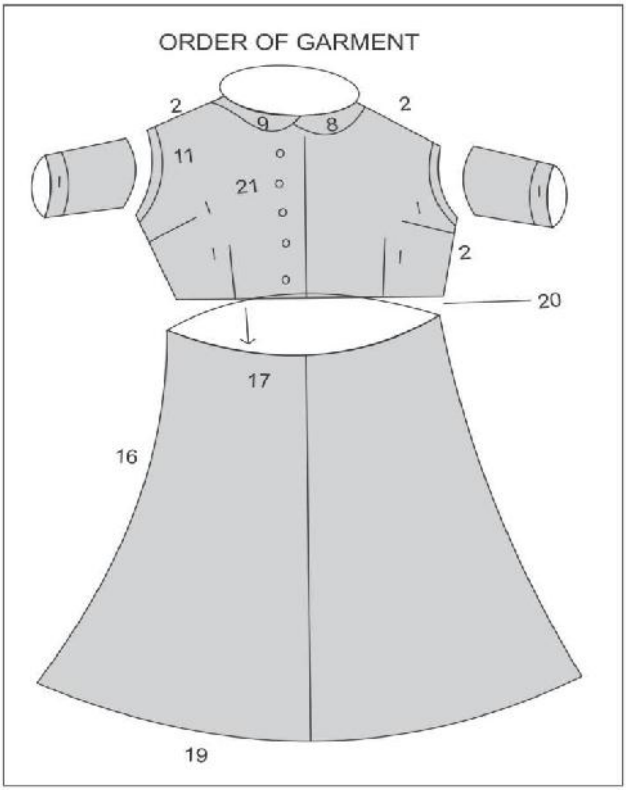
It helps to keep the work flat. It reduces handling of the fabric which could lead to stretching and distortion of the garment for the in experienced garment marker. It helps the sewer to focus on one unit at a time.

2. Round method of garment assembly

This method follows the order below

1. Tack bodice
2. Tack shoulder
3. Fit bodice
4. Stitch, neaten and press bodice
5. Apply interfacing to collar, cuffs and fronts
6. Complete collar and cuffs
7. Attach collar
8. Stitch, and neaten sleeve seam
9. Attach cuffs
10. Insert sleeves
11. Tack skirt seams together
12. Tack skirt to bodice
13. Second fitting
14. Untack waist live
15. Stitch and neaten skirt seams
16. Retack skirt to bodice, stitch and neaten edges together
17. Hang up for some time to allow hem to “drop’’
18. Level and complete hem
19. Insert zip
20. Work button holes and sew and buttons
21. Final press

Order of garment assembling



ROUND METHOD
Fig 2.4

3. Flat Method

This method is used for simple garments that do not require much fitting

1. Join style seams and darts, press
2. Join shoulder seams and neaten, press
3. Complete neckline
4. Set in sleeve
5. Tack and fit centre back and side seams
6. Insert zip
7. Level and complete hem
8. Final press

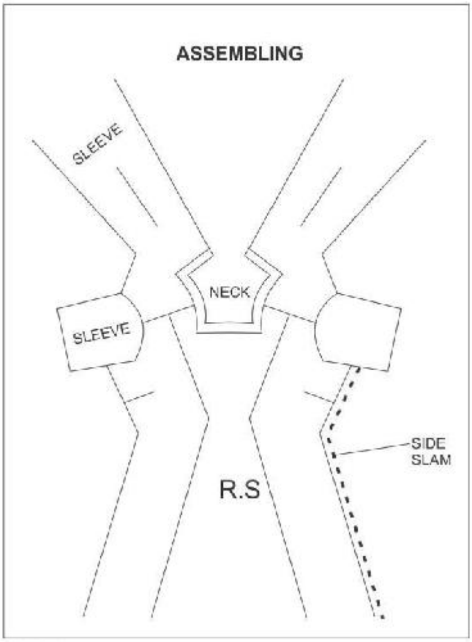


Fig 2.5
FLAT METHOD

Garment assembling construction system in the big manufacturing companies
There is six garment production or assembling methods in the industry.

1. **The make through system**

Here a tailor completes a garment he/she makes the pattern, or uses a ready-made pattern, cuts the fabric and finishes the garment.

2. **Progress bundle system**

Here different operators finish different parts of a garment. Here cut parts are fed in to a bundle from. An operator receives a bundle and moves the bindle to the next operator. Here a number of people are involved in the making of a garment. These methods increase performance. This method is use by companies' to mass produce and that export their goods

3. **Section production system**

This is similar to the progressive bundle, the difference between the two is that in the section approach work is divided into sections instead of one line. Machines doing similar jobs are place together for example in the making of men's shirt, collar, cuffs, and sleeves are in the preparatory sections and sent to assembly section. This method helps in maximum use of human resources

4. **Modular production system**
   Here sewing operators work as a team. Multi-skilled operators work together and each of the members do multiple works. Here operators help one another to finish a work quickly and ensure quality

5. **One Piece Flow System**
   Instead of making a bundle of multiple pieces, a bundle is made with all components of a single piece. Sewing machines are arranged in a straight-line modular form
6. **Overhead production system (UDS) (Unit Production System)**

Here components of a garment are clamped in a hanger and the hanger moves on an overhead rail. It is a kind of single flow system

7. **Piece rate production system**

This is popular in small organized factories. Here workers are paid based on how many pieces of garment produced. This enhances the speed of production as everyone would want to produce as much as possible.

Basic principle in garment construction

The basic principles of garment design are functional, structural and decorative. Clothing construction is the process of stitching garments and all the sewing techniques involved

Functional design

This is really about appropriateness of a garment. How the garment physically works and performs.

Clothing needs to be functional for it to be worn. For example; a nurse, lab scientists uniform need to be functional. They need protection for the unique jobs they perform. Fashion and function go hand in hand for example pants and skirt, need to held up at the waist or hip.

Structural design

The structure of a garment is everything that holds the garment together. Garment making processes like the seam shaping are all details that give a garment structure.

Decorative design

This refers to the aesthetic surface finish of a garment after its functional and structural elements have been considered. This helps to draw attention to the garment. This can be achieved through buttons, bows, trimming, embroidery, print, pattern colours. It enhances the design of the garment.

Necklines and necklings finishes

A neckline is the edge of a garment at or below the neck used with reference to it height or shape. It is the top edge of a garment that surrounds the neck especially from the front view.

It is also referred to as the overall line between all the layers of clothing and the neck and shoulders of a person ignoring the unseen undergarment. The neckline is a style and helps the shape of the upper edge of a garment like the collar, cowl, darts or pleats.

Importance of necklines:

1. Necklines add style to fashion garments.
2. Show off the beautiful shoulders and elegant necks of a garment wearer
3. Enhance the way necks are worn.

4. Add value and originality to a garment.

Types of necklines

There are different types of necklines;

1. **Asymmetrical (one shoulder) neckline:** This is created by leaving one shoulder bare and strap running across the opposite shoulder to the underside of the armhole. It is most effective when constructed with a plain fabric.
2. **Boat neck:** This is a type of neckline that is very feminine in outlook. It is also called the bateau neckline. It can be very graceful. It draws the eye to the shoulder and lower neck of the wearer. It usually sits on the collar bone. It balances wider hips or narrow faces.
3. **Cowl neck:** This is usually soft and drapping in outlook. It is usually cut on a bias grain and requires extra fabric. It flatters all body shapes Soft fabrics produce drapes in cowl neck. It is best produced by stretch fabrics and sweater knit.
4. **Collared neck:** This is usually a collar set in a neck. It draws eyes away from the bust area. They can be rounded, pointed or even assymetrical. They came in different heights. Most collars fit well in garments with front button.
5. **Halter neck:** This flatters a person with wide shoulders. It creates a balance between broad shoulder and well-set arms. It draws away eyes from the width of the shoulder to a more central point of a design feature.
6. **High neck or turtleneck:** This suits a person with long neck. It sits under the chin and wraps round the neckline area. They consume a lot of fabrics which can be folded to desired height. They keep the body worm in cold weather.
7. **Keyhole neck:** It flatters the chest and looks like jewelry opening to the neck. This type of neckline does not suit persons that have big bust.
8. I**llusion neck:** This is very popular in bridal dresses. Here lace or net-like fabric is used to create a see-through look from above the bust to the neckline. It is best worn with a strapless bra.
9. **Off shoulder:** This is ideal for narrow shoulders. It is dramatic, shimmery in look and best worn with a strapless bra.
10. **Plunging neckline:** This is plunging or deeper. It elongates the frame of the wearer. It suits a person with short neck.
11. **Queen anne neck:** Named after Queen Anne. It has the sweet heart in front which is upheld by the sleeve or straps. It is popular in wedding garments.
12. **Round or crew neck:** This is a simple neckline that suits, different body shapes. It minimizes the amount of chest showing. It gives an illusion of short neck and fuller chest area.
13. **The U-Neck:** This is a larger version of the round neckline. It opens the neck area and the shape of the neckline.
14. **Scoop:** This is a deeper wider neckline that fits everyone. It lengthens the neckline and shows off the collar bone.
15. **Spagetti strap:** These are thin straps holding up the garment. The neck may be round or V shaped.

16. **Sweet heart neckline:** This shows off the natural curves and enhances the bust.
17. **Strapless neck:** Shows off the upper body area. Collar bones and necks.
18. **V-Neck:** Lengthens shorter necks and balances broad shoulders. It draws the eye inwards and places less emphasis on a wide torso

Source:www.treasure.com

Neckline finishes
Most necklines are finished with collar facing and binding.

Finishing neckline with facing

I. Cut facing and apply interfacing
II. Stitch on the facing to the neckline on the same line
III. Trim to reduce bulk
IV. Stay stitch to assist the facing to lie flat

Use of bindings in neatening neckline: This can be done with a bias binding

I. Fold binding in half-length wise and press
II. Fold seam allowance of one of the edges and press

III. Pin and sew unfolded edge of binding to neckline
IV. If there is an opening at the back neck fold end of the binding inwards and press
V. Fold bind over the seam and pin in place
VI. From the right side of the fabric sew stitch along stack seam line

Use of collar to neaten neckline edges

I. Prepare the collar
II. Prepare the center back (CB) of the shoulder seam
III. Sew the collar to the main blouse or dress
IV. Align the stitching lines
V. Sew the neckline pieces.

Disposal of fullness

This refers to the ways used to shape and drape fabrics so that they give a better shape, fit and appearance to garments. There are different ways of achieving disposal of fullness namely darts, gathers, tucks, pleats, shirring, smocking, easing-in darts.

Darts

These are construction details that shape fabric to the curves of the body.
They are wedged areas which are shaped to the body by holding the fabric in a round shape so that excess width or length of the fabric is removed. They must be tacked in position before fitting because adjustments may be needed.
Darts are positioned at the bust, hip, elbow, waist, shoulders, front and back necks.
Dart can be moved from one position to another in order to obtain styles.
Dart should always be pressed over a curved surface to keep the proper curve to accommodate the body contour

Tucks

They can be decorative and functional i.e. they are used for shaping and for decoration. A tuck is a fold in a material produced by stitching through a double fabric on the right side.
To calculate fabric needed for making tucks allow three times the finished width of a tuck. Tuck can be of various sides

Uses

They are used in bodice, yokes, cuffs, hems they are used to lengthen the hems of children's garment when the tucks are unpicked

Types of tuck

- Pin tucks: These are very narrow tucks that appear as fine ridges. They are used in fine fabrics like lawn and chiffon

- Group Tucks: These are worked together in groups of three or more. Tucks are made in front and back bodice, blouses, dresses and children wears.
- Cross tucks: They are worked in two directions to give decorative designs. Cross tuck most be done on fabric before placing the pattern pieces for cutting out. Tucks most be pressed in one direction before making the cross row
- Shell tucks: This are used for decorations on lingerie, they can be worked by hand or machine
- Release tucks: These types of tucks can be worked on the right or wrong side of fabric. The fabric must be stitched to form a short tuck then it is released to give a soft folded effect
- Diagonal tuck: This requires a lot of skill and practice to produce. It is usually worked on the cross grain. The tuck must not be distorted

Pleats

These are also used to apply fullness and shaping in garments. To produce accurate pleats, work on a flat surface. Make sure the working of pleat is even. Pleats are usually three times the width of the finished design

Types of Pleats

Pleats include the following

- ✓ Knife
- ✓ Inverted
- ✓ Box
- ✓ Sunray
- ✓ Concertina

Knife pleats

These are formed by series of folds facing the same direction. Like was earlier said the width of fabric for making thin pleat must be three times the finished width

1) Mark pleat lines with two different colours or using two different pattern symbols
2) Bring one colour over to the other and tack into position from top to bottom of fabric (length of fabric) through the three thickness of fabric.
3) Repeat the process until all the pleats are tacked and pressed

Inverted pleats

This is worked in a similar as knife pleats but in this case the two fold are brought together so that they meet

Box pleat

There the fabric is folded so that the two folds turn away from each other. This pleat is the opposite of inverted pleats.

Sunray pleats
These are mostly used for skirts or trimmings. Fabric is cut in circular or semi-circular. It is then pleated permanently. Most often this type of pleat is done by machine

Concertina pleats
As the name implies, they are usually not deeper than 1.25cm because they do not lie flat. They are usually commercially produced by a special machine. They are produced by a permanent-press process

Accordion pleats
The best fabric for this type of pleat is polyester fabric

1. Prepare the polyester fabric, hem the fabric before pleating
2. Place the fabric between the pleating moulds
3. Wrap the mould with cotton
4. Pleat with heat by applying steam iron use a hot oven as if you are baking the fabric
5. Allow to cool
6. Take out the pleated fabric

Gathering

1. Work two rows of fine running stitches along 1.0.5cm above the stitch line
2. Leave threads free at the end
3. Draw the two rows of thread together evenly to the required length, then wind round a pin
4. Distribute the gathering evenly

Shirring
This is done the same was as gathering the only difference is that you making four or five rows of gathering stitches.
These are pulled together making sure the gathering obtained from the 4 or 5 rows are pulled at the same time and are evenly distributed.

Smocking

1. This is best done on a check or plaid fabric where the check or plaid line act as guide
2. However, when using the fabric that is not check or plaid using a plain paper, marks dot which are then transfer to the fabric on the wrong side
3. Using a contrasting color of thread pick up the dots in rows across the fabric from right to left on the W.S of fabric, starting with a secure stitch while leaving the other end free.
4. Do not put not pull up until all rows are completed

5. Draw up two sets of thread at the same time to a third of the original size. Wind thread round a pin
6. Using any of the following decorative stitches to finish up
    i. Outline stitch
    ii. Cable
    iii. Diamond
    iv. Weave stitches working from left to right

Easing in

This is most commonly carried out or sleeve heads when the sleeve head in slightly more than the armhole or arm scyc. This involves applying slight gathering at the sleeve head before inserting into the armhole of the garment. It gives a slight amount of fullness without showing gathers or pleating

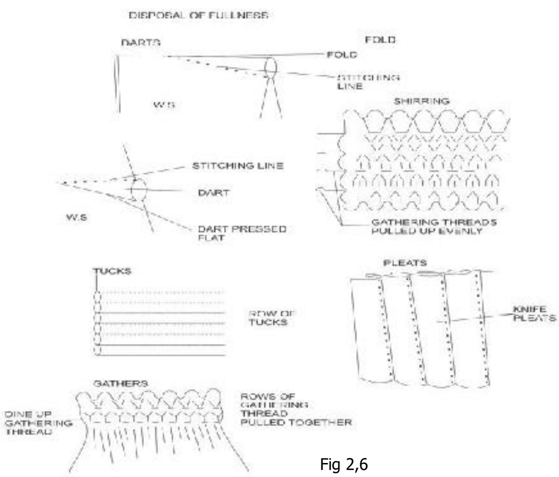


Fig 2,6

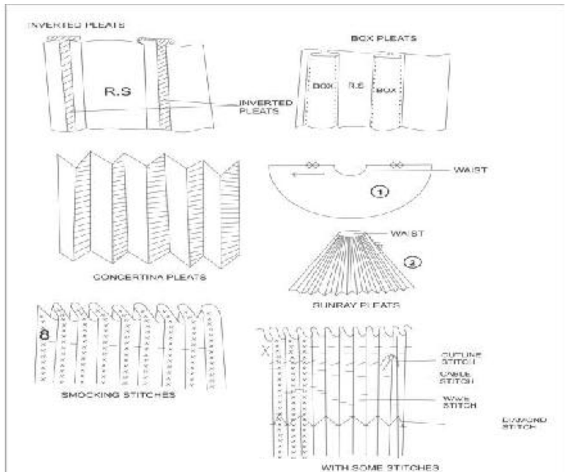


Fig 2.7

Set in sleeves

The set-in sleeve is a basic sleeve shape, the sleeve is made up, seams neatened at the cuff or band. They must be finished before setting it into the armhole. The measurement of the sleeve head is always slightly greater than the armhole by approximately 4cm or 1½'' so it has to be eased in

Method of setting in sleeve

1. Pin sleeve into armhole placing pins at right angles to fitting line
2. Match notches underarm and at shoulder points
3. Manipulate sleeve between thumb and fore finger, distribute ease evenly
4. Pin and secure
5. Tack into armhole using short stitches to hold ease in position. Stitch carefully trim seam, neaten raw ledge's together, press seam towards the sleeve

Ironing and pressing in garment construction

Pressing is a very important process in garment making. It helps to produce professional looking garments by inexperienced dressmakers.

Role of pressing in garment making

1. It helps to smoothen away unwanted crease and crush marks
2. Helps to make crease where the design of the garment requires it
3. Mould the garment to the contour of the body
4. Improves the appearances of a garment
5. Flattens and smoothens puckers that occurred during serving
6. Helps garment to shrink and stretch thus fitting the body

Equipment/ tools needed for pressing

1. **Iron**
   The iron must have a thermostat. Steam iron is very useful for pressing because little moisture is needed. The surface of the iron must be clean and smooth
2. **Ironing board**
   This must be well padded. It must have a cover which must be clean and washed
3. **Sleeve board**
   This is a small version of the ironing board. As the name implies it is useful in pressing small areas such as short seams and sleeves
4. **Tailors ham**
   This is a small oval shaped cushion used for securing surfaces. It is used for moulding and shaping it comes in difference size
5. **Padded roller**
   This is a long cylindrical roller used during pressing to prevent the transfer of imprints to the rights side when pressing seams. This can be improvised by covering a long broom handle with foam and covering with cotton fabric
6. **Tailors clapper**
   It is used to press woolen or difficult fabric. It helps seams to trap air for a longer time inorder to make the seam firm and flat

7. Pressing cloth

This prevents shine or the right side of a garment. The pressing cloth is made from cotton. It must be clean and lint free

8. Needle board

This is a narrow board made of a bed of upright wires. The needle board is used for pressing piles and nap fabrics for example velvet. They come in various sizes. Needle board is stored in a dry place to prevent rust

Principles of pressing

1. Press after each process before starting the next.
2. Remove tacking and pins before pressing
3. The iron must be lifted and lowdered not pushed along
4. Test fabric before pressing for reaction to heat and moisture
5. Good pressing is not over pressing

Fabric pressing guide

- Cotton-Hot iron, right or wrong side (W.N)
- Linen- Hot iron W.S. slightly damp
- Woolen-Medium heat, W.S. over damp cloth or using steam iron
- Silk-Medium heat, W.S. slightly damp
- Nylon- Little pressing required, cool iron, dry
- Terylene-Little pressing, required cool iron, dry
- Acrylan-Little pressing, required cool iron, dry
- Rayon-Cool iron, W.S. sometimes damp

Pressing techniques

Always test a sample of the fabric to determine moisture temperature and pressure. To apply moisture use damp cloth. Do not apply too much moisture as this will mark the fabric and give an over pressed look. Do not remove garment from the pressing board while it is wet. Use dry pressing cloth to remove excess moisture

Temperature

Always check the temperature of the iron through thermostat. Never use very hot iron as very hot temperature on the fabric will cause shine on the right side of the fabric.

Pressure

Do not use the full weight iron to rest on the garment. Use lifting and lowering motion during pressing in order to keep an even pressure on the garment being produced

Pressing darts of a garment

i. Place the dart area over the curve of the tailors, ham and press along the stitching line

ii. Do not press beyond the point of the dart
iii. Press waist line and shoulder towards the center
iv. Press bust and elbow dart downwards
v. Clip the center of double pointed dart at the widest point so that they can pressed flat
vi. Cut through the center of heavy weight fabrics to avoid bulk
vii. Do not press dart tucks beyond the stitching line.

Seams

i. Press seams before joining them
ii. Press over machine stitching then press open the seam to produce a flat finish
iii. Press both edges of a seam to the same side to emphasize a style
iv. Press over padded roller to avoid imprints on the right side of a garment
v. Mould curved edges over a tailor ham to maintain the rounded look
vi. Press armhole seams lightly towards the sleeve
vii. Press waist seams towards the bodice

Gathering and shirring

i. Do not create creases in gathered sections
ii. Move iron towards stitching line in gathers instead of side by side
iii. Do not press beyond seam line when a plain section of a garment join a gathered section

Pleats

i. Tack before pressing
ii. Pressing along the fold line and the stitching on the wrong side
iii. To remove shine on the right side of garment remove tacking thread before pressing.

Zip fasters

i. Do not press over the teeth of metal fasters
ii. Press on the W.S. upwards
iii. Press on the right side over a padded surface
iv. Avoid imprint on the right side of the garment
v. Do not use hot iron when pressing nylon garment to avoid nylon melting
vi. Turn iron thermostat to correct fabric being pressed

Hems

i. Start pressing from the hem or lower ledge of garment upwards
ii. Avoid stretching the hem line of a garment by not pressing the full depth of the hem
iii. Press over padded surface when pressing the right side of the garment

Neck hem

i. Do not stretch the neck line of a garment by pulling the neck line
ii. Hold the curved edge carefully
iii. Press sleeve over a sleeve board or a tailor's ham

Pressing velvet

i. Press cotton velvet on the W.S. lightly with a cool iron

ii. Use the velvet board when ironing other velvets
iii. Seams and processes can be pressed by standing the iron up on end and pulling the W.S. of the section firmly across the surface of the iron

Final pressing

Very little final pressing is needed if the garment maker followed all the instructions while ironing the parts

i. Press sleeves, collars, cuffs and trimmings
ii. Press bodice
iii. Pressing skirt
iv. Never over-press

Construction of garment for various figures/ages

Students are to sketch the following

i. One sheet gown
ii. One skirt adaption
iii. One blouse

A. They will draft the patterns based on their measurements
B. Construct these garments under the supervision of their lectures and technologists

Summary

This chapter identified the major figure types and garments that flatter or hide their figure faults. It described how to prepare fabrics for cutting out, how to lay patterns and how to transfer pattern marks. Methods of garment assembling were also discussed. The chapter also described types of necklines in garment construction and how to finish necklines. It finally discussed disposal of fullness and the pressing processes in garment manufacturing.

Exercise

1. Describe how to determine body shapes using the measurements of the following:
    i. Shoulder
    ii. Bust
    iii. Waist
    iv. Hip
2. Mention the styles that best fits individuals with the following body measurements
    i. Inverted triangle body shape
    ii. Pear or regular triangle
    iii. Hourglass

iv. Rounded body shape
v. Rectangular body shape

3. Briefly describe the five major activities to be carried out by a garment maker before the actual sewing
4. Explain the five major garment components
5. What is garment assembly;
   i. Mention the three major garment assembly methods
   ii. Describe the methods in full
6. Construct a one-piece garment.

References

Christensen, O. (1978). Concise Needle craft: Great Britain & Wheaton & Co. Ltd.

Chapman, E. (2020). Types of Necklines. www.treasurie.om date accessed: 22/08/2023.

Igbo, C. A. and Chukwuone, C. A. (2023). Clothing Basics and Entrepreneurship. Iselberg Ltd. In Print.

Walts Gwyneth (1981). Modern dress Making: A textbook for students. London Hutchinson.

www.treasure.com. Types of necklines.

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