Invigoration of Energy Efficiency Principles in the Design of a Vocational Training Center At Gbedun Village, Ona Ara, Oyo State.

Marvel Ewaoluwa OYEDEJI
LCU/PG/002847

Being a MSc Theses Submitted to the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State, Nigeria

In Partial Fulfillment of the Requirements for the Award of Master Degree (M.Sc) in Architecture

2023

Certification

This is to certify that Marvel Ewaoluwa Oyedeji with matriculation number LCU/PG/002847 carried out this research work titled "Invigoration of Energy Efficiency Principles in the Design of a Vocational Training Center at Gbedun Village, Ona Ara, Oyo State" in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State for the award of Master Degree (M.Sc.) in Architecture. The thesis is an outcome of an independent and original work. I have duly acknowledged all the sources from which the ideas and the extracts have been taken. The project is free from any plagiarism and has not been previously submitted to any other institution.

……………………………………………… ……………………………….

Arc. Aseyan Bababjide Sunday **Date**
(Supervisor)

……………………………………………… ……………………………….

Dr. (Arc.) F.M. Adedire **Date**
(Head of Department)

Dedication

This research is primarily devoted to Almighty God for his kindness and grace shown to me throughout my life, particularly during the research process. Additionally, I dedicate this to everyone who helped make the research a success by giving their time and support. I value each of you.

Acknowledgement

I would love to convey my sincere gratitude and admiration to God Almighty, who has always met my necessities and helped me advance in my academic career. To my father, Dr. Tunji Oyedeji for the solid foundation he laid for my education as well as my mother Mrs. Oluwaseun Oyedeji for her continuous emotional support.

I want to express my gratitude to my sisters; Oreoluwa, Didunoluwa and Ikeoluwa for always being there for me. To my best friend, Oluwatobiloba Afolayan, you deserve my unwavering love and thanks for your support towards the completion of this research. I also want to express my gratitude to Dr. (Arc) Adedire Funmilayo, the department chair, the entire team at Lead City University's Department of Architecture, and the postgraduate college's administrative personnel for making my time there a memorable educational experience. But most of all, I want to express my gratitude to Arc. Babajide Aseyan, my supervisor, for going through my work and mentoring me throughout the process. I owe a huge debt of gratitude to God for placing every one of you in my life.

Even if the aforementioned institution and individuals aided in the research process, I alone am responsible for any faults that are discovered in the work, if any.

Abstract

Due to the general rise in carbon emissions, energy efficiency in vocational centers is gradually becoming a necessity. Sustainable energy practices must be developed in order to alleviate the already present climate change challenges. The lack of energy efficiency in vocational centers results in increased operating costs and environmental impact, while also limiting educational opportunities and creating uncomfortable learning environments. The purpose of this study is to investigate how architectural design elements might improve the energy efficiency of vocational facilities. The issue is that user-friendly, aesthetically pleasing buildings can be created using anthropometry, space articulation, shape, volume, texture, and other architectural design concepts. The background of the argument is derived from the examination of pertinent case studies and literature. Case studies of real-world vocational institutions were explored as the research technique. Variables were thoroughly researched and utilized in the design of a proposed vocational training facility to drastically lower energy use. Additionally, the location of the site and its suitability for the planned construction were investigated. Finally, by utilizing energy-saving techniques There is a chance to reduce the building's energy use by roughly 70% during design and construction.

Keywords: Energy Efficiency, Vocational Center, Carbon Emission, Sustainability, Energy-saving Techniques.

Word count: 188

Table Of Content

Content **Page**

Chapter Three: Research Methodology

List of Tables

List of Figures

Chapter One

Introduction

1.1 Background to the Study

Energy issues have been a growing concern in recent decades. Limited energy resources and increasing energy consumption from one side and environmental pollution and waste of resources from the other side have substantially affected the future of human life. In this regard, buildings (residential and commercial) consume approximately 40% of the total annual energy in most countries (IEA, 2015) and produce about 26% of annual greenhouse gas emissions (EPA, 2013). For instance, about 50% of the UK's greenhouse gas emission is attributable to the energy used in buildings (Mithraratne, 2007). In Australia, approximately 25% of the total energy is consumed by buildings and households are directly responsible for about one-fifth of greenhouse emissions (Department of Industry, 2013).

Buildings use more energy than transportation and industry do in many nations. According to Estimates from the International Energy Agency (IEA), the building industry accounts for 42% of all global electricity use (IEA, 2004). The building industry includes a wide range of end use activities with various effects on energy demand. The efficiency of the buildings in which temperature control and lighting systems are installed affects not only how much energy is used for space heating, cooling, and lighting, which together make up the majority of building energy usage in industrialized nations. For a specific group of end applications, building designs and materials have a substantial impact on energy consumption. On the other hand, even though these end uses are nevertheless attributed to the building sector, building design has no impact on how much energy is used in cooking or by appliances (UN, 2008).The capacity to almost entirely utilize the energy used is known as energy efficiency. Protecting the environment will ensure that civilization continues to grow sustainably, according to policymakers (EIA, 2022). Additionally, it covers a broad range of designs, industrial behaviors, and inventions in addition to policies and products. It also offers applications that are pertinent to the majority of industries in a growing economy. As a result, it can provide answers to various policy signals and enable a financing strategy to accomplish energy savings.

The IEA predicts that by the year 2022, concerns about energy security worldwide and the inflationary effects of higher energy prices on the global economy have substantially increased as a result of the energy crisis brought on by the Russian Federation's invasion of Ukraine. Since the start of the crisis, efforts to reduce energy use and better manage it have been a top priority. As a result, improvements in energy efficiency are expected to increase by about 2% in the coming years (IEA, 2022).

1.2 Statement of Problem

The issue of excessive energy use in buildings has come to the forefront of international discussion thanks to sustainable development and its wider linkages to the environment. Numerous studies (Perez-Lombard, 2008; Brown, 2010; Mu'azu, 2012) show that a disproportionate fraction of the world's total energy use is attributed to the built environment.

Up to 48% and 76% of the energy and power used in the US are accounted for by structures, respectively (Sector, 2010). Global warming is significantly exacerbated by the construction industry. Furthermore, studies show that a considerable share of the energy consumed by buildings in several countries, including the United States, Hong Kong, the United Kingdom, and China, is accounted for by commercial buildings, (Mu'azu, 2012). Consequently, it is more essential than ever.

1.3 Aim and Objectives of the Study

The aim of this project is to design an energy efficient vocational building by exploring how energy efficiency principles can be used for energy efficiency in the proposed vocational center in Oyo state.

By fulfilling this aim, the objectives of this study are;

1. To evaluate the energy efficiency in previous vocational buildings.

2. To investigate the consequences of non-energy efficiency in vocational centers.

3. To design a vocational center that is energy efficient.

1.4 Research Questions

This research intends to answer the following questions;

i. Why vocational study centers should be energy efficient.

ii. How should vocational study centers be made energy efficient.

iii. Why vocational study centers are not energy efficient.

1.5 Significance of the Study

The promotion of energy efficiency is one of the Sustainable Development Goals (SDG) that will be helped by this study. It will give architects specialized knowledge and serve as a helpful resource as they embrace architectural design features for the construction of energy-efficient vocational study center. This will assist decision makers in the construction of public buildings, not just vocational study centers, and including architectural design aspects with regards to energy efficiency.

It will also provide skills for the youths in the village because most of the youths are not literate.

1.6 Scope of the Study

This research shall focus on vocational building types, vocational (courses) offered in a vocational study center as well as spaces in a vocational study center. It will also focus on energy efficiency principles and how these principles can be incorporated into the proposed vocational study center design and also to come up with a good design of a vocational study center that will promote energy efficiency.

1.7 Operational Definition of Terms

1. **Invigoration**: the act or process of making something stronger, more exciting, or successful; We need to put more invigoration and enthusiasm into the organization.

2. **Energy:** power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines.

3. **Energy Efficiency:** the process of reducing the amount of energy required to provide products and services. For example, insulating a building allows it to use less heating and cooling energy to achieve and maintain a thermal comfort.

4. **Energy Efficiency Principles:** taking utmost account of cost-efficient energy efficiency measures in shaping energy policy and making relevant investment decisions.

5. **Vocation:** a particular occupation, business, or profession.

6. **Vocational Study Center:** a facility for the instruction of specific skills, which meets the state and/or federal requirements to be accredited.

Chapter Two

Literature Review

2.1 Conceptual and Theoretical Review

The definition of the term "energy efficient building" is highlighted in this chapter, along with a thorough analysis of the literature that further explains the idea of energy-efficient architectural design principles. This chapter examines and digs into earlier investigations made by numerous other researchers in this field of study, as well as some of the existing volumes of literature, to determine precisely how the studies were managed conceptually and philosophically.

2.1.1 Historical Development of Energy Efficiency

One strategy to stop, manage, and reduce the accelerated growth in excessive energy usage is to increase energy efficiency. When the quantity of work completed is greater than the usual amount of energy used, we refer to something as being energy efficient. It is essential to reduce the energy required to maintain a specific level of occupant luxury, air quality, and other requirements in order to increase a building's efficiency (International Energy Agency IEA, 2015).

Homes and construction techniques are just one illustration of how mankind has been able to harness and alter natural processes to enhance and improve the general quality of life since the dawn of time. Even though the word "energy efficiency" was less persuasive than it is today, people were already developing and spreading good practice guidelines before the 20th century. As a result, preliminary tests had a significant impact on how techniques were employed to build a house. This approach was effective at the time for maintaining and improving specific building and construction practices. Fascinatingly, while every historical era has brought about fresh innovation and expanded upon those that had existed, the renewable energy technologies in use today have links to old historical thoughts and undertakings (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015). According to historical evidence, people in the Carpathian region started partially sinking their homes around 5500 BCE in order to maintain a more comfortable and pleasant temperature inside the structure (Constantin et al., 2015).

Formerly, Native Americans, Essene communities in the Middle East, and Cappadocian people used the heat transfer qualities of the ground and dirt for their comfort and ease through both extremely cold and hot weather conditions. The Persians' "badghir" (wind tower) harnessed both wind and subterranean energy in carefully planned circuits to maintain the comfort of the building's occupants (A'zami, 2005). The "malqaf" (wind catchers) were similarly employed by the Egyptians to harness wind power (Constantin et al., 2015).

Smart building concepts have been developing since 1980, when a few newly constructed buildings began gradually integrating the control of various devices and systems.

When construction mechanization systems were first developed, they could only operate one machine at a time, but as time went on, they became more sophisticated and could operate multiple machines at once. Today, a single AI system is capable of monitoring and controlling electrical, HVAC/EC, and security operations. Using wireless devices and the internet, new technologies offer remote monitoring and administration. Wang (2010) claims that the intelligent building era has gone through four distinct stages, beginning in the 1980s with integrated single function/dedicated systems made to handle just one specific task, continuing through the 1990s with more integrated multi-function networks, and entering the current era with computer integrated and controlled buildings and enterprise network integrated systems (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015).

2.1.2 Concepts of Energy Efficient Buildings Design

If energy efficiency is improved, it is reasonable to control and lower the rise in energy demand. When something produces more with the same amount of energy input or keeps the same output while using less energy, it is said to be energy efficient. Lowering the amount of energy required to meet a building's occupants' needs for lighting, ventilation, and climate control may improve the building's efficiency (International Energy Agency IEA, 2015). Throughout the start of human history, humans have been able to improve the quality of their lives by utilizing and adapting natural techniques to produce more comfortable living conditions, such as the planning and construction of homes. Although the word "energy efficiency" was not as common as it is now, best practices laws were already being created and put into place before the 20th century. This meant that the method used to build a house was refined over time based on experience. This tactic served its purpose at the time for sustaining and improving specific building practices. It is remarkable to consider that the current renewable energy technologies have historical precursors, despite the clear reality that each new period has brought fresh discoveries and improvements to older systems (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015). Evidence suggests that humans began partially burying their homes in the Carpathian region around 5500 BCE in order to keep a more constant internal temperature (Constantin et al., 2015).

Subsequently, Native Americans, Cappadocian people, and Essene groups in the Middle East built their homes to take advantage of the earth's thermal properties. By harnessing wind and soil energy in precisely planned circuits to maintain ideal interior temperatures, the Persian "badghir" (Wind tower) advanced these concepts (A'zami, 2005). Similar to how Americans capture energy from the wind, Egyptians utilize "malqaf" (wind catchers) (Constantin et al., 2015).

The idea of the intelligent building has been developed since the 1980s, when a small number of buildings began to gradually integrate the administration of various equipment and systems. Initially, a single unit could only be controlled by building automation systems. But as technology grew, these systems evolved to be able to run multiple machines at once. Security, HVAC/EC, and power are just a few of the utilities that may now be controlled and monitored by a single system. Technology advancements have made it possible to use the internet and wireless devices for remote monitoring and management. Wang (2010) distinguishes four distinct epochs in the development of intelligent buildings, starting in the 1980s with integrated single function/dedicated systems, moving through the 1990s with integrated multifunction systems, and ending in the present with computer-integrated systems. (Constantin, Tudor, Gabriela-Elena, Horia, & Adrian, 2015).

2.1.3 Principle and Application Of Energy Efficiency

The energy efficiency of a building as a whole is influenced by site analysis, site planning, building form, building plan, appropriate space organization, building envelope design, material choice, site landscaping, and the use of renewable energy. These essential concepts are further explained in this section.

2.1.3.1 Site Selection

Three crucial design factors are hemisphere, slope, and aspect. A building's placement affects its microclimate, which in turn affects how efficiently it uses energy. A structure's cost of heating and cooling will depend on things like solar exposure, air temperature, air movement, and humidity (Zeybek, 2009). The many micro-climates that could develop depending on the slope direction are shown in Figure 1a. The west side of the mountain has the warmest winters and hottest summers in terms of temperature. While the North Slope is the most peaceful and shady area, the top is the windiest. Because cold air rushes down and settles there, low places are frequently colder than slopes (Lechner, 1991; Izzet and Tülay, 2019). The optimal location for a building in a hilly area is on a slope, though this varies depending on the time of year and the type of structure being erected.

Sites like those in Figure 2.1 would be perfect for envelope-dominated structures like homes and institutions due to the climate.because, cold air drains into low places and gathers there, low areas are often cooler than slopes (Lechner, 1991; Izzet and Tülay, 2019).

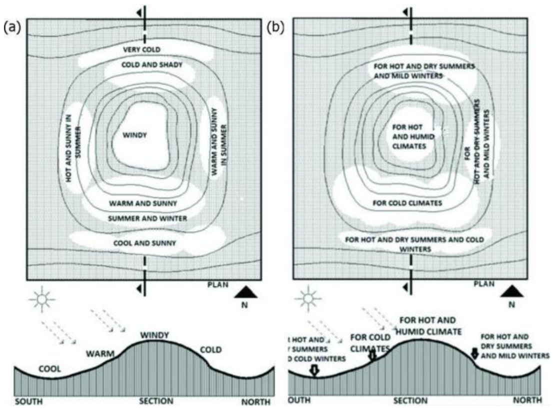


Figure 2.1 suitable land for settlement according to the different climate zones[12]. (a) Microclimate around a hill; and (b)preferred building sites around a hill in response to climate for envelope-dominated buildings
Source: (Lechner, 1991)

Depending on the weather and the type of project, certain sides of a hill could be better for construction.Sites like those in Figure 2.1b would be suitable for envelope-dominated buildings like institutional buildings because to the favorable weather conditions.

2.1.3.2 Site Planning

How much natural light can be used within a building and how well artificial breezes can be captured depends on the distance between buildings. The building's surrounds should be taken into account alongside the structure itself throughout the design process. How well buildings perform in terms of energy usage during actual use depends on the distance between them. A building's exposure to solar radiation is reduced when it is in the shade of surrounding structures, but its energy needs are increased.

The height of a building must be higher than the highest structure that can provide shade nearby in order to benefit from the sun's beams. In addition, a building's energy efficiency is impacted by the position and orientation of nearby structures (Izzet & Tülay, 2019). The ratio of solar radiation absorbed by a building's sides determines how much solar radiation is absorbed overall. The direction of the wind has an impact on a building's natural ventilation, convection heat loss, and air shortage. In order to protect themselves from or benefit from the sun and wind, depending on the local conditions, constructions must be oriented (Izzet & Tülay, 2019).

2.1.3.3 Building Form

The geometrical features of a building's design, such as its height, plan length-to-depth ratio, roof type, roof gradient, front gradient, and bossages, all affect how much heat is gained or lost from it. Depending on the surface area to volume ratio of its surroundings, a structure's heat loss-gain may go up or down (Izzet & Tülay, 01 July 2019). The energy performance of the structure is influenced by its volume, surface rate, and frontal movements. The shape of a structure affects its ability to use energy efficiently.

Researchers found that masses with the same volume but different shapes performed energetically quite differently (Soysal & Konut, 2008). The masses had allegedly different shapes, but their overall surface areas were similar in size.

On the cube's outside, the number 100 served as a guide (Figure 2.2). In regions with erratic weather patterns, a building's form is crucial. In colder climates, compact designs with less heat loss are favored. In hot, dry summer climes, compact shapes and courtyards may reduce heat gain while providing adequate shade and cooling for residents. Long, thin designs with their long axis aligned with the direction of the wind are most effective in hot, humid climate zones. The optimum cross-ventilation is provided by the prevailing breeze. For mild climates, compact, more adaptable types are suitable.

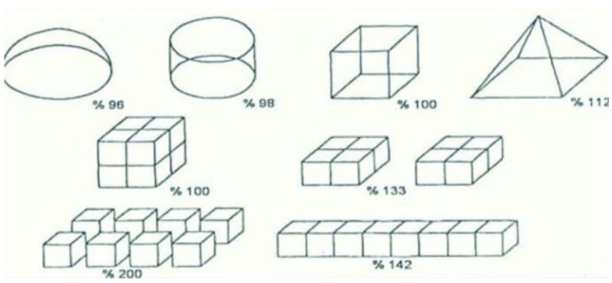


Figure 2.2 Building form-surface relationship
Source: (Soysal & Konut, 2008)

2.1.3.4 Building Plan and Appropriate Space Organization

Energy efficiency should be considered while choosing a building's layout and geometry. In order to gather as much heat as possible during the winter and as little heat as possible during the summer, buildings should be constructed. Since they have a lower surface area than more complex floor designs, squares and rectangles retain and radiate heat more slowly. According to Yüksek & Esin's 2013 study on the energy efficiency of traditional rural homes in Turkey, smaller homes require less energy overall for lighting, heating, and cooling.

A building's interior design can affect how much energy it uses. If solar heating is optimized, it might reduce the amount of heating energy used. In contrast, private areas like the pantry, bathroom, and toilet might act as heat-insulating buffer zones. For instance, sun chambers facing south may store solar radiation for use in heating the structure later (Yüksek & Esin, Study of traditional rural dwellings in Turkey in terms of energy efficiency, 2013).

Zoning can be accomplished by classifying building designs according to factors like the buffer zone, sanitary spaces, noise level, lighting level, and heating requirement. Thus facing south is the best option for areas that are frequently visited all day.

2.1.3.5 Building Envelope

The walls, floors, roof, and windows/doors that enclose or expose conditioned space to the outside make up the building envelope. It considerably reduces energy use as an indoor and outdoor reagent (Ylmaz & Akll, 2005). Building envelopes only contribute 15 – 40% of the building's overall cost, but they account for about 60% of life cycle expenses, particularly energy costs (Izzet & Tülay, 01 July 2019). In order to control the flow of air, heat, cold, and light between the inside and outside of a building, the skin of the structure serves as a filter (Izzet & Tülay, 01 July 2019). The building envelope's summer and winter heat gain and loss should be kept to a minimum.

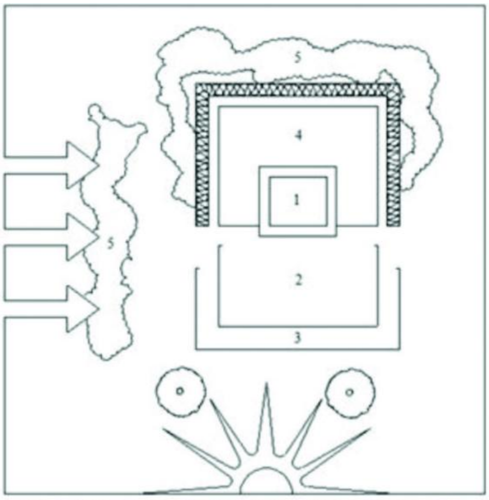


Figure 2.3 Spatial Zoning
Source: (Izzet & Tulay, 01 July 2019)

2.1.3.6 Energy-Efficient Landscape Design

By creating an energy-efficient landscape, it is possible to save heating and cooling costs for the summer and winter by up to 30%. Vapor transmission is how outdoor and grass flooring produce a cooling effect. Asphalt is one material that continues to expand heat after the sun goes down, increasing nighttime radiations. Materials like this one retain heat in their bodies. Using materials that retain heat and reflect light sparingly and protecting buildings from direct sunlight are among steps that can be taken to reduce cooling expenses (Izzet & Tülay, 01 July 2019).

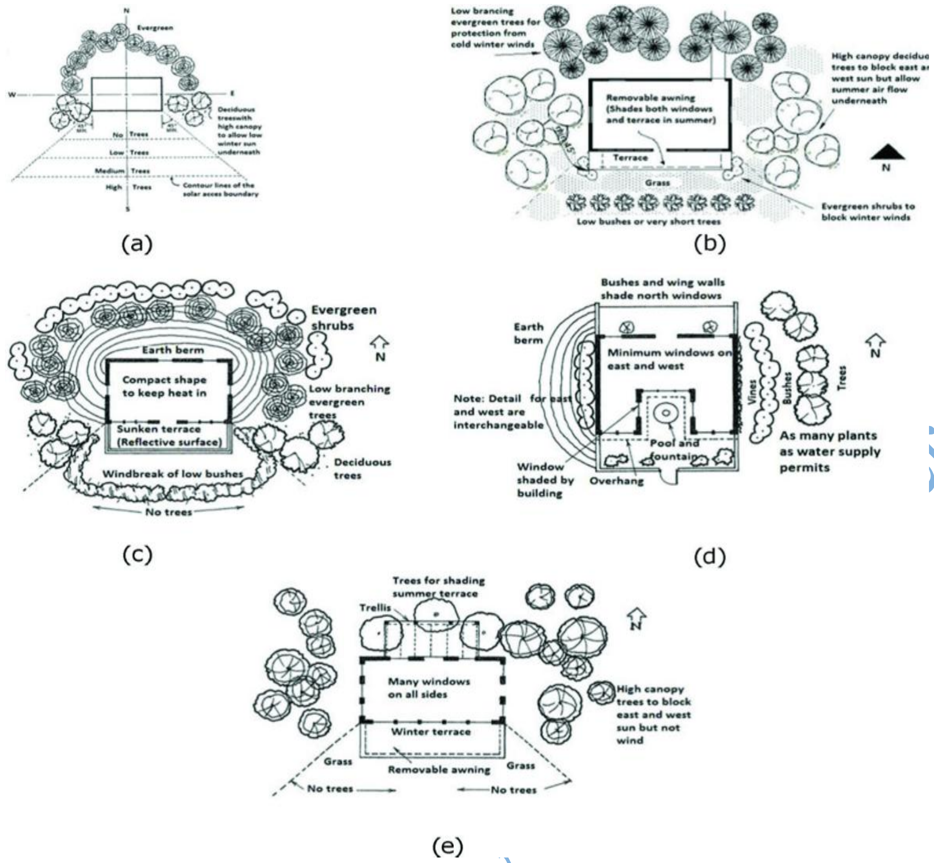


Figure 2.4: landscape design strategies for four climatic zones(cold, hot, dry and humid. (a) landscaping practices for a milder climate, (b) the standard tree-planting logic for most countries. For example, (c) landscaping strategies for very cold regions, (d) landscaping techniques for hot and dry climates, and (e) landscaping techniques for hot and humid climates.

Source: (Izzet and Tulay, 01 July 2019)

Each region has its own energy-saving landscaping techniques. Figure 2.4 shows a variety of landscaping techniques arranged by location and importance.

2.1.3.9 Usage Renewable Energy Resource

All life on Earth may benefit from the constant replenishment provided by renewable energy sources like the sun, wind, biomass, biogas, geothermal energy, hydroelectricity, wood, ocean thermal energy, ebb and flow, waves, and sea currents. The benefits of renewable energy sources can be attained through the use of passive and active strategies.

How to harvest renewable energy sources passively:

Unassisted or subsidized heating: Depending on how the solar array is connected to the building, passive solar heating systems can be categorized. According to Izzet & Tülay (01 July 2019), there are three categories for passive solar heating systems: direct gain, indirect gain, and isolated gain. As the name suggests, passive solar heating includes using the sun's rays to warm a building's interior.

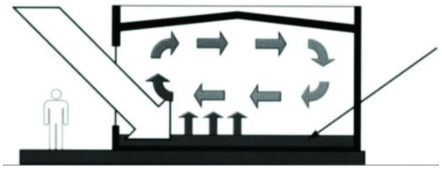


Figure 2.5: Direct gain schematic
Source: (Izzet and Tulay, 01 July 2019)

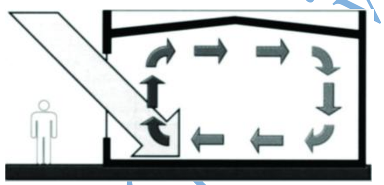


Figure 2.6: Direct gain plus storage schematic
Source: (Izzet and Tulay, 01 July 2019)

Winter light enters the living space through windows in passive solar constructions with direct gain systems. These solar gains can be used right away to support the building's heating system or can be stored as thermal mass for later use.

The following characteristics are typical of direct gain structures:

1. To let in the winter light, this area needs lots of windows that face south in the northern hemisphere.
2. Making use of thermal mass within the insulating envelope to lessen temperature changes.
3. If the overhang above the south window is strategically placed, the glass can receive winter sun at a lower angle while being protected from the sun's rays in the summer.

4. Reduced heat loss during night

Natural light can enter a direct gain construction through windows. These energies are absorbed by massive interior surfaces and released as heat (often concrete floors and brick walls). Instantaneously, some of the surface heat is returned to the space. The thermal mass progressively warms up from the remaining heat, as seen in the Figures, and at night, the heated mass is released back into the interior.

Systems with indirect gain: The heat storage for an indirect gain passive solar system is located between the interior and exterior surfaces. Figure 2f and 2g (Izzet & Tülay, 2019) illustrates how buildings may absorb and store heat in an exterior wall or on the roof (with water or brick/concrete), then release that heat into the interior.

Separated gain systems: In a passive solar design with separated gain, the solar gathering and storage are meant to prevent heat transfer from the outside to the inside of a building. A sunspace is employed in the majority of isolated gain systems. The spaces used for gathering and storing things are not thermally connected to the real living spaces. A sunspace is defined in Figure 2h and 2i (Izzet & Tülay, 2019) as "a room next to or connected with the outside of a building in which the room temperature may rise and fall beyond the thermal comfort zone."

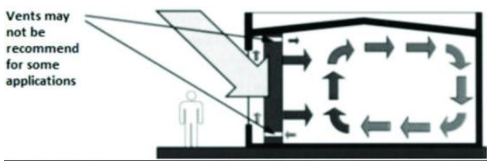


Figure 2.7: Indirect gain schematic.
Source: (Izzet & Tulay, 01 July 2019)

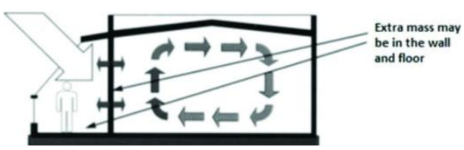


Figure 2.8: Sunspace schematic.
Source: (Izzet & Tulay, 01 July 2019)

There are several types of passive solar heating, each appropriate for a particular purpose. On the other hand, passive cooling makes more sense when viewed as a collection of disciplines that look into fundamental heat sinks. Although this structure is advantageous to researchers and innovators, designers and policymakers may find it difficult to use because many real-world systems require more than one heat sink (Izzet & Tülay, 2019).

But first, let's define what we mean by passive cooling.

Warm indoor air is expelled and replaced with cooler external air to create this ventilation cooling effect. By flowing air over them, convection and evaporation cool people's bodies. In passive applications, the necessary airflow is typically provided by wind or the stack effect. Fans may aid in movement in hybrid applications, as seen in Figures 2.9-2.11 from (Izzet & Tülay, 2019).

All interior objects are ideal for use in passive cooling systems since they all emit and absorb varying amounts of radiant radiation. If the net flow is directed outside the structure, radiation may chill objects inside the structure. In comparison to a clear night sky, a structure emits a significant amount more long-wave infrared radiation. As a result, there is a net outflow into space, as shown in Figure 2.9 (Izzet & Tülay, 2019).

By using water features like fountains, cascades, or ponds, evaporative cooling can be used to lower the temperature inside buildings. The air becomes cooler as a result of heat being lost as water evaporates. Evaporation is the process through which water absorbs sensible heat from its environment and releases it as water vapour.

The temperature decreases when sensible heat turns into latent heat. There are two methods for utilizing this phenomenon to cool indoor spaces. The air will be cooled and humidified if the water evaporates inside the building or at the fresh air intake. Direct evaporative cooling is the term for this strategy.

The method is known as indirect evaporative cooling if, on the other hand, the building's or its interior air is cooled by evaporation without being humidified, as shown in Figure 2.11. (Izzet and Tülay, July 1, 2019).

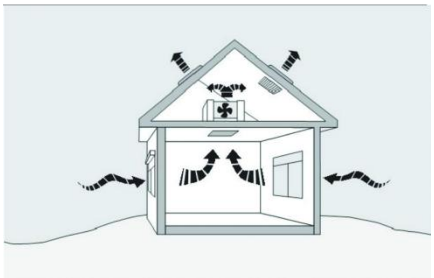


Figure 2.9: Air flow circulation model.
Source: google

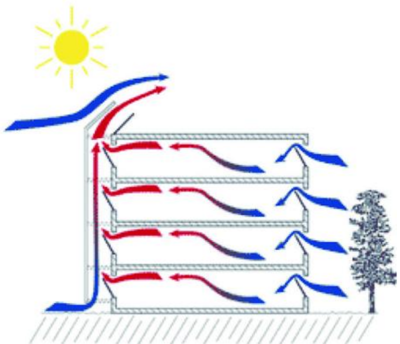


Figure 2.10:(a)direct evaporation, (b)indirect evaporation.
Source: (Izzet & Tulay, 01 July, 2019)

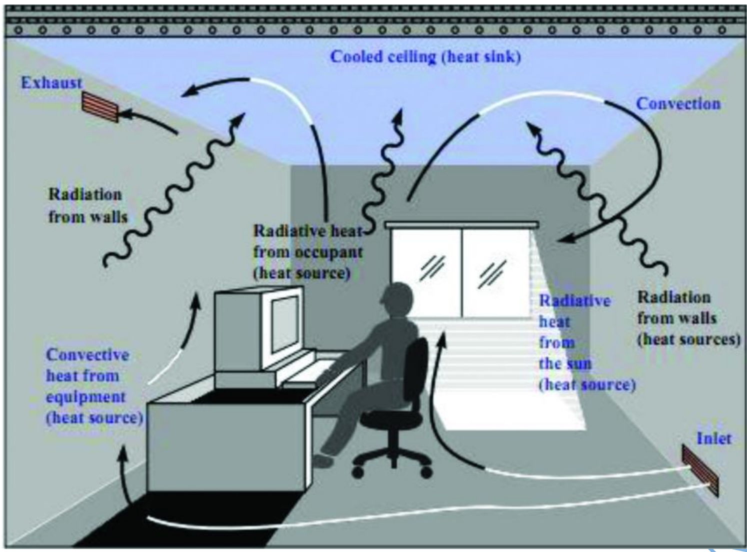


Figure 2.11: indirect evaporative cooling.
Source: (Izzet & Tulay, 01 July, 2019)

Dehumidification is the process of reducing the relative humidity of an interior environment by reducing the amount of water vapor in the air by condensation, evaporation, or ventilation. Desiccation and condensation are adiabatic heating processes because they involve the exchange of latent heat in the air for the sensible heat of water droplets on surfaces (Izzet & Tülay, 01 July 2019).

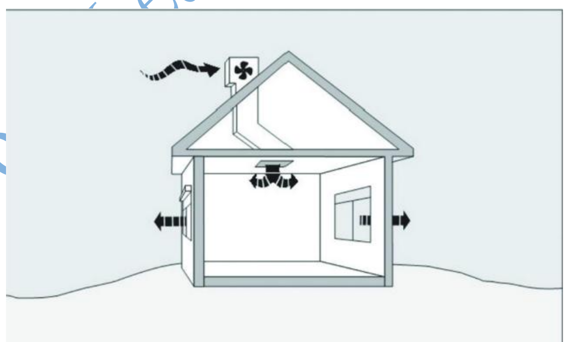


Figure 2.12: indirect flushing.
Source: (Izzet & Tulay, 01 July, 2019)

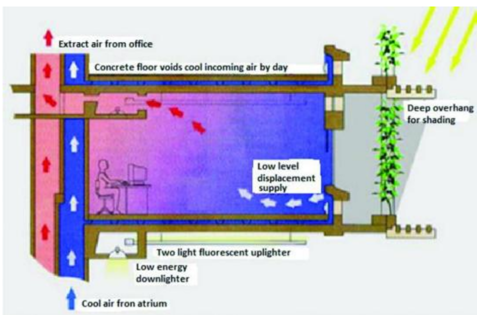


Figure 2.13: Flushing method of daily-cycle mass-effect cooling.
Source: (Izzet & Tulay, 01 July, 2019)

Mass Effect Cooling: "Mass effect cooling" is the practice of using thermal storage to remove heat from a particular area during the hottest part of a cyclical temperature cycle and then release it when temperatures decline. Figure 2.13 shows the night flushing method of daily-cycle mass-effect cooling, which involves pumping cold night air through a structure to release heat that has been trapped inside its massive floors and walls all day. (Izzet and Tülay, July 1, 2019).

2.2 Definition of a Vocational Center

A vocational center or trade school is a learning institution that provides people with career-focused education and training that is centered on a specific area of interest. (George S. 2010)

2.2.1 Design Considerations for Vocational Center Buildings

The list of acceptable design aims as indicated below is part of the Whole Building Design Guide (2010), which looked into detail about the common traits of vocational center buildings.

2.2.1.1 Cost-Effective

Life saved is a gauge of the worth of a high-performing educational institution. In order to save money on operations and maintenance in the long run, owners may need to be willing to spend greater sums up front to maximize a building's performance. Value engineers evaluate several design alternatives during the design stage of a building's development to enhance the projects' expected cost/worth ratio. Contractors are encouraged to apply their specialized "know-how" to suggest changes to the construction process that lower costs while retaining or improving quality, value, or functional performance through shared savings.

2.2.1.2 Functional/Operational

Tenant Requirements

The layout of the building must take into account the needs of each individual. Organizational and group size, growth potential, the consistency of the need over the long term, group assembly needs, electronic equipment and technology requirements, acoustical requirements, special floor loading and filing/storage requirements, specialized utility services, and desired public image are all things to take into account. Logistics, including the need for loading, filing, and storage; utility services; operational process flows for material handling; health considerations; the need for and means of transportation; and financial goals.

Flexibility

- A successful vocational center should be adaptable enough to take on new design plans and color schemes. When management is reorganized, student enrollment rises, project models are modified, or new technology is introduced, infrastructure, interior systems, and student furnishings must adjust.
- Consideration should be given to raised flooring that makes it simple to access wiring and power distribution, as well as increased air distribution capabilities to accommodate individual occupant comfort.
- Conference hubs, modular and controlled wiring and buses, and plug-and-play floor boxes for power, data, phone, and fiber are a few things that ought to be present.

2.3 Architectural Design Elements

The fundamental building blocks of every design or artistic expression are known as elements. The principles and components of universal design help to define the creative process. Users are better able to design a well-rounded and alluring experience when they are aware of these elements. Whether they operate on the inside or outside of a structure, architects, designers, compositors, and creative artists all use architectural design elements. When used properly, they can aid artists in bringing their ideas to life through their creations. Similar to how crucial environmental factors are necessary for human survival, certain unavoidable characteristics must be present in order to construct an effective and imaginative architecture design. The following components are necessary to achieve design harmony through painstaking attention to detail.

2.3.1 Color

In design, the choice and application of color schemes are of vital importance. By carefully selecting color schemes, it is possible to design interiors and constructions that are visually beautiful. The representation of day and night, light and dark, intensity and force are all possible with the help of this design element. This design element consists of color selections, color wheels, and color palettes. Unfortunately, a poor layout cannot be fixed by adding color.

Radiant energy is reflected away from the inside of a house with white siding, a white roof, and/or reflective coatings. Grey, even in the lightest shade, is favored to blue or green. Hence, adopting vibrant colors and reflecting surfaces could reduce the cost of air conditioning.

2.3.2 Light

Similar to color, light is a crucial component in the design of both indoor and outdoor spaces. Lighting, whether produced artificially or naturally, can be used for aesthetic purposes. By just changing the lighting and compositions in which they are used, many design components may be changed. Location of the door and window imitate natural illumination. Your compositions will produce spectacular results for your audience if you only use natural light.

While making plans for energy-efficient indoor and outdoor lighting, improving illumination quality and efficiency is a major goal. Lighting should be included into the overall design of a new home.

Take a look at some essential design principles and techniques for creating interior lighting that uses less energy.

Energy-efficient lighting design guidelines include the following:

• Use natural light as much as possible.

• Keep in mind that amount of light is not always as preferable to quality of light.

• When installing task lighting, make sure to reduce ambient lighting in other areas and match the amount and quality of light to the task at hand.

• Use energy-saving lighting fixtures, controls, and systems (such as timers, occupancy sensors, and linked home software) (i.e., timers, occupancy sensors and connected home apps).

Here are some fundamental methods for creating low-energy indoor lighting:

• Utilize light fixtures and bulbs that have earned the ENERGY STAR® label.

• Consider installing ENERGY STAR-certified LED fixtures in place of fluorescent or LED replacement bulbs in all frequently used ceiling and wall-mounted lights, particularly those that will be on for longer than 2 hours each day, such as those in the kitchen and living room, bathroom, corridor, and other high-use areas.

• Replace all portable lighting fixtures with LEDs.

• Make use of timers, occupancy sensors, or networked home technology to have the lights turn on and off automatically as needed.

- To lessen the need for artificial lighting, think about selecting wall surfaces with lighter tones.
- When installing recessed lighting in a ceiling with an unconditioned space above it, use only Underwriters Laboratories (UL)-approved, airtight, IC (insulation contact)-rated, and ASTM E283-compliant fixtures to decrease the need for artificial illumination.

2.3.3 Material

With the advancement of manufacturing techniques, the variety of building materials utilized in construction has risen. Architecture designs have changed as well, making use of novel materials and compositions and occasionally straining their limits.

In order to reduce greenhouse gas emissions and save money, architects and engineers must select low embodied energy materials. Construction material's total energy consumption throughout extraction, processing, production, transportation, and management is referred to as embodied energy.

Fly ash bricks, fiber-reinforced bricks, wood, stabilized adobe blocks, and cement-replacement materials like silica fume, slag, and fly ash by-products of industries are some examples of construction materials with low embodied energy. In many parts of the world, including the Middle East, Europe, the United States, the United Kingdom, and India, contractors are increasingly using these materials. The embodied energy of common building materials is shown in Table 1.

Table 2.1: Embodied Primary Energy of Building Materials

Construction material	Primary energy input, MJ/kg	Ranking
Fly ash, volcanic ash, sand, aggregate, adobe, soil	>0.5	Low energy
Timber (sawn)	0.1–5	Medium energy
Sand-lime brick	0.8–1.2	
Precast	1.5–8	
Blocks	0.8–3.5	
In situ concrete	0.8–1.5	
Gypsum plaster	1–4	
Clay bricks and tiles	2–7	
Lime	3–5	
Plasterboard	8–10	High energy
Cement	5–8	

Glass	12–25	
Lead, zinc	25+	
Steel	20–60	
Stainless steel	100	Very high energy
Copper	100+	
Plastics	50–100	
Aluminum	200–250	

2.3.4 Shape/Form

When creating a framework, the shape is equally crucial to creativity and insight. There are many different types of shapes, such as geometric, abstract, and organic. The shape that the element is given during use or manufacturing determines how it behaves. The two-dimensional and three-dimensional forms are both respectable substitutes. By using a range of shapes for different structures or the same shapes for multiple related items, users can use shapes to educate and deepen the design.

The emotion an observer has as a result of a construction solution is one of its "initial" consequences. To get the intended result, the architect may employ his or her understanding of how various shapes and forms affect people.

2.3.5 Mass

In architectural practice, a design solution's three-dimensionality is referred to as its volume. In this case, the element symbolizes the blocky, geometric design of the overall form. Every building project starts with a block, a sketch, or a sculptural form. Mass is the name for this fundamental form. A building's massing significantly affects how it looks and how people react to a design solution.

2.3.6 Texture

An object's aesthetic appeal can be altered by changing the texture of its exterior. Visually and physically are the two ways that architectural texture can be experienced. When describing something, the word "texture" includes terms like "smoothness," "roughness," "softness," etc.

When designing a structure, architects must take texture into account since it affects the viewer's first impression. The density of the texture can be changed to provide a variety of effects. A variety of emotional responses, such as warmth and connection, may be elicited by going from a smooth to a rough surface.

The hardness and heat retention of the material are correlated with texture. Smooth surfaces, despite seeming chilly, frequently feel uncomfortable to hold because of their poor heat retention. Rough surfaces may trap heat in the logical extreme, producing an uncomfortable yet opposing sensation. Although rougher textures may be viewed as softer, smooth textures are invariably seen as being more rigid (even though they may be harder than smooth textures.).

2.4 Energy Efficient Buildings

According to Geissler et al. (2018), the threat of climate change and the rapidly rising metropolitan temperatures have increased demand for energy-efficient buildings more than before. Gosztonyi claims that further repercussions of climate change include uncomfortable and hot interior conditions (2010). This is because more solar radiation is penetrating buildings through gaps in their walls, roofs, and construction materials.

Residents of a structure should have access to two amenities: thermal comfort and visual comfort. This supports El-Darwish and Gomaa's (2017) claim that building experts are better able to ensure that energy is used efficiently to give occupants a level of thermal and visual comfort that is acceptable given climate change and related challenges about energy consumption in buildings.

2.4.1 Energy Efficiency Design Strategies In Vocational Center Buildings

The results show that a variety of technologies are available that enable energy-efficient structures. Buildings that are energy-efficient use less energy for basic tasks like lighting, heating, and cooling since these features were considered during construction. Energy-efficient design concepts may be included into new construction or existing structures throughout the planning stages of a project. Day and Gunderson (2015) claim that the popularity of energy-efficient design solutions for buildings in general, and vocational center buildings in particular, has increased as a result of building laws and corporate policies that prioritize environmental preservation.

Nwofe asserts that an energy-efficient structure would require less electricity to cool and illuminate its interior while maintaining the occupants' security and comfort. The aforementioned techniques may specifically assure that buildings use less energy while offering significantly improved thermal and visual comfort to their occupants. Table 2 provides a summary of the various techniques as a result.

Table 2.2: Energy efficient design strategies

S/N	Energy Efficiency Design Strategies	Description
1	Building skin	The physical separator between the conditioned and unconditioned environment of a building
2	Shape of Building	Configuration of a building
3	Building Form	The point of contact between mass and space
4	Building orientation	Position of building relating it to sun and wind direction.
5	Specification of Energy Efficient Building Materials	Materials that takes less energy
6	Building Plan and Appropriate Space	Space plan will also define the circulation patterns that show how

Organization	people will move through the space.

Chapter Three

Research Methodology

3.1 Research Design

The strategy utilized to evaluate the methodologies employed as information sources is covered in this section, along with a study of the suggested building type based on the literature review.

The research includes an examination of the fundamentals of architectural design for a vocational school's energy efficiency.

Exploring architectural design principles for energy efficiency in vocational centers is the aim of this study. Since the goal of the study is to analyze a region's peculiarities, the explorative method was chosen for the investigation. The intricacy of the subject and the difficulties of quantifying perception make it evident that this study is qualitative in nature. Before trying to quantify it and its underlying causes, it is crucial to understand what makes a vocational center an energy efficient building.

3.2 Case Study Method

A case is an isolated event in time and space (Johansson, 2003). According to Veal (2006), a case study can be both a research methodology and an analytical unit because it evaluates special instances (cases) of the subject under investigation. Case studies serve the objective of providing an in-depth account of a complex instance and examining the instance in relation to its environment (the United States General Accounting Office, 1990). In order to collect information on a small number of occurrences that satisfy some of the topic's distinctive characteristics, this study will employ an empirical methodology. These conclusions are supported by a detailed investigation of both published and grey literature based on mixed qualitative case study data. Based on the characteristics of social interaction, we analyze it in this case study.

3.2.1 Case Studies Selection Criteria

Schon (1991) asserts that architectural processes rely on a knowledge repertoire of conditions drawn from first-hand experience or well-established precedents. According to Veal's (2006) research, choosing examples for a case study is similar to sampling in quantitative research because both circumstances involved carefully choosing the instances. In light of these research, Oluigbo (2010) proposed that identifying instances requires having certain inherent traits that are relevant to the topic at hand.

The case studies that would form the basis of my thesis were chosen with great care.

- As a structure that has undergone a sufficient investigation of the range of facilities needed to enable it to function as a vocational center.
- As a building which has implemented the principles of energy efficiency techniques.

3.3 Data Collection

The utilization of standard data collection methodologies may be required for case studies for theoretical architecture study (Oluigbo, 2010). In addition to observation and participant observation, visual surveys and checklists, questionnaires, interviews, models and simulations, and scientific measuring instruments are some of these tools. For the purpose of this study, visual survey interview, questionnaire, and checklist analysis based on the evaluation of the degree of successful location for social interaction on the chosen case studies were utilized.

3.3.1 Instrument of Data Collection

Many data gathering sources will be used as part of the case study technique in order to fully account for the complexity of situations (Yin, 2003; Veal, 2006; Johansson, 2003). The Visual Survey employed here may be portrayed in several ways, depending on the nature of the study at hand. Images of significant case studies to assess the effectiveness of energy-efficient office construction strategies. Furthermore, stated were several case study components. These examples help us understand how various case studies use space. A field form will also be used to specify the variables of design elements that are taken into account in architecture in relation to different types of public buildings. It will also be recorded whether there are any other amenities present and what kind of amenities they are.

3.3.2 Procedure for Data Collection

We looked at vocational centers in our region and around the world to acquire this data, noting the aesthetic characteristics of the buildings and sketching their floor layouts. Based on descriptive accounts of what was observed and recorded using data collection techniques, the analysis of the data obtained through visual survey and observation is conducted. Three main topics were discussed in this description;

1. Site planning and landscaping
2. Building envelope and material types
3. Building form and shapes

3.4 Operationalization Of Variables

In light of the literature review highlighting methodological approaches to case study investigations on vocational centers and energy efficiencies, it is clear that regardless of organizing framework, methodological, and philosophical differences, the approaches for designing an energy-efficient building typically comprise:

- Site Planning/Landscape.
- Building Shape/Form.
- Building Envelope.
- Energy Efficiency Material.
- Spatial Concept.

The aforementioned factors will be used in accordance with the methods for developing energy-efficient buildings.

1. Site planning and landscaping.
2. Building envelope and material types.
3. Building Orientation and Form.

3.5 Case Study Analysis

3.5.1 The Polytechnic Ibadan Vocational Skill And Entrepreneurship Study.

The Polytechnic Ibadan is one of Nigeria's oldest institutions of higher learning, established in 1970.

Situated in Ibadan, the capital city of Oyo State in southwestern Nigeria, the institution has played a crucial role in providing technical education and training to a diverse range of students. The study area, Ibadan, is the largest city in West Africa and the third-largest city in Africa in terms of landmass. With an estimated population of 3,847,472 in 2007, Ibadan serves as a prominent transit point between the coastal region and the areas to the north. The Polytechnic Ibadan is located in a strategic location within the city, with easy accessibility to various parts of the metropolitan area. This case study aims to provide a comprehensive analysis of the site where The Polytechnic Ibadan is located, taking into consideration its geographical features and the surrounding environment.

To begin the site analysis of The Polytechnic Ibadan, it is important to examine its geographical location within the city of Ibadan. The campus of The Polytechnic Ibadan covers a significant area, situated in the southeastern part of the city.

Figure 3.1: Exterior view of building.
Source: google search

3.5.1.1 Site Planning and Landscaping

The Polytechnic Ibadan is situated on a sprawling campus that covers a significant area. The site analysis considers factors such as topography, climate, and existing infrastructure. The campus is located on relatively flat land, allowing for efficient space utilization and construction. The campus layout takes advantage of the natural surroundings and optimizes the available space for academic and support facilities.

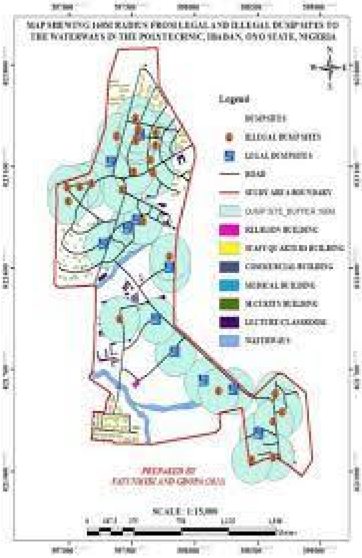


Figure 3.2: site plan.
Source: google search

3.5.1.2 Building Envelope and Material Types

The building envelope of the Vocational Center is the outer layer that separates the interior spaces from the external environment. It serves multiple purposes, including thermal insulation, moisture protection, soundproofing, and visual appeal. An effective building envelope design is essential to ensure a comfortable and sustainable learning environment. The selection of materials for thermal insulation is crucial in a tropical climate like Ibadan, Nigeria, where temperature control is vital. The building envelope of the Vocational Center does not incorporates insulation materials such as expanded polystyrene (EPS) or mineral wool to minimize heat transfer. This insulation helps maintain a stable interior temperature, reduces reliance on artificial cooling systems, and promotes energy efficiency. Considering the high humidity levels prevalent in Ibadan, moisture protection is a significant consideration in the building envelope design. The materials used for walls, roofs, and foundations should effectively prevent water infiltration, condensation, and related issues. Moisture-resistant materials, such as damp-proof membranes and waterproof coatings, are likely incorporated into the building envelope to safeguard the structure from water damage and maintain a healthy indoor environment.

Figure 3.3: Building Exterior.
Source: google search

3.5.1.3 Building Orientation and Form

The orientation of the building refers to its positioning in relation to the cardinal directions (north, south, east, and west). A well-considered orientation can harness natural elements such as sunlight and prevailing winds to enhance energy efficiency and occupant comfort.

Figure 3.4: view of building exterior and car park showing landscaping.
Source: google search

Other features include:

a. ***Solar Orientation***: The Vocational Skill and Entrepreneurship Study Centre is ideally oriented to take advantage of the sun's path throughout the day. By aligning the building's longest facades with the east-west axis, the design maximizes exposure to natural light and minimizes direct solar heat gain. This orientation helps to reduce the reliance on artificial lighting during daytime hours and promotes a bright and inviting learning environment.

b. ***Shading and Glazing***: To optimize energy efficiency and minimize solar heat gain, the building design incorporates appropriate shading devices such as overhangs, sunshades, or louvers on windows and glazed areas. These elements help to control the amount of direct sunlight entering the building, ensuring a comfortable indoor temperature and reducing the need for excessive air conditioning.

c. ***Efficient Floor Plan***: The form of the center's floor plan is carefully considered to maximize functionality and efficient space utilization. The layout may prioritize open and flexible spaces to accommodate various vocational training activities, classrooms, laboratories, and collaboration areas. The arrangement of rooms and departments ensures a logical flow and easy navigation for students and staff.

d. ***Aesthetic Appeal***: The architectural form of the Vocational Skill and Entrepreneurship Study Centre may showcase a contemporary design that blends functionality with visual aesthetics. The choice of materials, façade treatments, and building proportions can create a visually appealing structure that reflects the purpose and identity of the center.

f. ***Iconic Features***: Architectural forms can include iconic features or unique design elements that distinguish the Vocational Skill and Entrepreneurship Study Centre. These features may serve as landmarks, creating a sense of identity and pride within the institution and the surrounding community.

g. ***Sustainable Design***: The architectural form may integrate sustainable design principles, such as passive solar strategies and natural ventilation techniques. For example, the shape of the building could be optimized to capture prevailing winds, allowing for cross-ventilation and reducing the reliance on mechanical cooling systems. Green roofs or rooftop gardens may also be incorporated to enhance thermal insulation, mitigate heat island effects, and promote biodiversity.

3.5.1.4 Merits

- It is easily accessible.
- Spaces are well interrelated.
- Properly landscaped.
- Spaces are voluminous and adequately provided.
- Materials for building are standard.

3.5.1.5 Demerits

- The building is isolated from administrative environment into residential quarters.

Table 3.1: Checklist Assessment Criteria for Energy Efficient building

S/N	Variables	Checklist	Level of Application					Remarks
			1	2	3	4	5	
1.	**Building envelope**	Suitability of the materials to the climate			●			
		Use of external Insulation	●					
		Use of smooth surface Finishes		●				
		Use of light colors			●			
2.	**Natural lighting**	Wall to window ratio(40%)				●		
		Use of spectrally selected glass		●				
3.	**Natural ventilation**	Use of openable Windows				●		The use of openable casement windows,

4.	**Site and external spaces**	Use of interwoven Landscape			●		Fairly adequate Use of landscaping
		Use of impervious Surfaces		●			
5.	**Building form**	Large building surface Area			●		Fairly appropriate building form based on climate
6.	**Building orientation**	Sun orientation; E-W			●		The optimum orientation is NW-SE
		Wind orientation; SW-NE		●			
7.	**Wall/Window shading**	Use of horizontal and vertical shading devices		●			There is outdoor area for green area and presence of overhang
		Use of interior blinds		●			
		Use of recessed walls	●				
		Use of overhangs		●			
		Use of plants			●		
8.	**Existing energy source**	Use of PV cells		●			Fairly efficient lighting
		Use of natural gas				●	

3.5.2 Talent Builders Vocational Institute, Ibadan.

The talent builders institute is an affiliate of Obafemi Awolowo University. (OAU) and it was founded in the year 2014. They are also in charge of the Kola Daisi vocational studies. Talent builders was founded by Mr. Abolaji, who is the CEO of the institute. The spaces offered includes fashion, make-up studio, production room, director's room, reception, music production room, class room, reception, production manager's room, business development office and a store. The Talent Builders Vocational Institute is situated in Ibadan, Nigeria, a city with a rich historical background. The building itself is in some way reflective of the institutional goal, designed to be conducive for vocational training. Although it does not do a god job of representing it. It was constructed with the specific objective of fostering an environment that encourages both theoretical and practical learning in various vocational disciplines. The building encompasses classrooms, workshops, and specialized labs for specific vocational training areas. This design supports a hands-on approach, which is crucial in vocational training. The history of the building is intrinsically linked to the history of vocational education in Nigeria.

Figure 3.5: Building Exterior.
Source: google search

3.5.2.1 Site Planning and Landscaping

1. ***Location Selection***:

The selection of the institute's location appears to be inadequate. The specific site and building within Ibadan lacks proper research and analysis in terms of its suitability for a vocational institute. It may not be easily accessible to students and staff, resulting in transportation challenges and limited enrollment from potential students residing in other parts of the city.

2. ***Site Configuration and Utilization***:

The site configuration and utilization are poorly planned, leading to inefficiencies and inadequate space allocation. The limited area may restrict the institute's ability to expand and accommodate essential facilities, such as classrooms, workshops, laboratories, and recreational areas. Insufficient space allocation may hinder effective teaching and learning, as well as limit the institute's capacity to offer diverse vocational programs.

3. ***Accessibility Challenges***:

The site lacks proper accessibility infrastructure. The absence of well-designed pathways, ramps, and elevators makes it difficult for students and staff with disabilities to navigate the campus comfortably. Additionally, inadequate parking spaces result in congestion and inconvenience for those commuting to the institute by private vehicles.

4. ***Infrastructure Deficiencies***:

The institute suffers from various infrastructure deficiencies. Inadequate electricity supply disrupts normal operations and hampers the effective use of technological tools in classrooms and laboratories. Insufficient water supply and poor sanitation facilities pose health and hygiene risks for students and staff. The absence of reliable internet connectivity further hinders the institute's ability to leverage digital resources for teaching and learning.

5. ***Neglected Environmental Considerations***:

The site planning and landscaping demonstrate a lack of attention to environmental considerations. Insufficient green spaces and tree cover result in limited shading and inadequate outdoor recreational areas for students. The absence of sustainable practices, such as rainwater harvesting, waste management systems, and energy-efficient infrastructure, indicates a disregard for environmental conservation.

6. ***Non-compliance with Zoning Regulations***:

The institute appears to have overlooked local zoning regulations and land use policies. This non-compliance may lead to legal issues and strained relationships with neighboring properties. Failure to adhere to setback requirements and height limits can negatively impact the aesthetics and functionality of the site, as well as compromise the overall harmony of the surrounding area.

7. ***Limited Future Expansion Opportunities***:

The site planning lacks consideration for future growth and expansion. Inadequate space allocation for potential future buildings or facilities may necessitate costly relocation or significant renovations. This lack of foresight restricts the institute's ability to adapt to evolving educational needs and limits its capacity to accommodate a growing student population.

Figure 3.6: Exterior of building showing poor landscaping.
Source: google search

3.5.2.2 Building Envelope and Material Types

1. ***Inadequate Insulation***:

The building envelope lacks proper insulation, resulting in poor thermal performance. Inadequate insulation can lead to increased energy consumption for heating and cooling, causing discomfort for occupants and higher energy costs for the institute. Insufficient insulation also compromises the building's ability to maintain a consistent and comfortable indoor temperature throughout the year.

2. ***Substandard Weatherproofing***:

The building envelope fails to provide effective weatherproofing. Improper sealing of windows, doors, and other openings allows air infiltration and moisture ingress, leading to issues such as drafts, water leaks, and potential structural damage. These shortcomings can negatively affect the indoor environment, compromising occupant comfort and potentially causing health concerns.

3. ***Weak Structural Integrity***:

The choice of building materials and construction techniques may result in weak structural integrity. Inadequate structural design and the use of low-quality materials can lead to structural instability, posing risks to occupants' safety. The lack of durability and resilience in the building envelope could result in increased maintenance and repair costs over time.

4. ***Inefficient Glazing***:

The selection of glazing materials and inadequate window design contribute to poor energy efficiency. Inefficient glazing allows excessive heat gain during hot weather and heat loss during colder months, increasing reliance on mechanical heating, ventilation, and air conditioning systems. This inefficiency negatively impacts energy consumption, leading to higher operational costs and a larger carbon footprint.

5. ***Limited Daylighting***:

The building envelope design does not prioritize adequate daylighting. Insufficient natural light penetration can lead to a reliance on artificial lighting throughout the day, increasing energy consumption and diminishing the overall quality of the indoor environment. Lack of access to natural light can also negatively impact occupants' well-being, productivity, and concentration.

6. ***Unsuitable Exterior Cladding***:

The choice of exterior cladding materials may not be suitable for the local climate or architectural aesthetics. Inappropriate cladding can lead to premature deterioration, moisture-related issues, and a compromised building appearance. Additionally, if the cladding materials contain hazardous substances or have a high carbon footprint, they can have negative environmental implications.

7. ***Poor Noise Insulation***:

The building envelope does not adequately address noise insulation. Insufficient soundproofing measures can result in noise disturbances from external sources or between different parts of the building, impacting the learning environment and occupants' comfort.

3.5.2.3 Building Orientation And Form

1. ***Poor Solar Orientation***:

The building's orientation does not take advantage of solar principles for energy efficiency. Inadequate consideration of solar angles can result in excessive heat gain during hot seasons and limited natural light penetration during colder months. This leads to an increased reliance on mechanical heating, ventilation, and air conditioning systems, leading to higher energy consumption and operational costs.

2. ***Inefficient Space Utilization***:

The building form exhibits inefficient space utilization. The layout may not optimize available space, resulting in areas that are underutilized or difficult to access. Poor space planning can lead to a waste of resources and inadequate facilities for vocational training, potentially limiting the institute's ability to offer diverse courses and accommodate a growing student population.

3. ***Lack of Natural Ventilation***:

The building form does not prioritize natural ventilation. Inadequate placement of windows, vents, and openings hinders the flow of fresh air, leading to a reliance on mechanical ventilation systems. The lack of natural ventilation can result in stagnant air, increased indoor pollutants, and reduced indoor air quality, negatively impacting the health and comfort of occupants.

4. ***Ineffective Shading***:

The building's form lacks effective shading strategies. Insufficient overhangs, shading devices, or landscaping elements can result in excessive solar heat gain within the building. The absence of proper shading can also lead to discomfort for occupants and increased cooling demands, contributing to higher energy consumption.

5. ***Inadequate Daylight Optimization***:

The building form does not optimize natural day-lighting. The placement and size of windows and openings may not consider maximizing the use of natural light throughout the building. Inadequate daylighting negatively impacts the visual comfort of occupants, necessitating greater reliance on artificial lighting during the day, which escalates energy consumption.

6. ***Insufficient Passive Design Strategies***:

The building form lacks integration of passive design strategies. Elements such as thermal mass, natural cross-ventilation pathways, and building massing for solar gain are not adequately incorporated. This absence of passive design measures compromises the building's energy efficiency and sustainability, leading to higher operational costs and a larger carbon footprint.

7. ***Aesthetically Unappealing***:

The building form lacks architectural appeal and may not align with the institute's branding and image. An aesthetically unappealing design can impact the institute's reputation and create a negative impression among students, staff, and visitors. This may affect student enrollment and hinder the institute's ability to attract qualified faculty and staff.

Figure 3.7: Building Interior.
Source: google search

3.5.2.4 Merits

- Material used for building are of standard quality.
- Situated in a business district and an administrative environment.

3.5.2.5 Demerits

- Building was built for some other intentions primary.
- It is not easy to access the entrance spaces are not well defined.

- Partitioning walls enhanced dark spaces.
- Headroom is not to standard.
- No defined landscape.

Table 3.2: Checklist Assessment Criteria for Energy efficient building

S/N	Variables	Checklist	Level of Application					Remarks
			1	2	3	4	5	
1.	**Building envelope**	Suitability of the materials to the climate		●				
		Use of external Insulation	●					
		Use of smooth surface Finishes		●				
		Use of light colors			●			
2.	**Natural lighting**	Wall to window ratio(40%)		●				
		Use of spectrally selected glass	●					
3.	**Natural ventilation**	Use of openable Windows		●				There are no casement windows
4.	**Site and external spaces**	Use of interwoven Landscape	●					Inadequate landscaping
		Use of impervious Surfaces	●					
5.	**Building form**	Large building surface Area	●					Poor building form based on climate
6.	**Building orientation**	Sun orientation; E-W			●			The optimum orientation is NW-SE
		Wind orientation; SW-NE		●				
7.	**Wall/Window shading**	Use of horizontal and vertical shading devices		●				There is outdoor area for green area but there are overhangs
		Use of interior blinds	●					
		Use of recessed walls						

		Use of overhangs	
		Use of plants	
8.	**Existing energy source**	Use of PV cells	Low efficiency lighting
		Use of natural gas	

3.5.3 Senator Abiola Ajimobi Vocational Institute, Ibadan, Nigeria

The Senator Abiola Ajimobi Vocational Institute, located in Ibadan, Nigeria, is a prominent educational institution that aims to provide vocational skills training to empower young individuals and enhance their employability in various industries. This case study analysis will explore the institute's background, objectives, key features, impact on the local community, challenges faced, and recommendations for improvement.

The Senator Abiola Ajimobi Vocational Institute was established in honor of the late Senator Abiola Ajimobi, a former governor of Oyo State, Nigeria, known for his commitment to education and youth development. The institute was established in 2019 with the vision of bridging the skills gap and promoting economic growth by providing quality vocational training. Originally in 2004-2018, the building was used as an office of the late senator before it was converted to the vocational training center it is used for now.

Figure 3.8: Building Exterior.
Source: google search

3.5.3.1 Site Planning and Landscaping

The site planning and landscaping of the vocational institute lack innovation and creativity. The design appears to be conventional and doesn't do a very good job of stand out among other educational institutions. The absence of unique and imaginative elements diminishes the overall appeal and fails to create an inspiring environment for students and staff.

Insufficient Green Spaces and Recreational Areas: The institute's site planning and landscaping do not adequately prioritize the incorporation of green spaces and recreational areas. The limited presence of gardens, seating areas, and outdoor recreational spaces restricts opportunities for students and staff to relax, unwind, and engage with nature. This deficiency undermines the potential for a holistic and enriching educational experience.

- ***Poor Accessibility and Inclusivity***: While accessibility and inclusivity are essential considerations, the site planning of the vocational institute fails to meet these requirements satisfactorily. Insufficient provisions for wheelchair ramps, accessible pathways, and appropriate parking spaces hinder the mobility and convenience of individuals with disabilities. The lack of attention to universal design principles compromises equal access and inclusion within the institute's premises.
- ***Environmental Sustainability***: The site planning and landscaping do not prioritize environmental sustainability adequately. The absence of sustainable practices, such as water-efficient irrigation systems, native plant usage, and eco-friendly maintenance techniques, showcases a disregard for environmental responsibility. This oversight not only hampers the institute's commitment to sustainable development but also contributes to unnecessary resource consumption and increased maintenance costs.
- **Ineffective Space Management**: The layout design of the institute's site exhibits poor space management. The allocation and organization of functional zones, including academic buildings, workshops, administrative offices, and recreational areas, appear

haphazard and inefficient. This lack of coherent planning results in potential congestion, compromised functionality, and challenges in navigating the institute's premises.

Figure 3.9: building exterior.
Source: google live imaging search

3.5.3.2 Building Envelope and Material Types

a) ***Insufficient Insulation***: The building envelope lacks adequate insulation, leading to energy inefficiency and increased reliance on heating, ventilation, and air conditioning (HVAC) systems. This deficiency can result in higher energy consumption and operational costs, negatively impacting the institute's sustainability goals.

b) ***Poor Air Tightness***: The building envelope's air tightness is inadequate, allowing air leakage and infiltration. This can lead to energy loss, increased HVAC load, and compromised indoor air quality. The lack of proper sealing and insulation can also make the indoor environment uncomfortable for occupants.

c) ***Lack of Natural Lighting***: The design of the building envelope fails to prioritize natural lighting. Insufficient use of windows, skylights, and other daylighting strategies limits the penetration of natural light into the building's interior. This not only increases reliance on artificial lighting but also impacts the occupants' well-being and productivity.

Unsuitable Material Types:

The choice of materials used in the construction of the vocational institute's building raises concerns regarding durability, sustainability, and overall performance.

a) ***Poor Thermal Properties***: The material types used in the building construction may have low thermal resistance properties, resulting in increased heat transfer through the walls and roof. This can lead to uncomfortable indoor temperatures, higher energy demands for cooling, and increased energy costs.

b) ***Limited Durability***: The materials used may lack durability, potentially resulting in premature deterioration and increased maintenance and repair costs. This can adversely impact the longevity and overall lifecycle of the building.

c) Insufficient Sustainable Practices: The material choices may neglect sustainable practices such as using renewable or recycled materials, considering local sourcing options, and minimizing environmental impact. This oversight can hinder the institute's commitment to environmental stewardship and sustainability.

d) ***Lack of Aesthetics***: The material types used may lack visual appeal, negatively impacting the overall aesthetics and image of the vocational institute. A visually unappealing building may fail to inspire students and create a positive learning environment.

3.5.3.3 Building Orientation and Form

- ***Solar Orientation***: The building orientation appears to take advantage of solar orientation, with careful consideration of the position and placement of windows, facades, and shading devices. This allows for optimal natural lighting and passive solar heat gain, reducing the need for artificial lighting and heating during daylight hours and potentially improving energy efficiency.
- ***Ventilation and Airflow***: The form and layout of the building appear to facilitate natural ventilation and airflow. Strategic placement of windows, courtyards, and open spaces can promote cross-ventilation, allowing for fresh air circulation and reducing reliance on mechanical ventilation systems. This can contribute to a healthier and more comfortable indoor environment.
- ***Design Integration***: The building form appears to integrate well with the surrounding landscape and site context. The design takes into account factors such as topography, views, and site features, creating a harmonious relationship between the building and its environment. This integration can enhance the aesthetic appeal and create a pleasant atmosphere for students, staff, and visitors.
- ***Limited Adaptability***: The building form may lack flexibility and adaptability to future changes or expansion requirements. If the design restricts future modifications or additions, it can limit the institute's ability to accommodate evolving needs or technological advancements.
- ***Spatial Efficiency***: The building form and layout may not optimize the use of available space effectively. Inefficient utilization of floor space can result in underutilized areas or cramped spaces, impacting functionality, workflow, and overall occupant experience.
- ***Accessibility Considerations***: The building form should be assessed to ensure that it adequately addresses accessibility requirements for individuals with disabilities.

Factors such as ramps, elevators, and barrier-free pathways should be carefully integrated to provide equal access and inclusivity for all occupants.

- ***Structural Considerations***: The structural integrity of the building form should be thoroughly evaluated to ensure its ability to withstand environmental factors such as wind loads, seismic activity, and other potential hazards. If the design does not adequately account for structural stability, it can compromise the safety and durability of the building.
- ***Heat Gain and Cooling***: Depending on the building's form and orientation, there may be potential issues with excessive heat gain, especially in areas with intense sunlight exposure. This can lead to increased cooling demands, energy consumption, and discomfort for occupants unless effective shading and insulation measures are implemented.

3.5.3.4 Merits

- It is easily accessible.
- It is situated in a business district.

3.5.3.5 Demerits

- Administrative arm is hidden not defined.
- It was not purposely built for the function it is serving.
- Walls are degenerating due to poor materials used and lack of maintenance.
- No proper site layout.
- No well-defined parking spaces.
- Inadequate learning facilities.

Table 3.3: Checklist Assessment Criteria for Energy efficient building

S/N	Variables	Checklist	Level of Application 1	2	3	4	5	Remarks
1.	**Building envelope**	Suitability of the materials to the climate			●			
		Use of external Insulation		●				
		Use of smooth surface Finishes		●				
		Use of light colors			●			
2.	**Natural lighting**	Wall to window ratio(40%)			●			
		Use of spectrally selected glass		●				
3.	**Natural ventilation**	Use of openable Windows				●		The use of openable casement windows,
4.	**Site and external spaces**	Use of interwoven Landscape		●				inadequate Use of landscaping
		Use of impervious Surfaces		●				
5.	**Building form**	Large building surface Area			●			Poor building form based on climate
6.	**Building orientation**	Sun orientation; E-W			●			The optimum orientation is
		Wind orientation; SW-NE		●				NW-SE
7.	**Wall/Window shading**	Use of horizontal and vertical shading devices			●			There is outdoor area for green area and presence of overhang
		Use of interior blinds	●					
		Use of recessed walls	●					
		Use of overhangs			●			
		Use of plants			●			
8.	**Existing energy source**	Use of PV cells	●					Low efficiency lighting
		Use of natural gas				●		

3.5.4 Sabtuan Regional Vocational Training Centre

The Sabtuan Regional Vocational Training Centre is a prominent institution in Canada that focuses on providing vocational training and improving the competencies of construction supervisors. According to Manoharan et al., vocational training institutions should prioritize enhancing the skills and knowledge of construction supervisors in various areas such as site management, labour management, construction planning, performance evaluation on labour skills, material handling, construction methods and procedures, understanding basic structural concepts, health and safety practices, leadership, decision making, and communication (Kesavan et al., 2022). The development of regional training centers, such as the Sabtuan Regional Vocational Training Centre, has become a key aspect of educational policy in Canada.

Figure 3.10: building exterior.
Source: google search

3.5.4.1 Site Planning and Landscaping

- ***Aesthetic Appeal***: The site planning and landscaping at the Sabtuan Regional Vocational Training Centre enhance the overall aesthetic appeal of the building. The careful selection of native plants and trees creates a visually pleasing and harmonious environment. The landscape design incorporates a variety of colors, textures, and seasonal interest, adding vibrancy and interest to the surroundings. This attention to aesthetics helps create a positive atmosphere for both students and staff.

- Integration with Surroundings: The site planning of the training centre demonstrates a seamless integration with its natural surroundings. The architectural design and landscaping have been executed to complement the existing topography and vegetation. The building's placement takes advantage of the natural contours, allowing for efficient use of space while preserving the site's integrity. The inclusion of outdoor seating areas and pathways encourages students to interact with the natural environment, fostering a sense of connection with the surroundings.
- ***Sustainable Practices***: The site planning and landscaping at the Sabtuan Regional Vocational Training Centre prioritize sustainability. The use of native plant species promotes biodiversity and reduces water consumption, as these plants are well-suited to the local climate and require minimal maintenance. The incorporation of rainwater harvesting systems and efficient irrigation techniques ensures responsible water management. Furthermore, the landscape design includes permeable surfaces and green infrastructure features, such as rain gardens and bioswales, to manage stormwater runoff and promote groundwater recharge.
- ***Functional Outdoor Spaces***: The site planning incorporates functional outdoor spaces that cater to the diverse needs of the students and staff. The inclusion of outdoor seating areas, gathering spaces, and recreational facilities encourages social interaction, relaxation, and physical activity. These outdoor spaces provide an extension of the learning environment and offer opportunities for outdoor classes, group discussions, and informal meetings. By integrating these functional outdoor spaces, the site planning enhances the overall educational experience and well-being of the occupants.
- ***Accessibility and Safety***: The site planning of the Sabtuan Regional Vocational Training Centre prioritizes accessibility and safety. Thoughtfully designed pathways

and ramps ensure easy movement for individuals with disabilities or mobility challenges. The incorporation of proper lighting along the pathways and parking areas enhances safety during evening hours. Adequate signage and wayfinding elements help visitors navigate the site effortlessly, contributing to a positive experience for all.

Figure 3.11: building exterior showing car park.
Source: google search

3.5.4.2 Building Envelope and Material Types

1. ***Building Envelope***:

The building envelope refers to the external shell of the structure, including the walls, roof, windows, doors, and insulation. The Sabtuan Regional Vocational Training Centre demonstrates a well-designed and efficient building envelope that offers several advantages:

Thermal Performance: The envelope is designed to provide effective insulation, minimizing heat transfer between the interior and exterior. High-quality insulation materials are incorporated to prevent heat loss during winter and heat gain during summer, thus reducing the building's energy consumption and enhancing occupant comfort.

- ***Air Tightness***: The building envelope is carefully sealed to minimize air leakage, ensuring energy efficiency and reducing the potential for drafts, moisture intrusion, and heat loss. A well-sealed envelope helps maintain consistent indoor temperatures and improves the overall thermal performance of the building.

- ***Moisture Management***: The building envelope incorporates moisture barriers and appropriate ventilation systems to prevent moisture buildup, condensation, and potential water damage. These features contribute to maintaining a healthy and durable indoor environment.

- ***Sound Insulation***: The building envelope is designed to minimize noise transmission from the exterior environment, creating a conducive learning atmosphere within the training center. Soundproofing materials and techniques are employed to reduce noise pollution and enhance occupant comfort.

2. ***Material Types***:

The selection of appropriate building materials is crucial for the functionality, durability, and sustainability of the Sabtuan Regional Vocational Training Centre. Several material types have been carefully chosen to meet these criteria:

- ***Structural Materials***: The primary structural elements of the building, such as the framework, columns, and beams, are typically constructed using robust materials such as steel, reinforced concrete, or engineered wood. These materials offer strength, durability, and structural integrity.

- ***Exterior Cladding***: The exterior cladding materials, such as brick, stone, metal panels, or fiber cement siding, are selected for their aesthetic appeal, durability, and weather resistance. These materials provide protection against the elements while enhancing the architectural character of the training center.

- ***Glazing Systems***: The windows and glass panels used in the building envelope incorporate energy-efficient glazing systems, such as double or triple glazing, low-emissivity (low-E) coatings, and insulated frames. These features enhance natural lighting, thermal performance, and occupant comfort while minimizing heat gain or loss.

- ***Insulation Materials***: The training center utilizes high-quality insulation materials, such as fiberglass, mineral wool, or spray foam, within the walls, roof, and floors. These materials effectively reduce heat transfer, provide thermal comfort, and contribute to energy efficiency by reducing the need for excessive heating or cooling.

- **Sustainable and Recycled Materials**: Where feasible, sustainable and recycled materials are incorporated into the construction of the Sabtuan Regional Vocational Training Centre. This includes materials with high recycled content, responsibly sourced wood products, and eco-friendly finishes. Such materials help minimize the environmental impact of the building and support sustainable practices.

3.5.4.3 Building Orientation and Form

- ***Solar Orientation***:

The building's solar orientation at the Sabtuan Regional Vocational Training Centre demonstrates a thoughtful approach to maximizing natural light and minimizing energy consumption. The placement of windows and glazed areas takes into account the path of the sun, optimizing daylight penetration and reducing the need for artificial lighting during the day. This not only enhances the learning experience but also reduces energy costs and promotes a sustainable design.

- ***Passive Solar Design***:

The building's form incorporates passive solar design principles, which utilize the sun's energy for heating, cooling, and lighting. The strategic placement of windows, shading devices, and thermal mass elements helps regulate indoor temperatures throughout the year. By harnessing natural solar energy, the building reduces its reliance on mechanical heating and cooling systems, resulting in energy savings and a reduced environmental footprint.

- ***Natural Ventilation***:

The form of the Sabtuan Regional Vocational Training Centre facilitates natural ventilation, promoting fresh air circulation and reducing the need for mechanical cooling systems. The building design includes operable windows and ventilation openings strategically placed to capture prevailing winds and encourage natural airflow. This not only enhances indoor air quality but also improves occupant comfort and reduces energy consumption.

- ***Building Form and Energy Efficiency***:

The form of the training center is optimized to maximize energy efficiency. The compact building design minimizes the surface area-to-volume ratio, reducing heat loss and improving insulation performance. The exterior walls and roof are well-insulated, ensuring thermal comfort and reducing the need for excessive heating or cooling. Additionally, the form of the building allows for efficient placement of HVAC systems and distribution of utilities, enhancing energy efficiency and maintenance accessibility.

- ***Aesthetic Appeal and Functional Space***:

The building's form at the Sabtuan Regional Vocational Training Centre combines aesthetic appeal with functional space. The design integrates a harmonious blend of architectural elements, creating an inviting and inspiring learning environment. The form of the building optimizes interior space, providing ample room for classrooms, laboratories, and communal areas, ensuring efficient use of space and fostering collaboration and productivity among students and staff.

- ***Contextual Integration***:

The building's form takes into account its contextual integration with the surrounding landscape and architectural style. It harmonizes with the natural surroundings while maintaining its own unique identity. The form of the training center respects the site's topography, maintaining a balanced relationship with the environment and contributing positively to the visual aesthetics of the campus.

Figure 3.12: Building interior.
Source: google search.

3.5.4.4 Merits

- Proper demarcation.
- Good drainage system.
- Easy access to facilities.

3.5.4.5 Demerits

- No demarcation of fence for security.
- No provision of well-defined walkway.

Figure 3.13: buildings exterior.

Source: google search

Table 3.4: Checklist Assessment Criteria for Energy efficient building

S/N	Variables	Checklist	Level of Application					Remarks
			1	2	3	4	5	
1.	**Building envelope**	Suitability of the materials to the climate					●	
		Use of external Insulation				●		
		Use of smooth surface Finishes					●	
		Use of light colors					●	
2.	**Natural lighting**	Wall to window ratio(40%)			●			
		Use of spectrally selected glass			●			
3.	**Natural ventilation**	Use of openable Windows		●				There are barely any casement windows,
4.	**Site and external spaces**	Use of interwoven Landscape					●	Exceptional Landscaping
		Use of impervious Surfaces				●		
5.	**Building form**	Large building surface Area					●	Perfect building form based on climate
6.	**Building orientation**	Sun orientation; E-W					●	The optimum orientation is NW-SE
		Wind orientation; SW-NE				●		

7.	**Wall/Window shading**	Use of horizontal and vertical shading devices				●	There is outdoor area for green area and presence of overhang
		Use of interior blinds			●		
		Use of recessed walls		●			
		Use of overhangs			●		
		Use of plants			●		
8.	**Existing energy source**	Use of PV cells			●		High efficiency lighting
		Use of natural gas	●				

3.5.5 South Labone Girls Technical Institute

The South Labone Girls Technical Institute building in Ghana serves as a significant educational facility, empowering young women with technical skills and knowledge. This case study aims to analyze the building's design, functionality, and its impact on the educational environment and local community.

Established in 2005, the South Labone Girls Technical Institute in Accra, Ghana, aims to provide technical and vocational education to girls in the region. The building acts as a platform for imparting practical skills in engineering, computer science, agriculture, and home economics. Its mission is to promote gender equality in technical education and empower girls to pursue traditionally male-dominated careers.

The architectural design of the South Labone Girls Technical Institute building combines functionality and aesthetics. It features modern classrooms, laboratories, workshops, administrative offices, a library, and recreational areas. The design incorporates elements such as natural lighting, ventilation systems, and environmentally friendly features to create a conducive learning environment.

Figure 3.14: building exterior showing landscaping.
Source: google search.

3.5.5.1 Site Planning And Landscaping

- ***Accessibility***: The South Labone Girls Technical Institute building is strategically located in a central area, making it easily accessible to students from various parts of the region. Its convenient location encourages enrollment and ensures that girls have equal opportunities to access technical education.

- ***Space Utilization***: The building's design effectively utilizes the available space, providing ample room for classrooms, laboratories, workshops, administrative offices, and recreational areas. The layout allows for efficient movement within the facility and ensures that each area serves its designated purpose effectively.

- ***Natural Lighting and Ventilation:*** The architectural design incorporates features that promote natural lighting and ventilation. This not only reduces energy consumption but also creates a pleasant and comfortable learning environment for students and staff.

- ***Safety Measures***: The site planning includes safety measures such as fire exits, emergency response systems, and designated evacuation routes. These precautions ensure the well-being of students and staff and contribute to a secure educational environment.
- ***Aesthetics***: The landscaping surrounding the South Labone Girls Technical Institute building enhances its visual appeal. Thoughtful selection of plants, trees, and flowers creates a welcoming and vibrant atmosphere, contributing to a positive learning environment.

- ***Outdoor Learning Spaces***: The landscaping design includes well-maintained outdoor spaces that can be utilized for practical demonstrations, group activities, and recreational purposes. These areas provide opportunities for students to connect with nature and engage in hands-on learning experiences.

- ***Parking Facilities***: Insufficient parking spaces can pose a challenge for students, staff, and visitors. Limited parking availability may lead to congestion and inconvenience, particularly during peak hours. This could be a potential drawback for the overall functionality of the facility.

- ***Traffic Congestion***: Depending on the location, the South Labone Girls Technical Institute building may be subject to heavy traffic, which can hinder accessibility and cause delays for students and staff commuting to the facility. Adequate traffic management strategies should be considered to mitigate this issue.

- ***Maintenance and Upkeep***: While landscaping enhances the visual appeal of the institute, ensuring proper maintenance and regular upkeep is essential. Neglected landscaping can quickly deteriorate, detracting from the overall aesthetic and potentially affecting the learning environment.

- ***Sustainability and Eco-Friendliness***: It is crucial to assess the landscaping practices in terms of sustainability and eco-friendliness. Implementing sustainable landscaping techniques, such as water conservation measures, native plant species selection, and proper waste management, can contribute to the institute's commitment to environmental stewardship.

- ***Accessibility for All***: The landscaping design should prioritize accessibility for all individuals, including those with mobility challenges. Consideration should be given to the implementation of ramps, pathways, and other features that ensure equal access to outdoor spaces for everyone.

Figure 3.15: Building Exterior.
Source: google search

3.5.5.2 Building Envelope and Material Types

- ***Inadequate Space Utilization***: The design of the institute fails to optimize the available space effectively. The layout may not adequately accommodate the needs of various departments and practical learning areas. Insufficient space can hinder students' ability to engage in hands-on activities and limit their access to necessary equipment and resources.

- ***Lack of Flexibility***: The design may lack flexibility, making it challenging to adapt the spaces to evolving educational needs or changing technologies. As educational requirements and teaching methodologies continue to evolve, a rigid design can limit the institute's ability to incorporate new teaching methods and technologies effectively.

- ***Limited Collaboration Areas***: The design may not prioritize collaborative spaces, hindering opportunities for group work and interaction among students. Collaborative learning is an essential aspect of technical education, and the lack of dedicated spaces for teamwork and group discussions can hinder the development of important collaborative skills.

- ***Inefficient Traffic Flow***: The design may overlook efficient traffic flow within the building, leading to congestion and bottlenecks in common areas, such as corridors and entryways. Inadequate traffic management can impede movement, causing delays, distractions, and disruptions to the learning environment.

- ***Lack of Sustainability Features***: The design may not adequately incorporate sustainability features, such as renewable energy sources or water conservation measures. Failing to prioritize sustainability hampers the institute's ability to reduce its environmental impact and instill sustainability values in students.

- ***Aesthetics***: The design of the South Labone Girls Technical Institute building may exhibit aesthetic appeal, creating an inviting and inspiring atmosphere for the students and staff.
- ***Safety Measures***: While there may be design concerns, it is important to recognize that safety measures such as fire exits, and emergency response systems are crucial components of the building design. These measures ensure the well-being and security of occupants during emergencies.

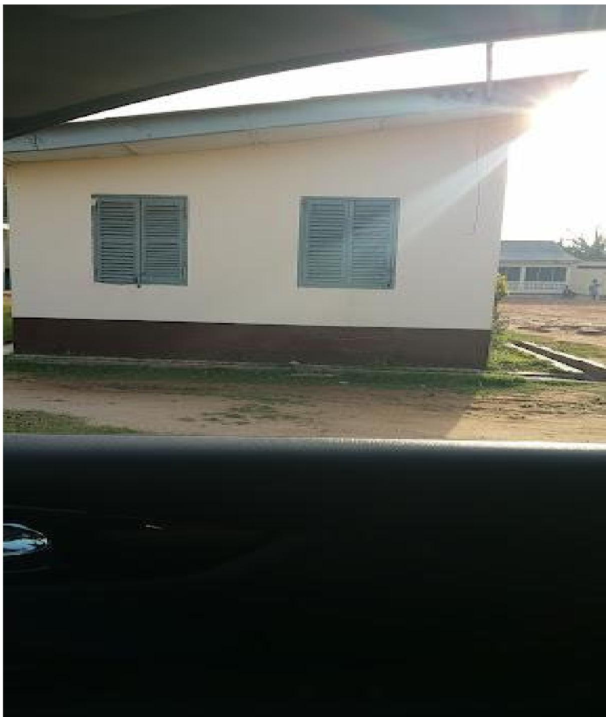


Figure 3.16: building exterior.
Source: google search

3.5.5.3 Building Orientation and Form

The orientation and form of the South Labone Girls Technical Institute building present several negative aspects that hinder its functionality, energy efficiency, and overall effectiveness. While it is important to acknowledge the positive elements, a critical assessment reveals the following:

- ***Inadequate Solar Orientation***: The building's orientation may fail to optimize solar exposure and natural daylighting. Improper alignment of the building in relation to the sun can result in limited access to natural light, leading to increased reliance on artificial lighting during daytime hours. This not only affects energy efficiency but also negatively impacts the well-being and productivity of occupants.

- ***Inefficient Ventilation and Cooling***: The form of the building may hinder proper ventilation and cooling strategies. Inadequate consideration of prevailing wind patterns and natural ventilation can lead to poor airflow, resulting in stuffy and uncomfortable indoor conditions. Insufficient cooling mechanisms can further escalate energy consumption and compromise the learning environment.

- ***Lack of Outdoor Spaces***: The form of the building may restrict the availability of outdoor spaces for recreation, relaxation, and outdoor learning activities. Insufficient consideration of well-designed outdoor areas deprives students of opportunities to connect with nature, engage in physical activities, and foster a holistic learning experience.

- ***Monotonous Architectural Design***: The form of the building may lack architectural variety and creativity. A monotonous design can contribute to a mundane and uninspiring environment, potentially affecting student motivation and engagement. Aesthetically pleasing and innovative architectural elements can positively impact the learning experience.

- ***Accessibility***: The design of the building may prioritize accessibility, ensuring that the facility is inclusive and accommodates individuals with mobility challenges. Incorporating ramps, wide hallways, and other accessibility features demonstrates a commitment to equal access for all.

- ***Structural Stability***: While there may be concerns about orientation and form, it is essential to acknowledge the importance of structural stability. If the building is designed and constructed to withstand environmental factors and potential hazards, it ensures the safety and well-being of the occupants.

3.5.5.4 Merits

- Proper demarcation of building facilities.
- Good drainage system.
- Easy access to facilities.

3.5.5.5 Demerits

- No demarcation of fence for security.
- No provision of well-defined walkways.

Table 3.5: Checklist Assessment Criteria for Energy efficient building

S/N	Variables	Checklist	Level of Application					Remarks
			1	2	3	4	5	
1.	**Building envelope**	Suitability of the materials to the climate		●				
		Use of external Insulation	●					
		Use of smooth surface Finishes		●				
		Use of light colors		●				
2.	**Natural lighting**	Wall to window ratio(40%)		●				
		Use of spectrally selected glass	●					
3.	**Natural ventilation**	Use of openable Windows			●			The use of openable wooden casement windows
4.	**Site and external**	Use of interwoven Landscape		●				Fairly adequate Use of landscaping

	spaces	Use of impervious Surfaces	●				
5.	**Building form**	Large building surface Area		●			Poor building form based on climate
6.	**Building orientation**	Sun orientation; E-W		●			The optimum orientation is NW-SE
		Wind orientation; SW-NE		●			
7.	**Wall/Window shading**	Use of horizontal and vertical shading devices	●				There is no outdoor area for green area and presence of overhang
		Use of interior blinds		●			
		Use of recessed walls				●	
		Use of overhangs			●		
		Use of plants	●				
8.	**Existing energy source**	Use of PV cells		●			Low efficienc lighting
		Use of natural gas				●	

Chapter Four

Site Analysis And Design Synthesis

4.1 Study Area

4.1.1 Site Location

The site is located at Gbedun village, Ono Ara, Oyo state, Nigeria. The site is very close to the local community secondary school.

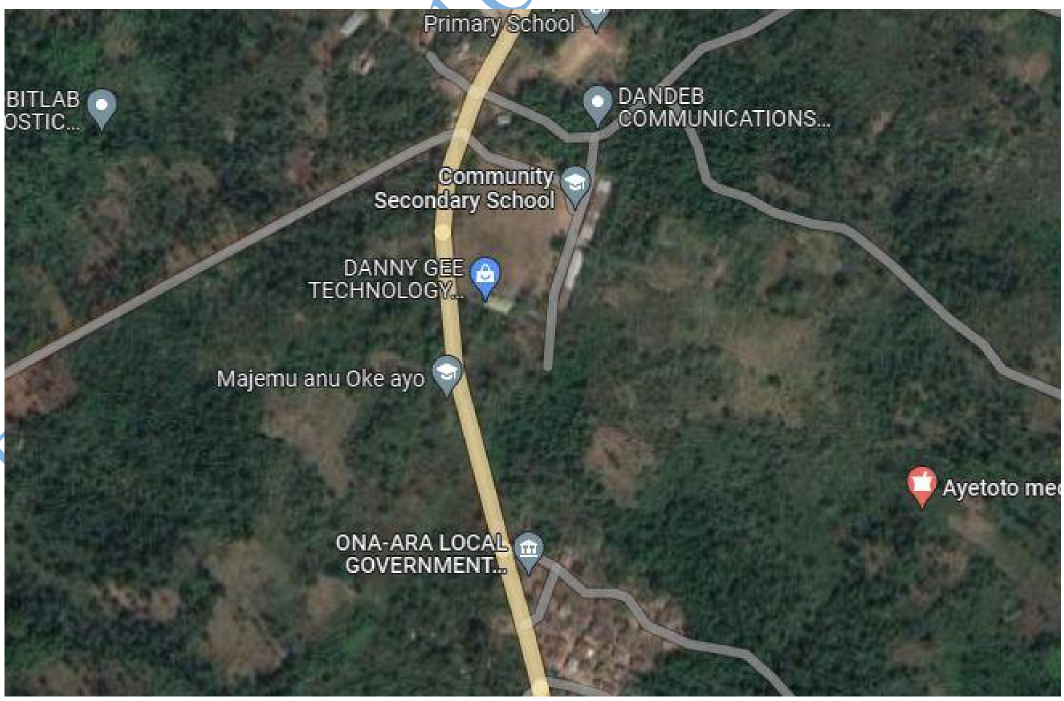


Figure 4.1: map of Gbedun village showing position of proposed site.
Source: google maps

4.1.2 Site Selection Criteria

The facility's functional use is strongly impacted by the site selection for this project; hence it was vital to take certain factors into account when choosing the location;

I. ***Land usage***: The land use guidelines outlined in the city's master plan are adhered to quite strictly in Oyo State.

II. ***Accessibility***: The land should be easily accessible by vehicle, waterway, and foot for the majority of the facility's intended users.

III. ***Amenities***: The location ought to have certain already-installed amenities, such as electricity and water reticulation.

IV. Closeness to a residential area.

V. ***Topography***: In order to improve outdoor activities and lower the cost of building outdoor pitches, the site's topography is anticipated to have a relatively mild slope.

VI. ***Expansion Possibilities***: As the user's needs grow, the construction site should be simple to expand to accommodate more outside activities.

4.1.3 Site Analysis

To ensure accurate and efficient design and to be able to utilize the site's full potential, the site's physical attributes are required to be documented.

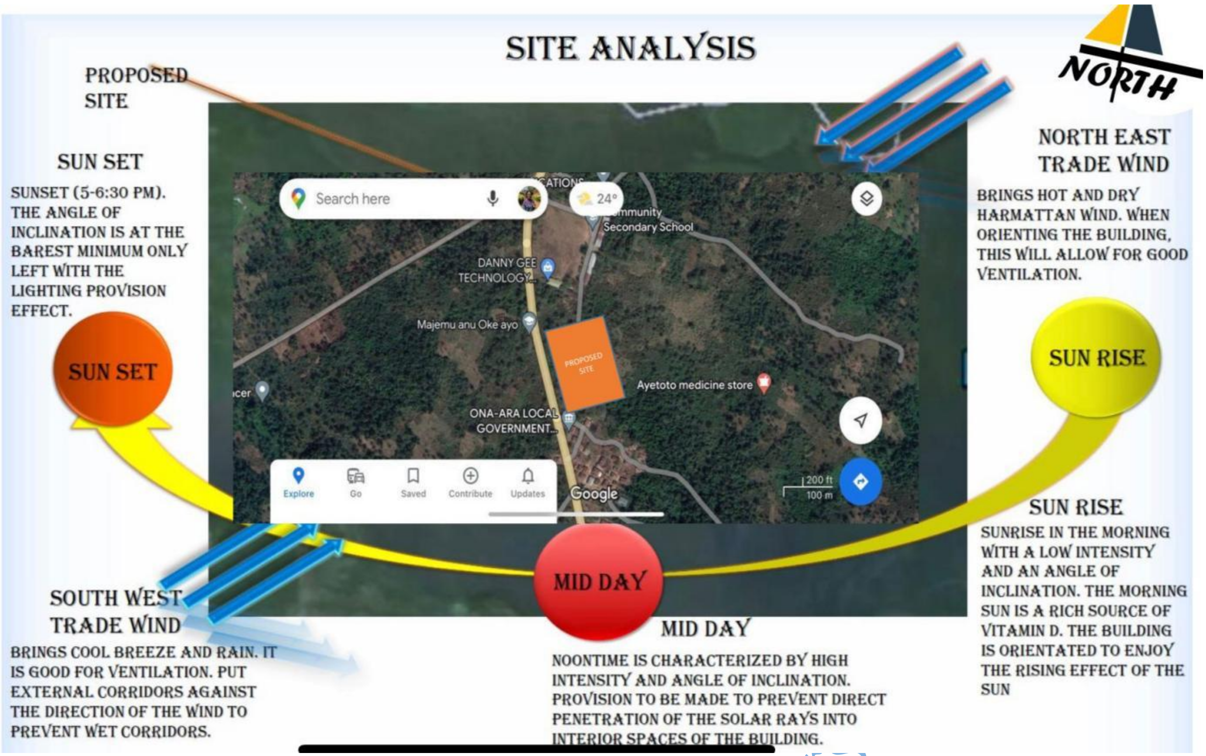


Figure 4.2: Site analysis

Site Accessibility

Both cars and people on foot can easily and conveniently visit the location. The main road that passes through the Ono Ara settlement of Gbedun provides effective access to the location.

Nearness to Public Utilities

Basic infrastructure is present, including roads, electricity, water, telecommunications, among other things.

1. Water supply: Access to a reliable and adequate water supply is essential for any development. The site should be located near a water source or have access to a municipal water system to ensure a sufficient and uninterrupted water supply for various purposes like drinking, sanitation, and irrigation.
2. Sewage and sanitation: Proper disposal of wastewater and sanitation facilities are critical for maintaining hygienic conditions. Proximity to a sewage system or the

availability of other appropriate means for wastewater treatment and disposal is vital to avoid environmental pollution and health hazards.

3. Electricity: Almost all types of developments require access to a reliable electricity supply. The site should be located within the service area of an electrical grid or have the potential for easy connection to the power distribution network.
4. Telecommunication infrastructure: In today's interconnected world, reliable telecommunication services, including telephone lines, internet connectivity, and mobile network coverage, are crucial for most developments. Proximity to existing telecommunication infrastructure minimizes the cost and effort required to establish reliable communication systems.
5. Transportation infrastructure: Adequate transportation infrastructure, such as roads, public transportation networks, is vital for the accessibility and connectivity of a site. Easy access to transportation routes facilitates commuting for residents, employees, and customers, and supports the movement of goods and services.

Drainage and Topography

The site has a slight slope that is distributed evenly. Drainages are also set up to collect water. The drainage set up does a good job of removing excess rainwater from the site seeing as the slight slope on the site allows gravity to do its work. The drainages are carefully placed to maximize drainage efficiency.

Vegetation

Because Gbedun village, Ono Ara, lies in the tropics, it has two distinct seasons: the cold and dry seasons. This makes it possible for a diverse range of species, from dense undergrowth, short grasses, and evergreen trees, to flourish nearby. Sandy soil has a poor capacity for bearing.

Soil Condition

Its loose sandy soil is suitable for building and landscaping, and the subsurface is in good shape. Without any rock crops, it provides an acceptable geological and soil condition.

Wind Direction

The cold, dust, and harmattan brought by the north-east trade wind are uncomfortable. The cool dampness brought by the south-west trade wind has a calming impact on humans. The effective arrangement of the building is thought to include proper ventilation. The east and west elevations of the building's long sides are positioned to get the most airflow. The projected vocational center's shorter sides are exposed to the north-east trade wind.

4.2 Project Analysis And Design Synthesis

4.2.1 Brief Analysis

Countries like China and Japan have been able to survive, have a good economy, and consistently create low unemployment rates as a result of the numerous policies that have been implemented to support indigenous manufacturing production of goods. The degree of education in China has also been attached to the growth disparity between China and other emerging countries in Sub-Saharan Africa and South Asia.

These countries acknowledged the value of vocational training education and made specific provisions for its growth by providing the necessary facilities and infrastructure. This project is necessary because vocational training education is one of the most important approaches to combat the nation's unemployment problem.

4.2.2 Brief Development

There were some areas that were discovered to be shared by all five case studies and some disparities between each of those looked at in this study. To ascertain the standard needed, the number of units per person, their capacity, and the precise purpose they serve in a vocational training center design, these spaces were closely examined. These are the spaces;

I. Administrative Section:

- Reception
- Counselor's Office
- General Manager's Office
- Assistance Manager
- Secretary's office
- Board room
- Stair hall
- Data Room
- Conveniences

II. Vocational Training Complex

- Exhibition Spaces
- Classrooms
- Maintenance department
- Photography Studio
- Tailoring workshop
- Leather Works - (Shoe and Bag Making)
- ICT and Computer Technology
- Outdoor Working Area, Cloak rooms for each Classroom and Instructors Offices.
- General Store and Conveniences.

III. Workshops

- Wood workshop
- Material store
- Instructor's office

- Cloak room
- Production hall
- Household products department
- Conveniences

IV. Recreational Facilities

- Basketball court
- Outdoor sitting and relaxation area

4.2.3 Design Consideration

4.2.3.1 Site Planning And Landscaping

The location of outdoor activities in relation to indoor facilities was carefully considered during site planning to provide simpler usage of both facilities. Vehicle mobility and pedestrian movement were distinct from one another at the same time. For the Vocational training Complex, enough greens are also introduced to cool and also supply fresh air.

4.2.3.2 Spatial Organization

The majority of the spaces were assigned based on requirements for vocational training centers and the human body's anthropometry in relation to the activities taking place in the spaces. Careful consideration was put into adequate spacing each component and compartment of the building for optimum efficiency.

4.2.3.3 Energy Efficiency Strategies

The vocational training center was designed with a heavy emphasis on energy efficiency.

Figure 4.3: 3D view of proposed building showing exterior and landscaping.

4.2.4 Conceptual Development

The design of the Vocational training center aims to provide a high-quality learning environment for people. It is here that numerous talents will be considered and acquired based on one's chosen field of interest using various modern and recent tools.

This influenced the conceptualization that was used. i.e., The form-follows-function principle which allows the free flow from regular shapes to be achieved.

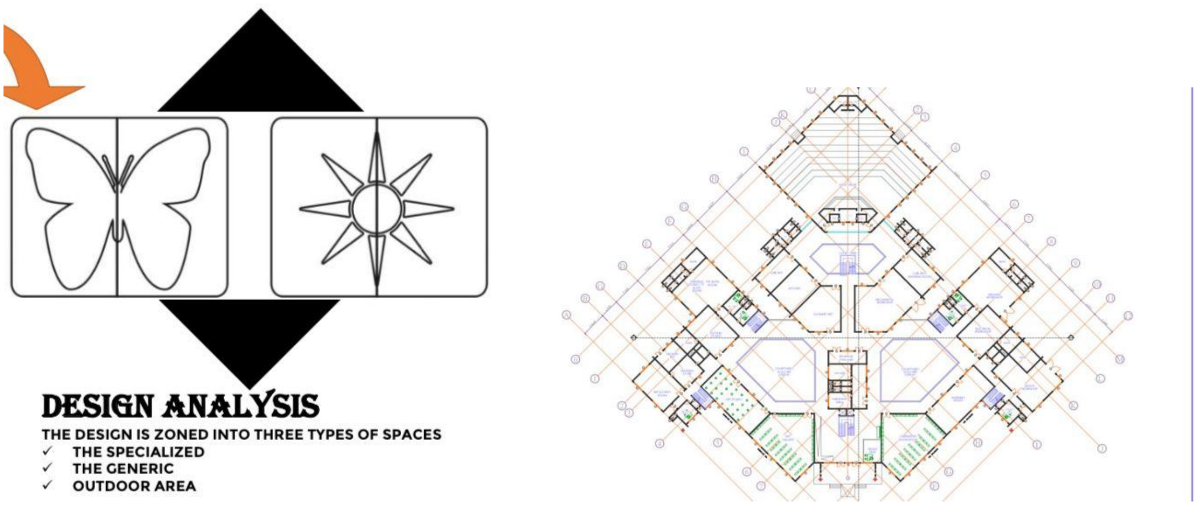


Figure 4.4: design and conceptual analysis.

4.2.7 Construction Methods and Materials

For the civil work, the frame framing system is the recommended construction approach; most other components should be manufactured on site and assembled in the proper order. The aluminum work will be finished by tower aluminum Nigeria and delivered to the site completed with the necessary specifications, whereas the steel work will be prefabricated and set in place. The structure will be supported by deep pile columns on a pile foundation because of the site's soil composition. The water supply pipes should be PPR pipes with fewer joints, which will reduce leaks, and all wiring and piping should be done through conduit.

The exterior work will be professionally finished, including the planting of trees and their careful maintenance, as well as the installation of concrete paving stone walkways. Concrete will be used in most construction projects; however, steel and glass may also be employed in some instances.

Reinforced Concrete

Concrete is the ideal material for the structural because of its strong structural strength (particularly when reinforced with steel). Reinforced concrete is a useful building material for curving, inclined walls because of its fluidity.

Steel

High strength and ductility are two of steel's many benefits. If corrosion is prevented, it is also resilient. In comparison, steel's higher yield stress allows for smaller sections, and its lower weight decreases the need for a foundation.

4.2.8 Building Services

4.2.8.1 Water Supply

The Oyo State Water Corporation provides water to the site, although storage space for the water will also be provided by way of a ground water tank and an overhead water tank. The building's damp regions are not far from the ducts. The ducts are large enough to allow for simple maintenance from behind.

4.2.8.2 Power Supply

The national grid of the Power Holding Company of Nigeria (PHCN) would be used to supply electricity. The design must, however, also account for its own power requirements. An integrated photovoltaic panel can be built as an alternative power source. A transformer will also be put in place at the location due to the facility's demand for a lot of power.

4.2.8.3 Refuse Disposal

There is a central refuse dump that is provided outside the building that houses all waste before the disposal company arrives for the final disposal, it will be transported from here to the disposal site.

4.2.8.4 Wastewater and Sewage Disposal

The sewage treatment facility or a general septic tank should receive the wastewater from restrooms and treat it before being disposed of by the environmental board.

4.2.8.5 Fire Fighting System

Fire hydrants for quick water collection by fire fighters, fire extinguishers strategically placed in the hallways, smoke detectors, and water sprinklers should be installed in each room and the hallways.

Chapter Five

Conclusion and Recommendation

5.1 Project Appraisal

The study is based on the idea that a vocational center's energy efficiency can be improved with better architectural design features. The study of vocational centers in and outside of Nigeria provides the backdrop for this argument.

Having a conceptual framework in which to apply architectural design components requires a review of the pertinent literature on the subject of energy efficiency. In order to create energy-efficient vocational centers, a few key strategies were identified and discussed in the research, including site design and landscaping, building envelope and material kinds, building orientation, form, and ventilation. In order to learn more about the study, case studies were analyzed using particular factors that were directly relevant to the topic of the research as well as by using structured questionnaires to ask users and maintenance staff. Thus, in order to create design and planning concepts for the proposed vocational training center, information from the literature review, questionnaire, and the five areas of interest were taken into consideration.

5.2 Conclusion

In order to solve the issues with energy efficiency in vocational centers, which have over time gone unaddressed, architects and designers are urged to do so at the outset of the design process. Doing so will result in a facility that uses less energy. This is first accomplished by implementing energy-efficient design and construction practices; doing so may result in a facility's energy consumption decreasing by as much as 70%.

5.3 Recommendation

The main conclusions of the study point out that thorough energy analysis by the architects and a subsequent approach to problem-solving from the drawing board will offer a better way to address the issue of energy efficiency and how these problems can be avoided in the future. Consequently, it is advised to implement the following recommendations:

i. Building complexity and energy consumption sensitivity should be made clear to architects and designers.

ii. To increase energy efficiency, adequate natural ventilation should be used.

iii. Architects and other building experts should be required to use energy-saving techniques. When planning and building.

Reference

A'zami, A. (2005). Badgir in traditional Iranian architecture. *Proceedings of international on passive and low energy cooling for the built environment,.* Santorini, Greece.

Akhimien, N. G., Isiwele, A. J., & and Adamolekun, M. (January 2018). The imperatives of Energy efficient buildings to the built environment. *International Journal of Engineering and Technology*, 109.

Arınç, U., & Enerji , V. (2013,). *Principles of Settlement and Design of Energy Efficient Buildings.* Ankara,.

Berköz, E., Küçükdoğu, M., Yılmaz, & Enerji , E. (1995). *Energy Efficient Housing and Settlement Design* . İstanbul; : TÜBİTAK, INTAG 201,.

Brown, G. (2010). *Architecture Industry; A hidden Culprit in Global Warming.* Retrieved from http://architecturalevangelist.com/green-architecture/the-architecture-industry-a-hidden-culprit-to-global-warming.html

Chen SY, Chu CY, Cheng MJ, & Lin CY. . (2009). The autonomous house: a bio-hydrogen based energy self-sufficient approach. . *Int J Environ Res Public Health* , 6(4):1515–29.

Constantin, I., Tudor , B., Gabriela-Elena, V., Horia, N., & Adrian, B. (2015). The historical evolution of the energy efficient buildings. *Renewable and Sustainable Energy Reviews*, 49 (2015) 243–253.

Davenport, C. (2018). *Major climate report describes a strong risk of crisis as early as 2040.* . The New York Times,.

Day, J. K., & Gunderson, D. E. (2015). Understanding high performance buildings: The link between occupant knowledge of passive design systems, corresponding behaviours, occupant comfort and environmental satisfaction. *Building and Environment,*, 84, 114-124. .

Department of Industry, 2013 Settlement Patterns. *The International Journal of Environmental, Cultural, Economic, and Social Sustainability: Annual Review, 3(3), 141–152. https://doi.org/10.18848/1832-2077/cgp/v03i03/54362*

El-Darwish, I., & Gomaa, M. (2017). Retrofitting strategy for building envelopes to achieve energy efficiency. . *Alexandria Engineering Journal,*, 56(4), 579-589.

Emokpae, E., Isidore, C. E., Eziyi , I., & Anthony , B. S. (March 2021). Energy Efficiency Design Strategies in Office Buildings: A Literature Review. *IOP Conference Series Earth and Environmental Science* , DOI: 10.1088/1755-1315/665/1/012025.

Furr JE, Kibert NC, Mayer JT, & Sentman SD. (2009.). *Green building and sustainable development: the practical legal guide.* Chicago: ABA Publishing.

Geissler, S., Österreicher, D., & Macharm, E. (2018). Transition towards energy efficiency:Developing the Nigerian building energy efficiency code. In *Sustainability,* (pp. 10(8), 2620).

Gosztonyi, S., Brychta, M., & Gruber, P. (2010). Challenging the engineering view:comparative analysis of technological and biological functions targeting energy efficient facade systems. In *WIT Transactions on Ecology and the Environment* (pp. 138, 491-502.).

Hahne, E. (2000). The ITW solar heating system: an oldtimer fully in action. . In *Sol Energy* (pp. 69(6):469–93.).

Hong, T., Taylor-Lange, S. C., D'Oca , S., & Yan, D. (2016). Advances in research and applications of energy-related occupant behavior in buildings. *Energy and buildings*, 116, 694-702.

Hor , K., & Rahmat , M. K. (2018). Analysis and recommendations for building energy efficiency financing in Malaysia. In *Energy Efficiency* (pp. 11(1), 79-95.).

Izzet , Y., & Tülay , T. K. (01 July 2019). Energy-Efficient Building Design in the Context of Building Life Cycle. *Energy Efficient Buildings*, Chapter 5.

IEA climate change policy database updated. (2004). International Journal of Sustainability in Higher Education, 5(4). https://doi.org/10.1108/ijshe.2004.24905dae.001

sIEA (2015). Biomass and Bioenergy, 72, I–VII. https://doi.org/10.1016/s0961-9534(14)00562-5

Klingenberg, K. (2008). Passive house concept. In *history and economic opportunities for the US building sector.* . The Passive House Institute US (PHIUS).

Lechner, N. (1991). *Heating, Cooling, Lighting Design Methods for Architects, Canada.* John Wiley Sons .

Levine, M., Ürge-Vorsatz, K., Blok, L., Geng, D., Harvey, S., Lang, G., . . . Yoshino . (2007). *Residential and commercial buildings. In Climate Change 2007: Mitigation.*

Contribution of Working Group III to the Fourth Assessment. Cambridge University Press.

Mithraratne, N., & Vale, R. (2007). Water Supply Infrastructure & Settlement Patterns. The International Journal of Environmental, Cultural, Economic, and Social Sustainability: Annual Review, 3(3), 141–152. https://doi.org/10.18848/1832-2077/cgp/v03i03/54362

Mu'azu, A. I. (September 2012). Scenario of Energy Consumption of Office . *International Journal of Science and Advanced Technology (ISSN 2221-8386)*, Volume 2 No 9 .

Nwofe, P. A. (2014). Need for energy efficient buildings in Nigeria. *International Journal of Energy and Environmental Research,*, 2(3), 1-9.Occupational Safety and 174, 672-681.

Olgyay , V. (1969). *Design with Climate Bioclimatic Approach to Architectural Regionalism,* . Princeton, New Jersey:: Princeton University Press.

Özdemir, B., & Sürdürülebilir , Ç. O. (2005). *Energy efficient building design as passive systems for a sustainable environment.* stanbul: Istanbul Technical University, Graduate School of Engineering and Sciences.

Perez-Lombard, L. J. (2008). A review on buildings energy consumption information. Energy and Buildings.

Raji, B., Tenpierik, M., & van den Dobbelsteen, A. (2017). Early-stage design considerations for the energy-efficiency of high-rise office buildings. In *Sustainability* (pp. 9(4), 623.).

Rolf Johansson (2003) *Proceedings of the international conference methodologies in housing research.* https://www.researchgate.net/publication/236143987_Case_study_methodology

Sector. (2010, December 18). *Total Energy Consumption in US*. Retrieved from Architecture 2030.: http://architecture2030.org/the_problem/buildings_problem_why

Soysal, S., & Konut , B. T. (2008). *Relation Between Design Parameters and Energy Consumption in Housing Buildings.* Ankara: Gazi University.

Spenser , R., Robert , S., Eunkyu , L., & Andrew , K. (July 2016). Demand for Green Buildings: Office Tenants' Stated Willingness-to-Pay for Green Features. *Journal of Real Estate Research*.

Spitler, J. (2006). Building performance simulation: the now and the not yet. . In *HVAC Res* (pp. 12(3a):549–51.).

UNEP. (2022). *Sustainable Buildings*. Retrieved from UN EVIRONMENT PROGRAMME UNEP: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/sustainable-buildings

Vale, B., & Vale , R. (1975). *The autonomous house: design and planning for self sufficiency.* London: T;: hames and Hudson.

Vale, B., & Vale , R. (1997). Ecological Architecture: The Cutting Edge? . *In: Proceedings of Solar 97 – Australian and New Zealand Solar Energy Society, Canberra, Australia;* , p. paper 72.

Veal, A. J. (2005). Business research method: a managerial approach (2nd ed). *Frenchs Forest: Pearson Addison Wesley.*

Yılmaz, a., & Akıllı , B. (2005). *Smart Buildings and Renewable Energy.* 23–26 Kasım 2005, İzmir, pp. 1–8.: 7. Ulusal Tesisat Mühendisliği Konferansı.

Yüksek, I. (2008). *A Study on Ecological Assessment in Traditional Anatolian Architecture (A Case Study: Rural Area of Kırklareli Province).* Trakya University.

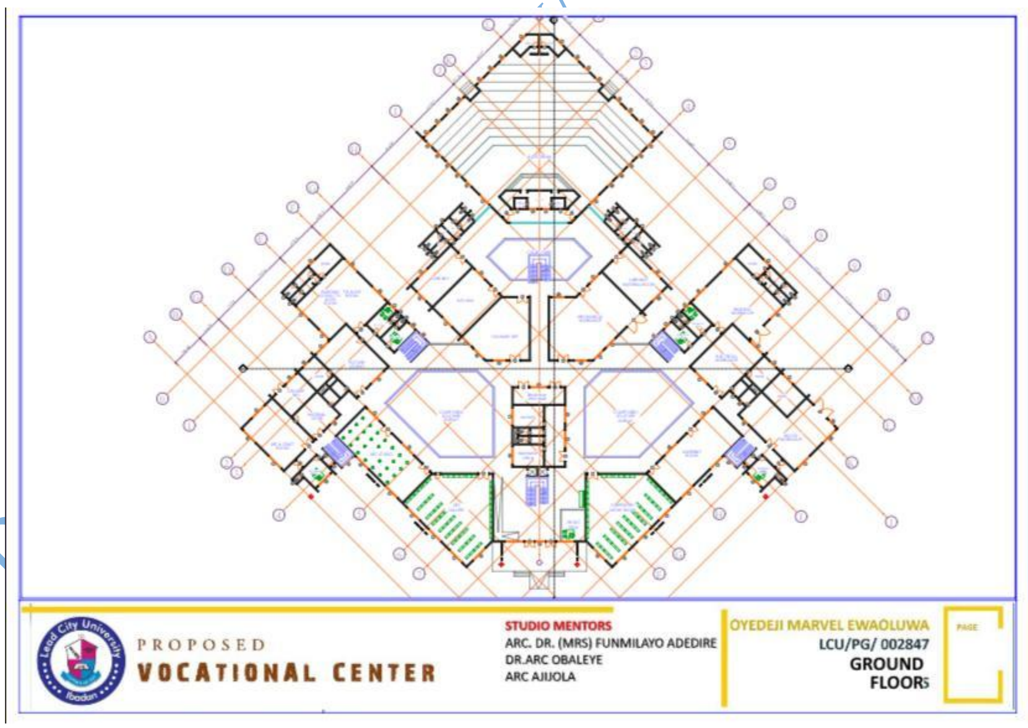
Yüksek, I., & Esin, T. (2013). Analysis of traditional rural houses in Turkey in terms of energy efficiency. *International Journal of Sustainable Energy*, 32(6):643–658.

Zeybek , Ö. (2009). *Energy Savings of Primary School Building in Turkey Through Energy Efficient Renovation Strategies in Building Envelope.* Istanbul: İstanbul: Technical University, Institute of Science and Technology;.

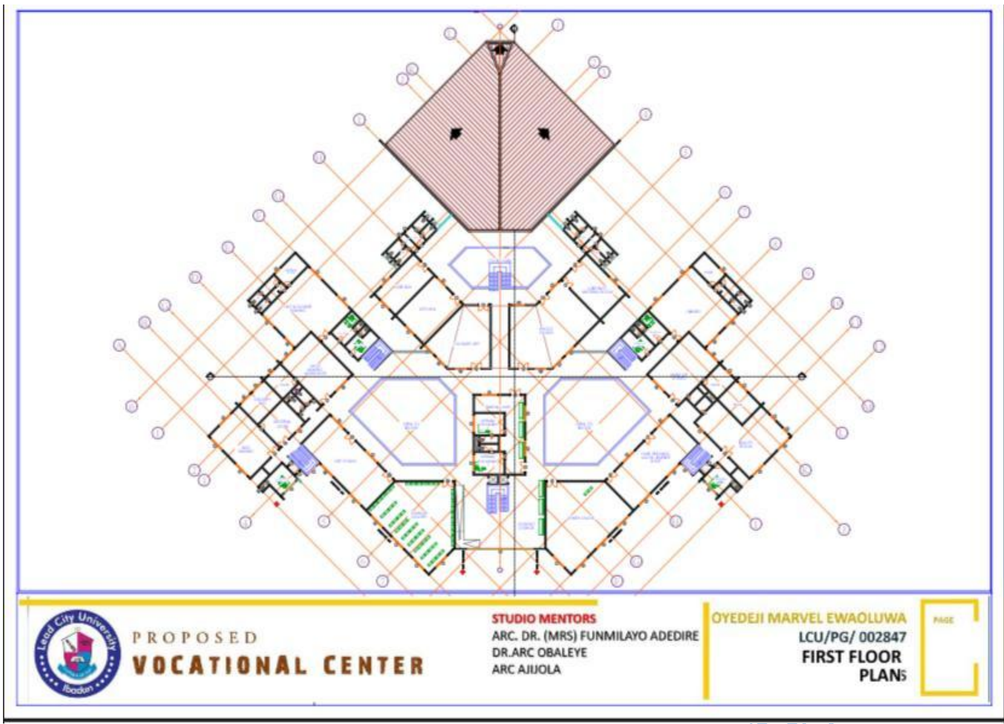
Appendix

Appendix I Presentation Drawings

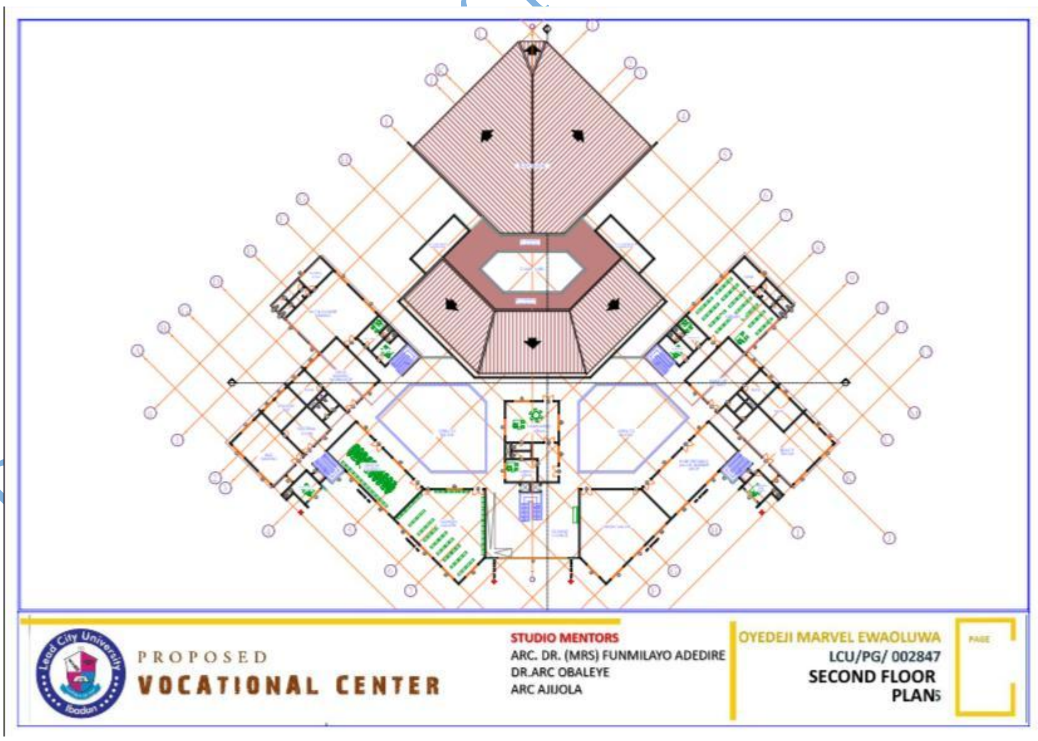
Site Plan



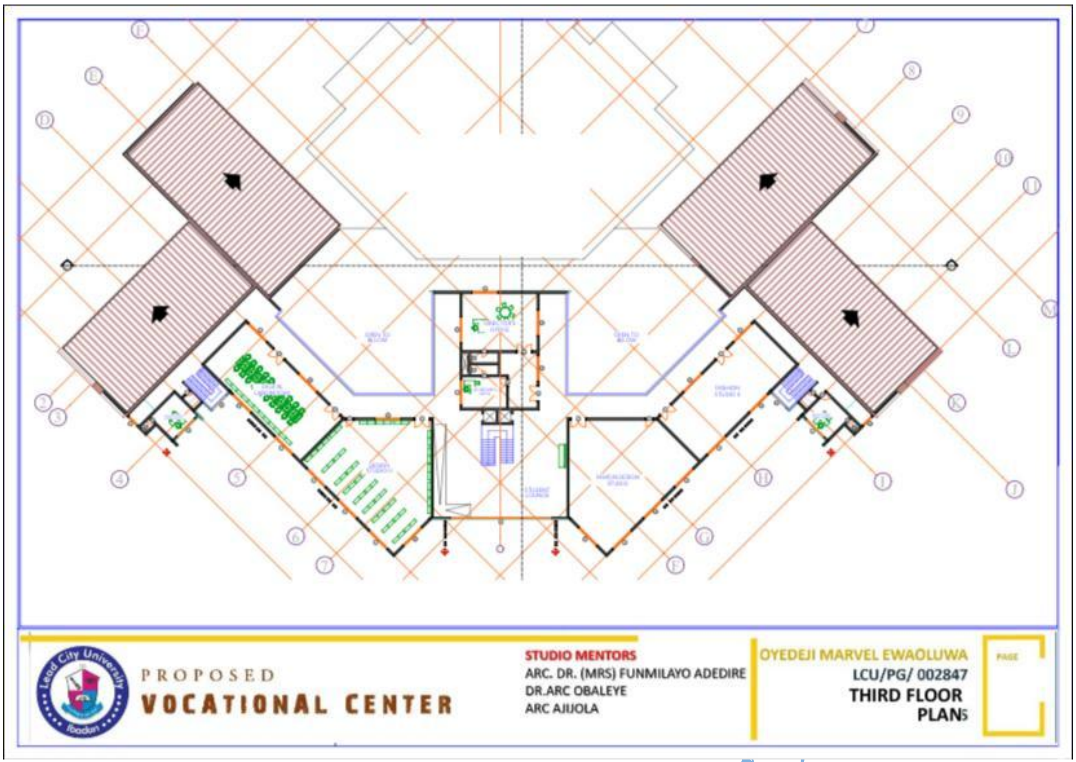
Ground Floor Plan



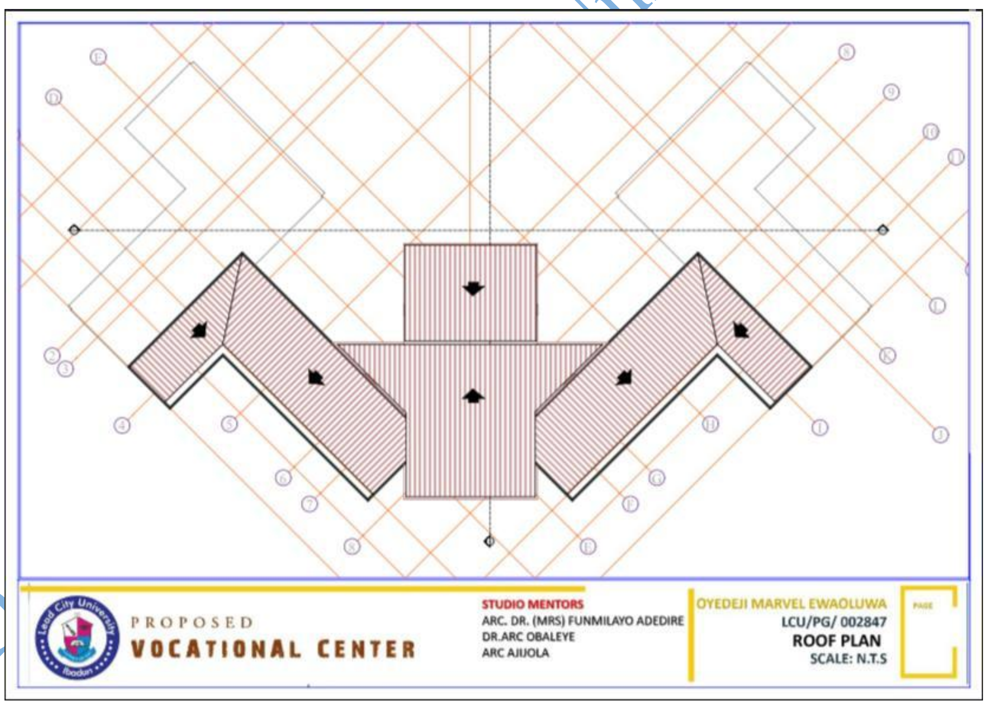
First Floor Plan



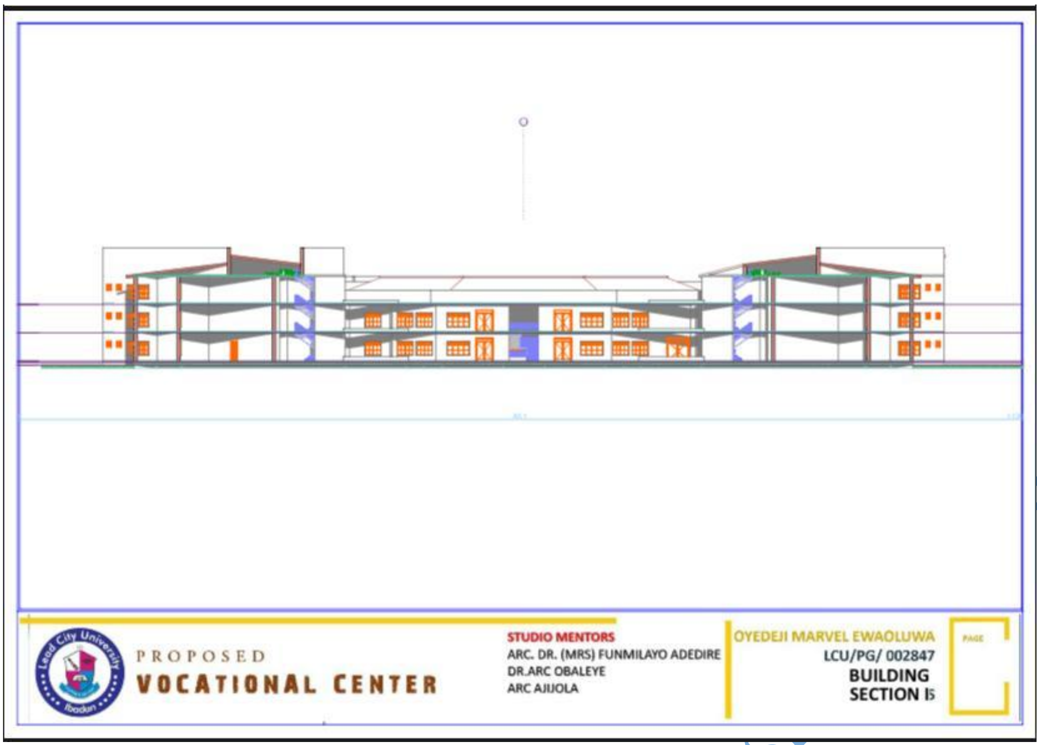
Second Floor Plan



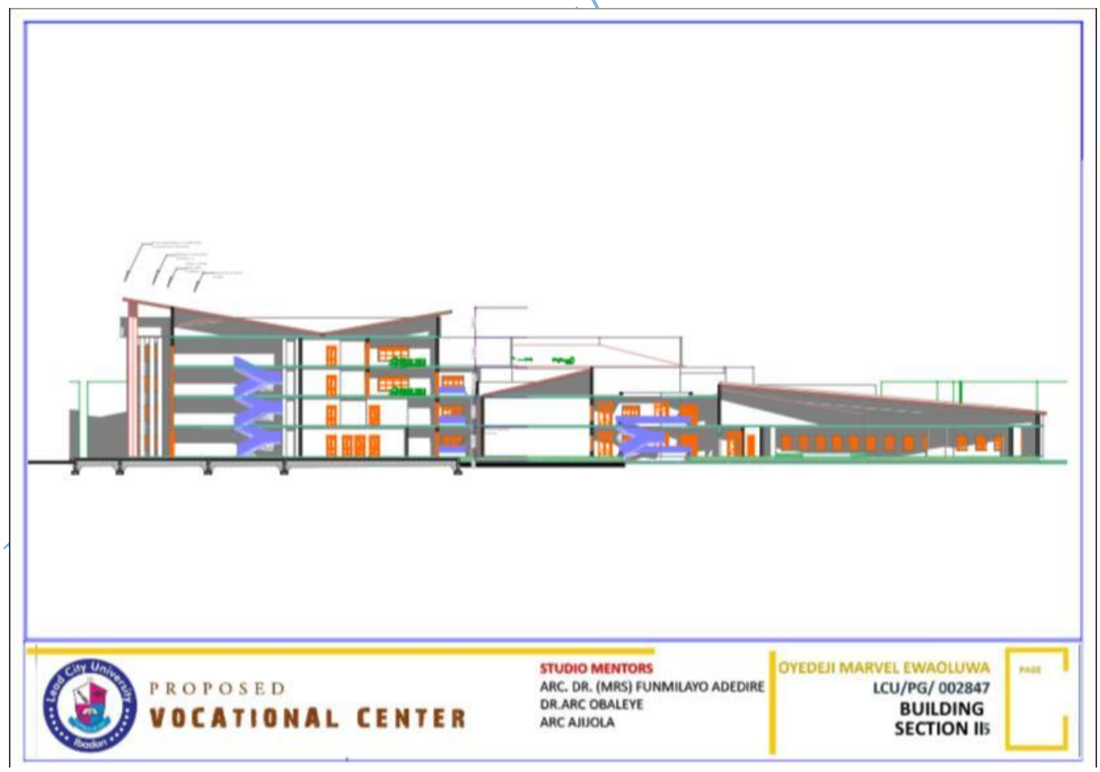
Third Floor Plan



Roof plan



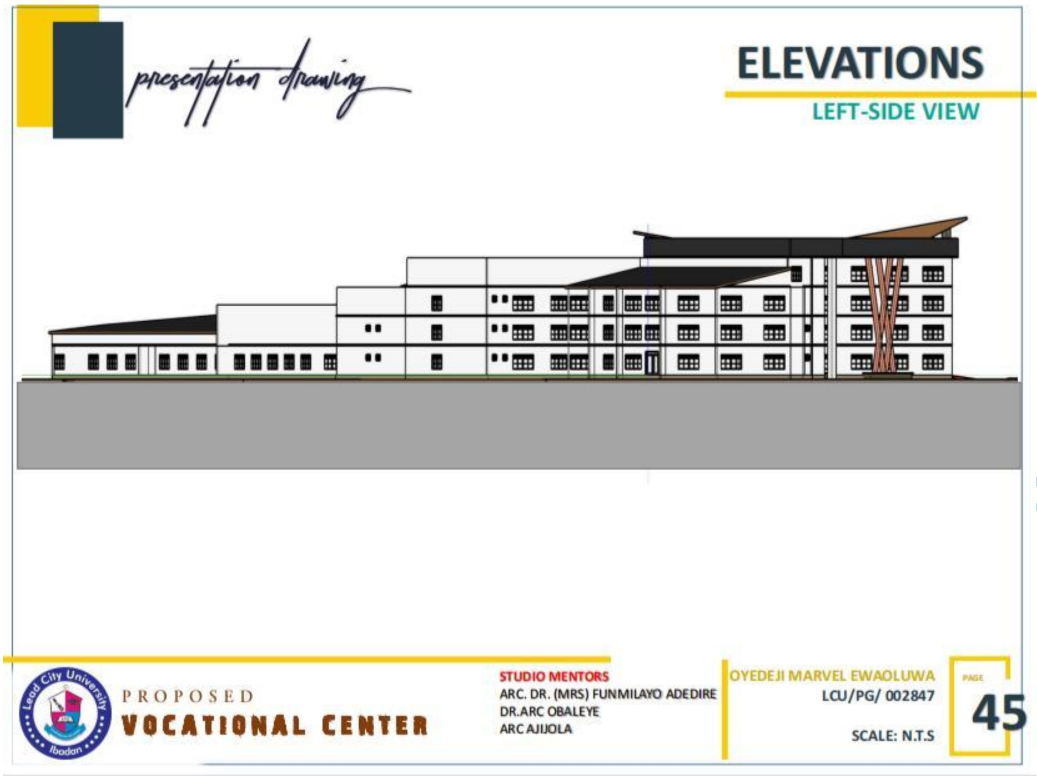
Section 1



Section 2

Front Elevation

Right Elevation



Left Elevation

Rear Elevation

3D View

3D View

3D View

3D View

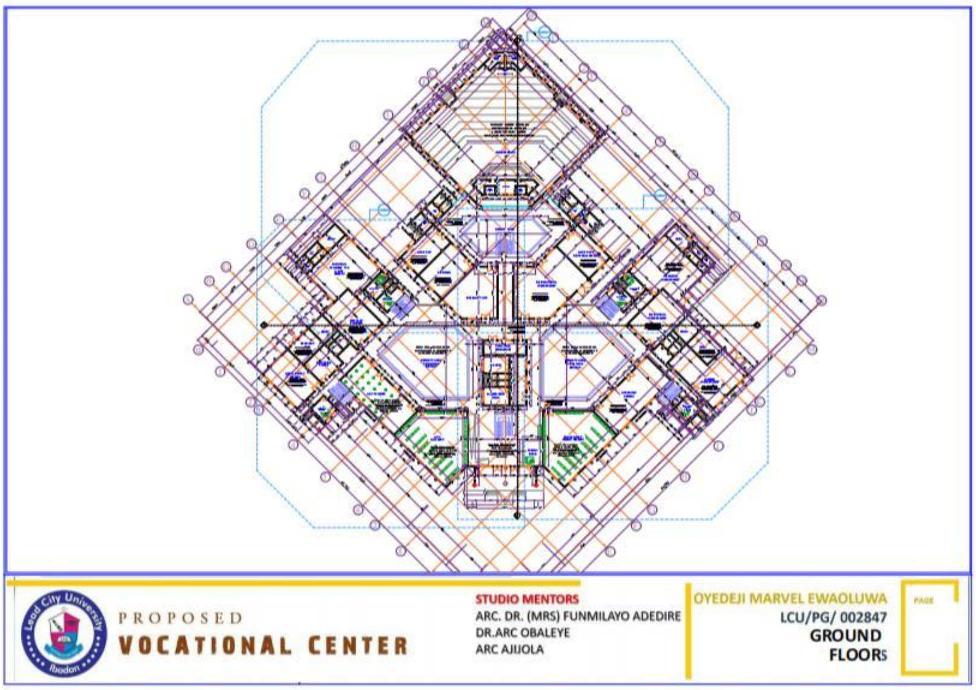
3D View

3D View

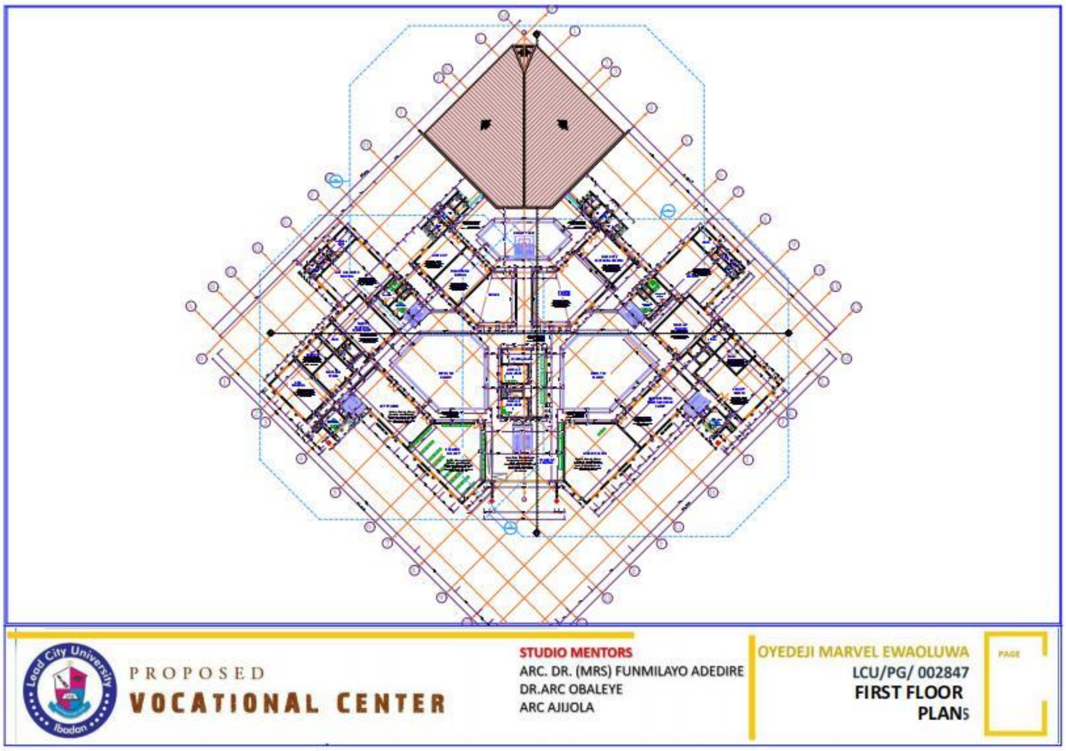
Appendix II

Working Drawings

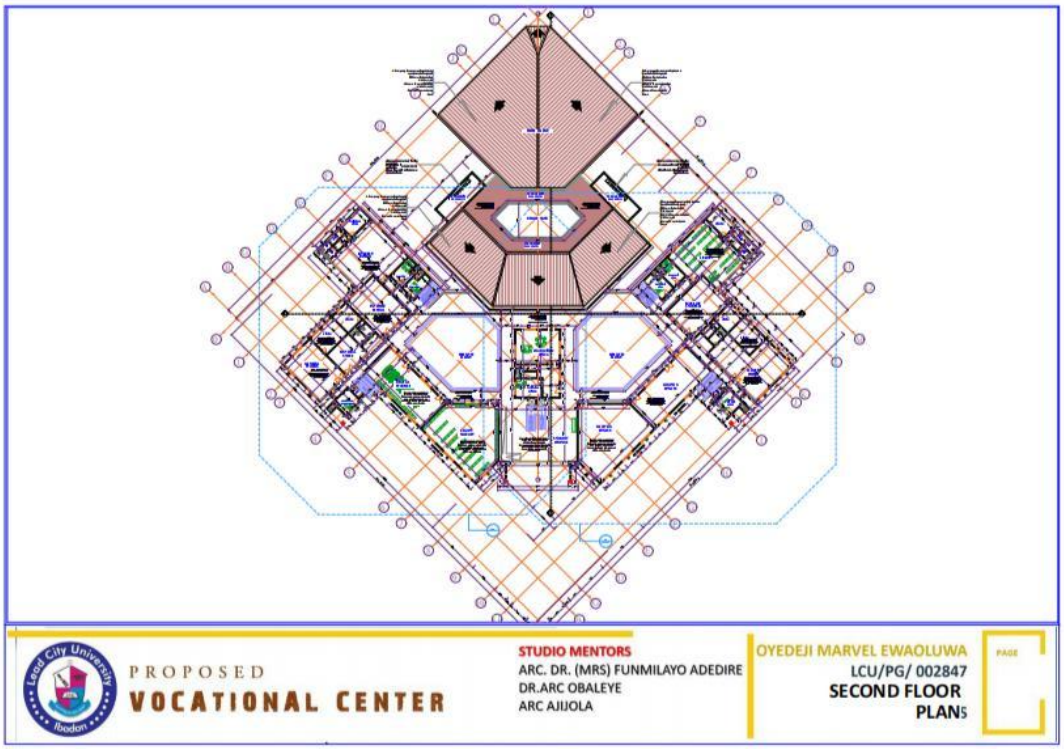
Site plan



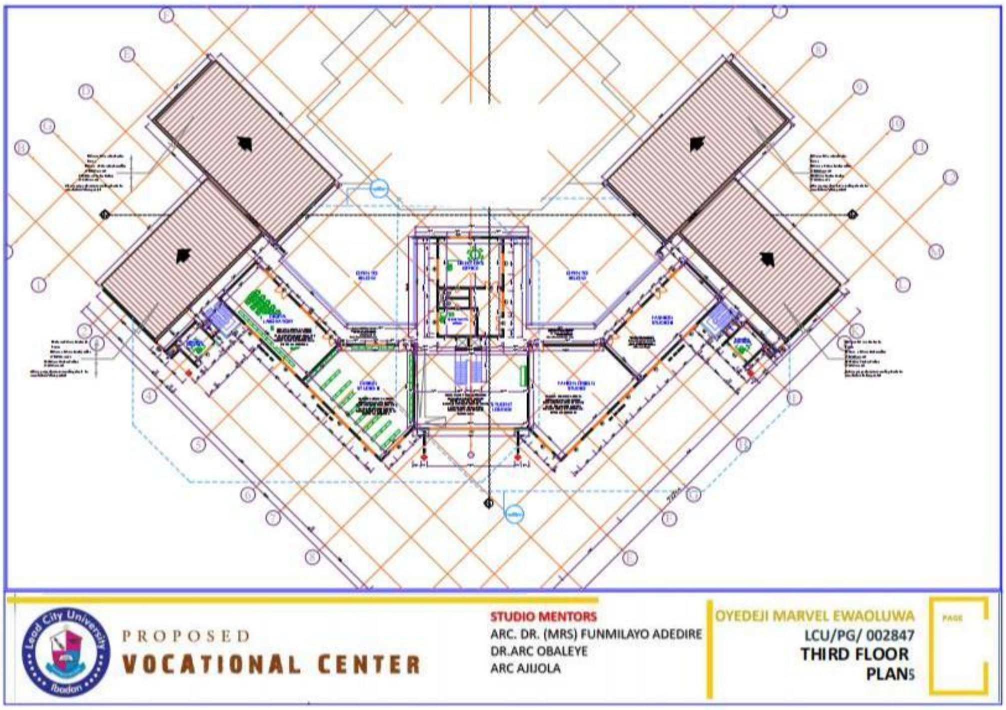
Ground floor plan



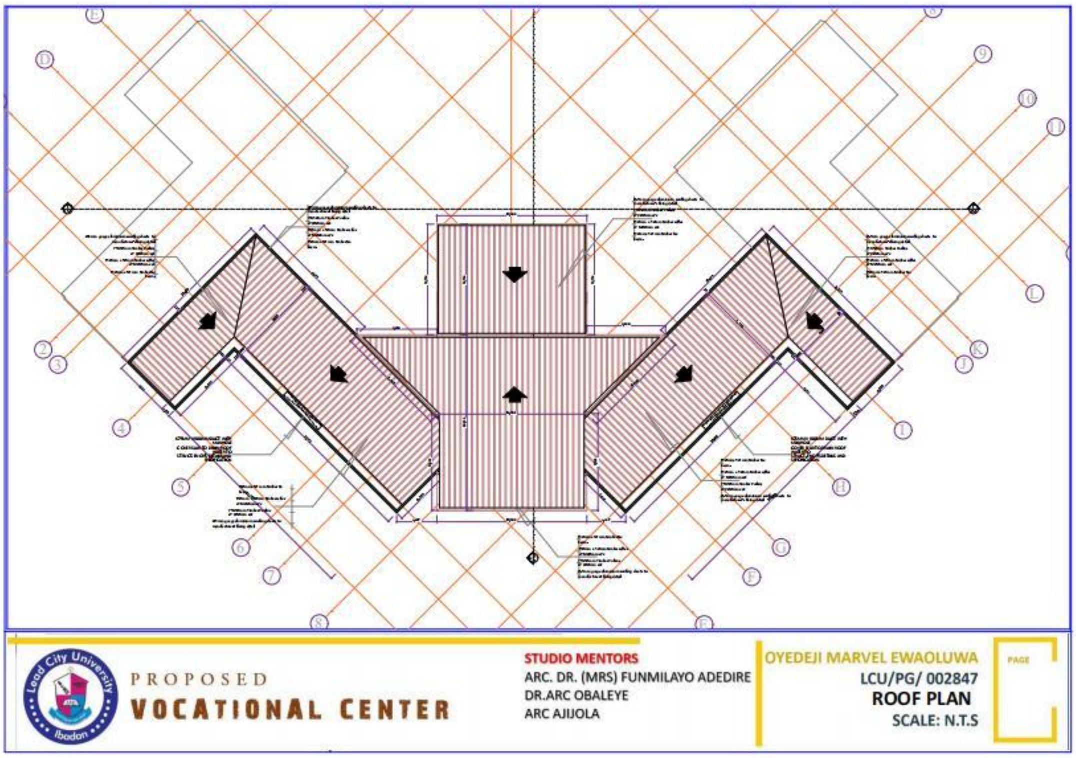
First floor plan



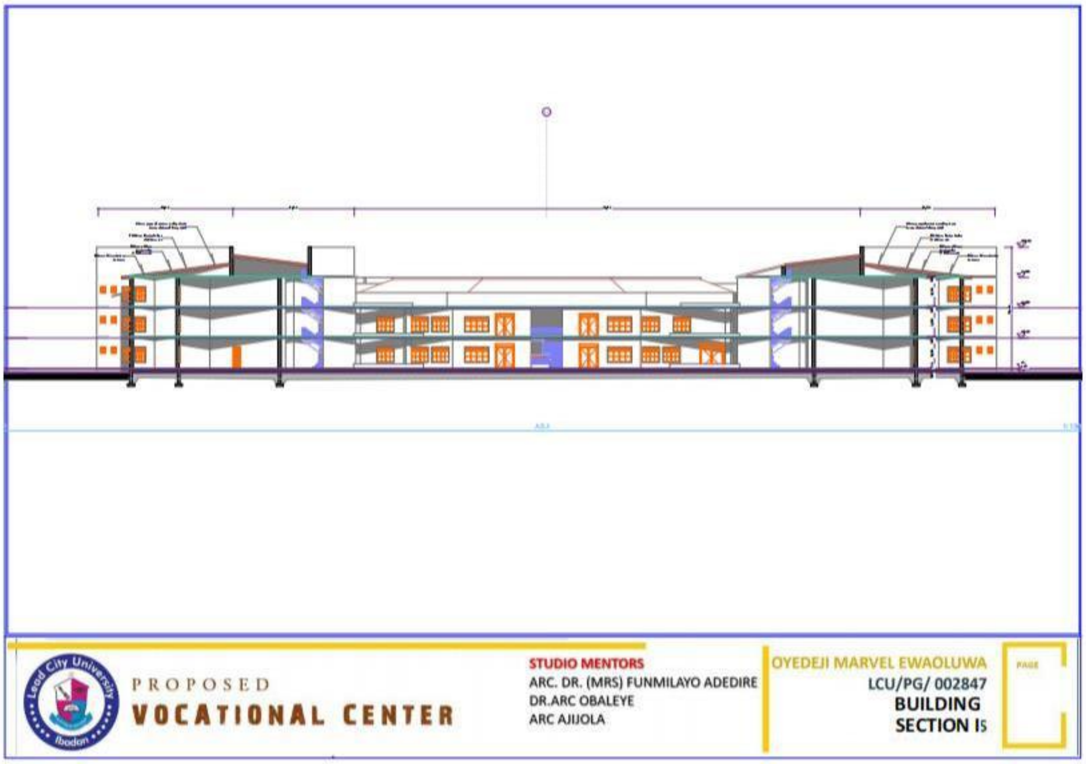
Second floor plan



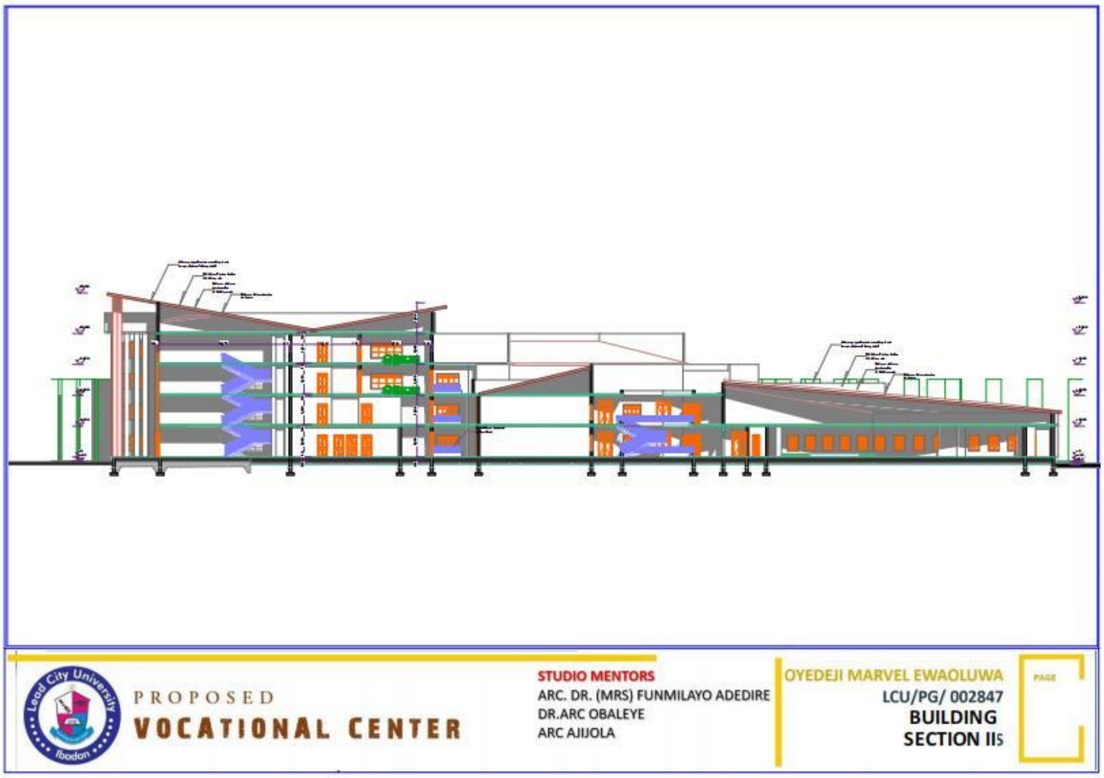
Third floor plan



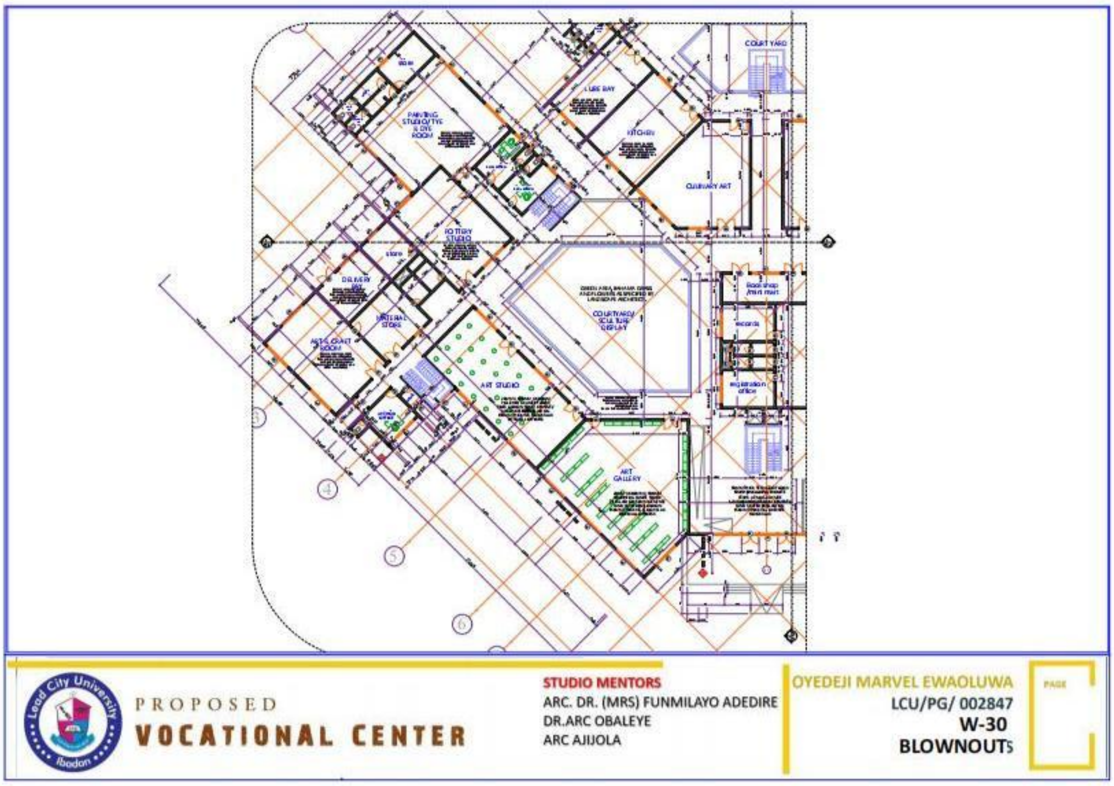
Roof plan



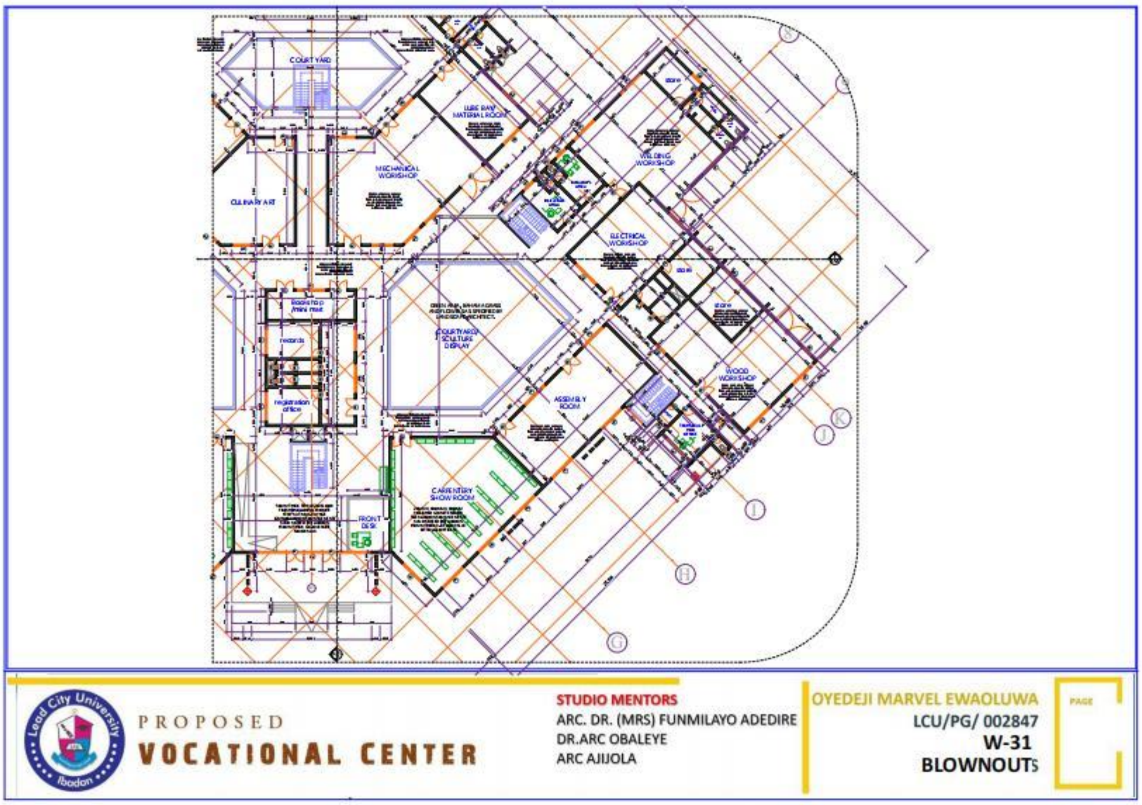
Section



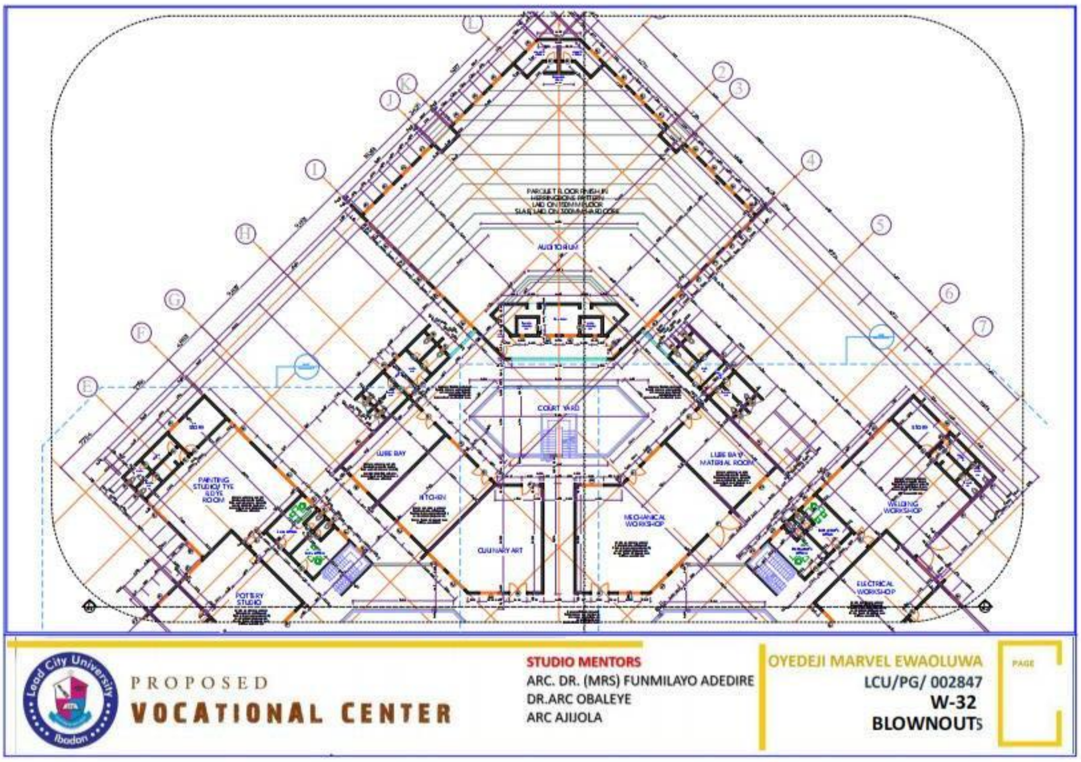
Section 2



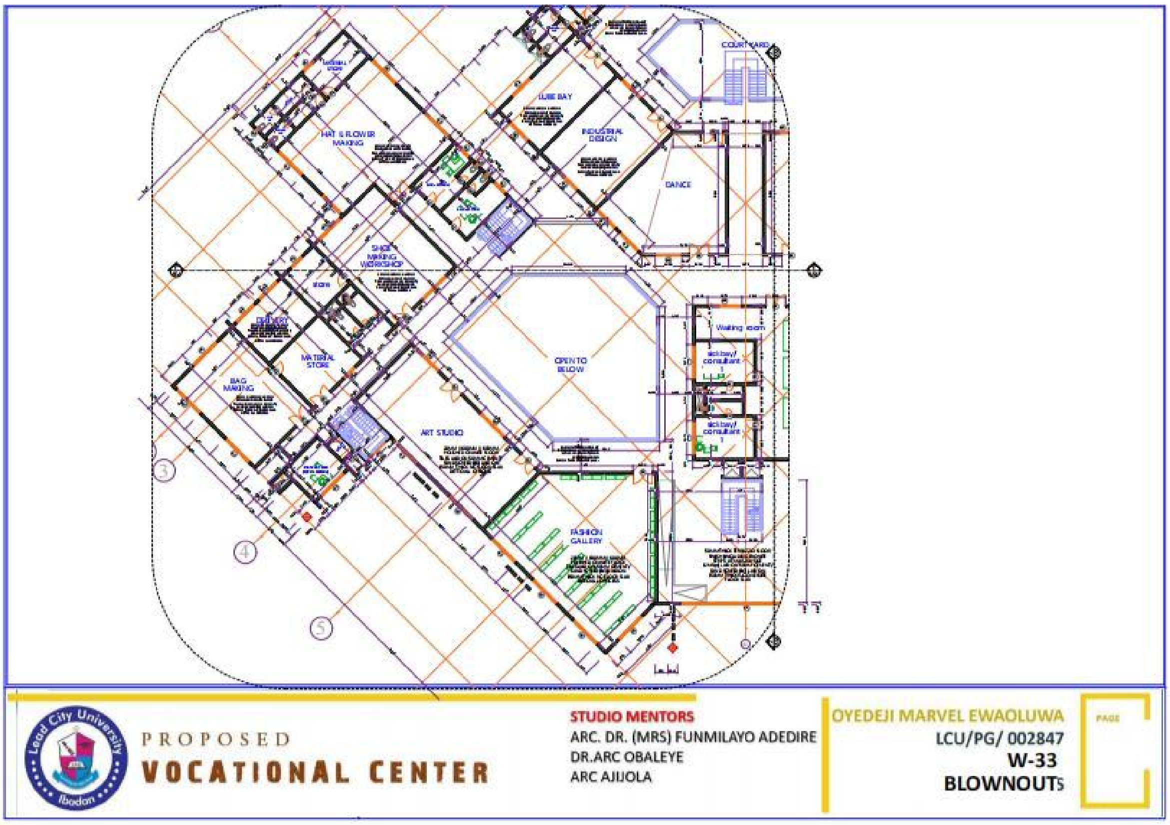
Blown-out 1



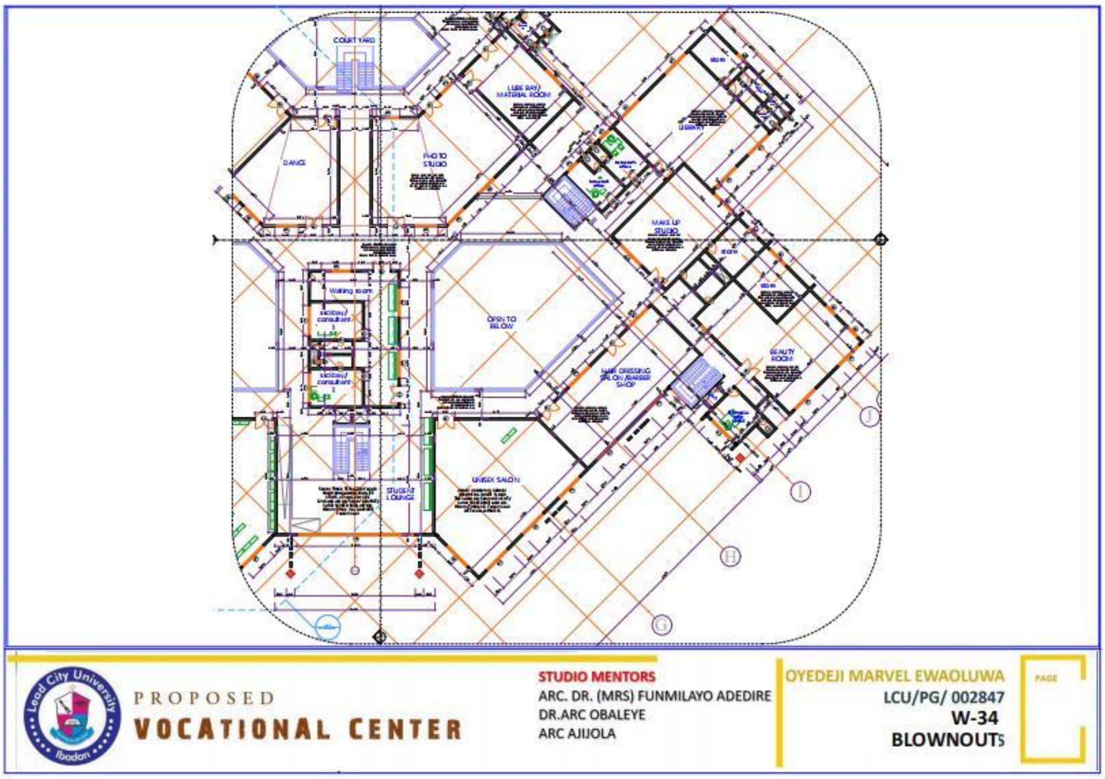
Blown-out 2



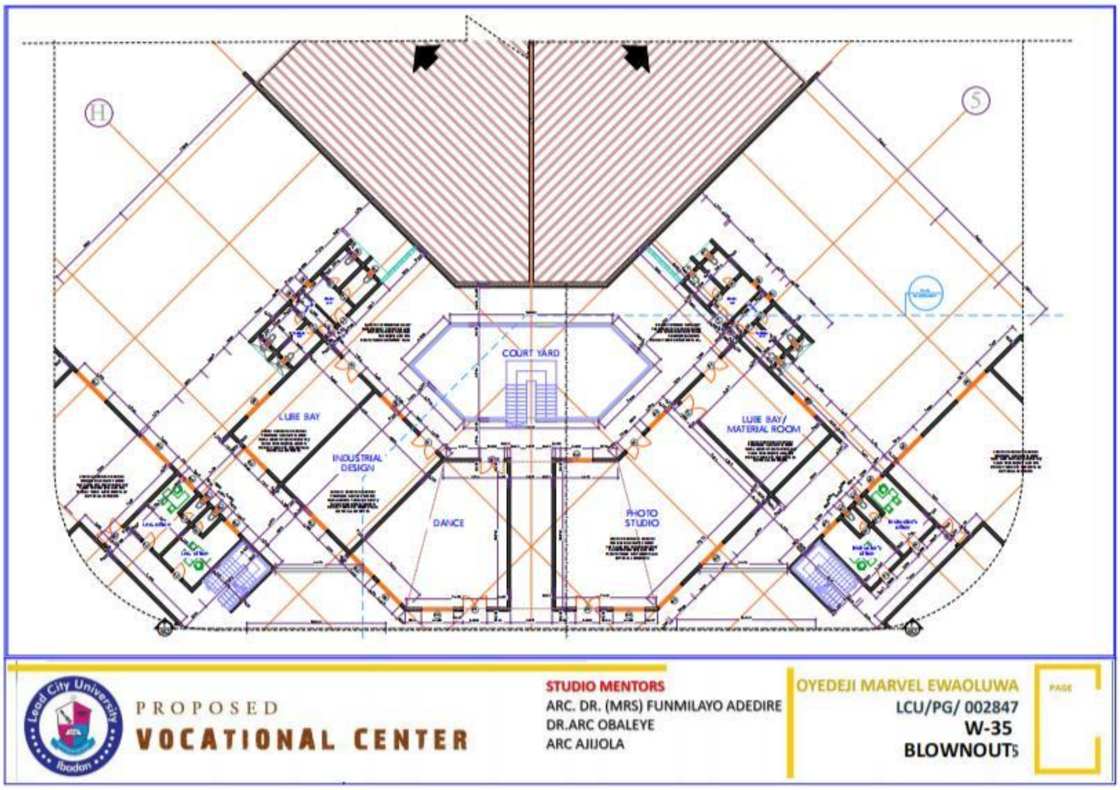
Blown-out 3



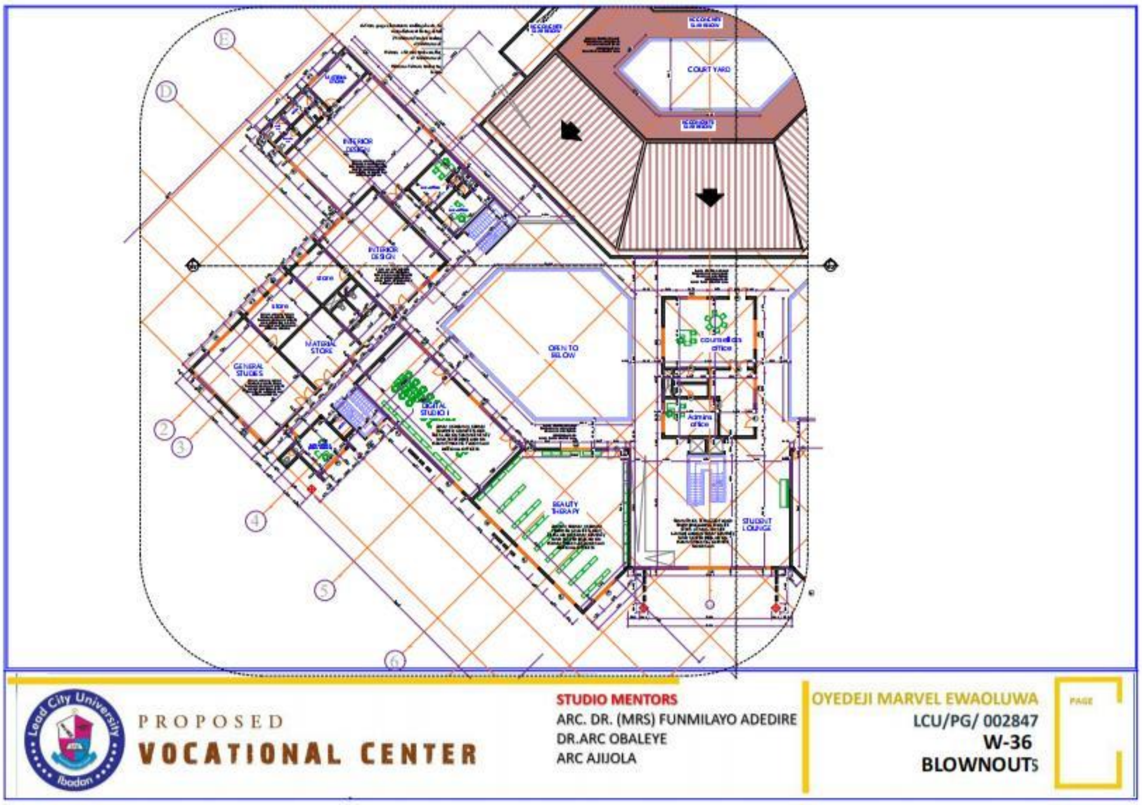
Blown-out 4



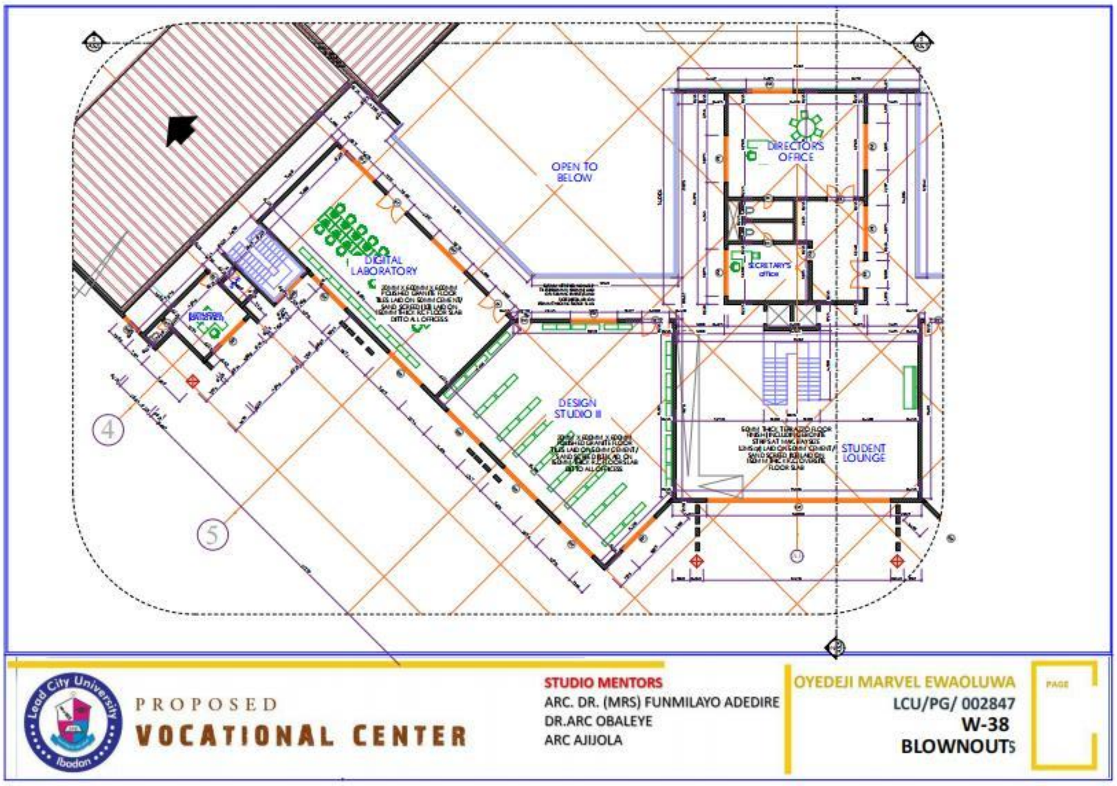
Blown-out 5



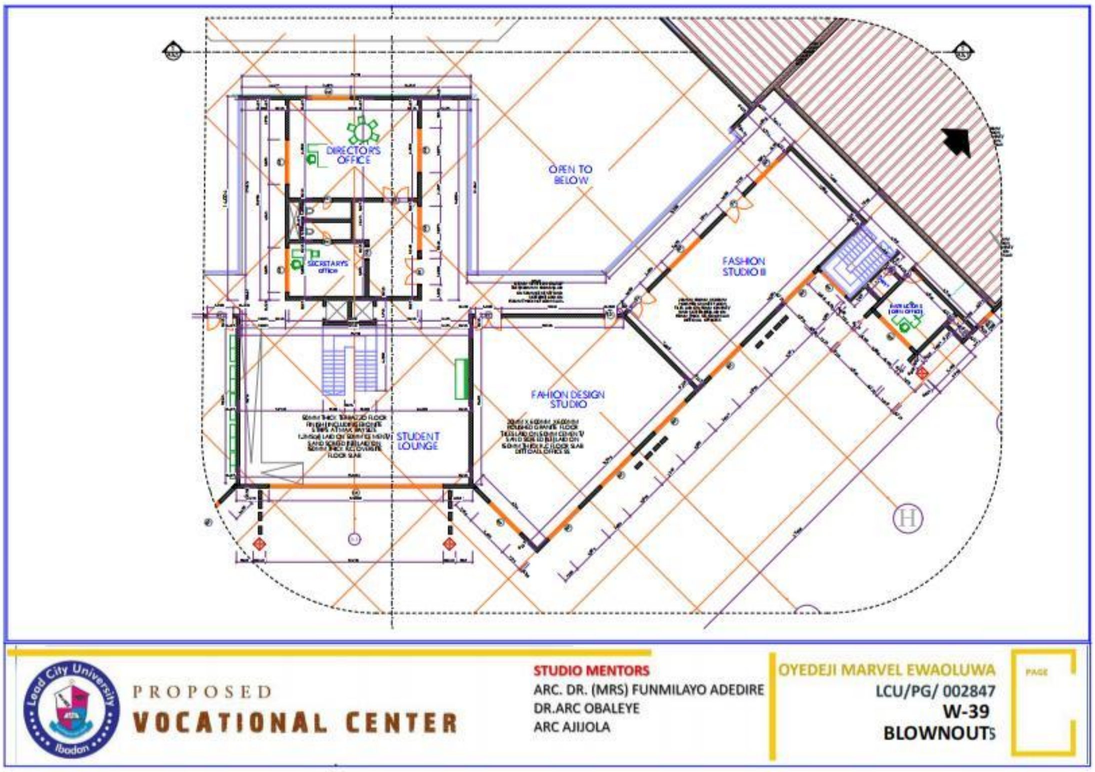
Blown-out 6



Blown-out 7



Blown-out 8


DIRECTOR'S OFFICE
SECRETARY'S office
OPEN TO BELOW
FASHION STUDIO II
FASHION DESIGN STUDIO
STUDENT LOUNGE
PROPOSED
VOCATIONAL CENTER
STUDIO MENTORS
ARC. DR. (MRS) FUNMILAYO ADEDIRE
DR.ARC OBALEYE
ARC AJIJOLA
OYEDEJI MARVEL EWAOLUWA
LCU/PG/ 002847
W-39
BLOWNOUTS
PAGE

Blown-out 9

Bio-Data

A. Personal Data

Full Name:	**OYEDEJI Marvel Ewaoluwa**.
Address:	No. 30, Peace zone, Agandi estate, Olodo, Ibadan.
Email Address:	girlymarvel@gmail.com
Phone Numbers:	08145248642
Date of Birth:	22nd December, 2000.
Nationality:	Nigerian.
Marital Status:	Single.
Name and Address of Next of Kin:	Dr. Tunji **OYEDEJI**, No. 30, Peace zone, Agandi estate, Olodo, Ibadan.

B. Educational Background

Educational Institutions Attended with Dates and Qualification:

Qualification	**Institution**	**Date**
MSc. Architecture	Lead City University, Ibadan, Oyo State.	2021 - Date (Ongoing)
Bsc. Architecture (Second Class lower Degree Honour)	Lead City University, Ibadan, Oyo State.	2017 - 2021
Secondary School Certificate	Regina James Academy, Ibadan, Oyo State. Triumph College, Ibadan, Oyo State.	2013 - 2017 2011 - 2013
Primary School leaving Certificate	Triumph Nursery and Primary School, Ibadan, Oyo State. Air Force Nursery and Primary School, Ibadan, Oyo State.	2009 - 2011 2005 - 2009

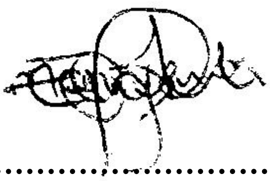
E. Publications

1. Energy Efficiency Principles in the Design of a Vocational Training Center.

Authors - Marvel Ewaoluwa OYEDEJI[1], Babajide Sunday ASEYAN[2], Saudat O. AJIJOLA[3*], Funmilayo M. ADEDIRE[4], Oludare J. OBALEYE[5]
[12345] Department of Architecture, Lead City University, Ibadan, Nigeria,
[1]Corresponding author E-mail: ajijola.saudat@lcu.edu.ng **T**; 07080152199

2. Understanding Categories, Credits and Prerequisite in Green Building Rating Sysytem.

Authors - Victor Adedeji ADEYEMO[1], Funmilayo M. ADEDIRE[2], Saudat O. AJIJOLA[3], Almustapha BAWA[4], **Marvel Ewaoluwa OYEDEJI[5]**, Oluwatobi Benjamin ADELEKE[6], Oluwafemi A. ADEWUMI[7]
[1234567] Department of Architecture, Lead City University, Ibadan, Nigeria,
[1]Corresponding author E-mail: adeyemo.victor@lcu.edu.ng **T**; 09064433894



10/10/2023

……………………………… ………………………………..

Signature **Date**

The University Compliance Certification

This is to certify that the Thesis by Marvel Ewaoluwa Oyedeji with the matriculation number LCU/PG/002847 in the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, is in full compliance with the University format and style of Thesis.

……………………………………..   ……………………………………

Signature   Date

OYEDEJI_MARVEL_EWAOLUWA_ MSC.docx LCU IBRARY

by Oyedeji_marvel_ewaoluwa_msc.docx
Oyedeji_marvel_ewaoluwa_msc.docx

Submission date: 15-Sep-2023 12:01PM (UTC+0100)
Submission ID: 2166825148
File name: OYEDEJI_MARVEL_EWAOLUWA_MSC.docx (4.25M)
Word count: 17654
Character count: 103132

OYEDEJI_MARVEL_EWAOLUWA_MSC.docx LCU IBRARY

ORIGINALITY REPORT

13%	10%	6%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.africanscholarpublications.com Internet Source	2%
2	www.intechopen.com Internet Source	2%
3	eprints.covenantuniversity.edu.ng Internet Source	1%
4	mafiadoc.com Internet Source	1%
5	Submitted to Federal University of Agriculture, Abeokuta Student Paper	1%
6	Submitted to Leeds Beckett University Student Paper	1%
7	theconstructor.org Internet Source	1%
8	Submitted to The University of Fiji Student Paper	<1%
9	wikimili.com Internet Source	<1%

61	"Passive and low energy cooling", Sustainable Energy Developments, 2016. Publication	<1 %
62	Arvind Chel, Geetanjali Kaushik. "Renewable energy technologies for sustainable development of energy efficient building", Alexandria Engineering Journal, 2017 Publication	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		