



MAKERERE UNIVERSITY

**COLLEGE OF ENGINEERING, DESIGN, ART AND
TECHNOLOGY.**

**DEPARTMENT OF ARCHITECTURE AND PHYSICAL
PLANNING.**

BACHELOR OF ARCHITECTURE

ARC5101 - RESEARCH REPORT

RESEARCH TOPIC:

A REVIEW OF THE LOCAL FURNITURE WORKSHOP DESIGN.

A CASESTUDY OF SELECTED WORKSHOPS IN KAMPALA.

PRESENTED BY:

KUNYA ISA
15/U/506

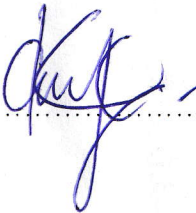
SUPERVISOR:

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF BACHELOR OF ARCHITECTURE, MAKERERE
UNIVERSITY

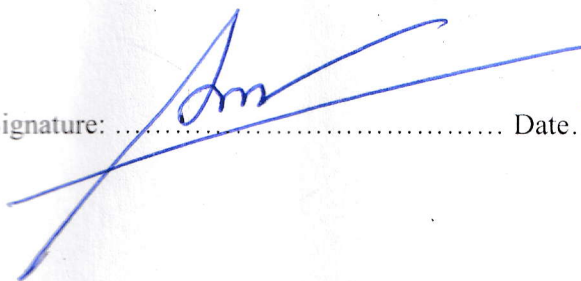
DECLARATION

I **KUNYA ISA** declare that this report is a compilation of my own original research work and has never been submitted for the award of a Degree of Bachelor of Architecture at Makerere University or any other learning institution in the world. All the information included in this report is based on my own findings.

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Signature:  Date: 30, 09, 2021

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DEDICATION

My loving Mum and Dad, thank you very much.

KJM, a friend that become family. Rest well.

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for taking me through this research by giving me strength and courage throughout this journey.

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MAY GOD BLESS YOU ALL.

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Glossary.

BRI	Building Related Illness.
CAD	Computer Aided Design.
CAGR	Compound Annual Growth Rate.
EMC	Equilibrium Moisture Content.
FLP	Furniture Layout Problem.
HAP	Hazardous Air Pollutants.
HDPE	High Density Poly Ethylene
IAQ	Indoor Air Quality.
MCS	Multiple Chemical Sensitivity.
MDF	Medium Density Fiberboards.
NCI	National Cancer Institute.
NESCAUM	The Northeast States for Coordinated Air Use Management.
NEWMOA	The Northeast Waste Management Officials' Association.
NWSC	National Water and Sewerage Corporation.
PF	Phenol-formaldehyde.
PMDI	Polymeric Diphenyl-Methane Isocyanate.
PVA	Polyvinyl acetate.
PWDs	People With Disabilities
SBS	Sick Building Syndrome.
UF	Urea-formaldehyde.
USD	United States Dollar.
USEPA	United States Environmental Protection Agency.

VHAP	Volatile Hazardous Air Pollutant.
VOC	Volatile Organic Compounds.
WIP	Work In Progress

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ABSTRACT.

The government of Uganda among the various stakeholders in the furniture industry invest heavily annually in empowering local manufacturing in the sector. This is evident in the development of training institutions all around the country. These have not only empowered the trainees with practical design skills, they have introduced them to a whole new way of design thinking especially in the furniture design sector.

The growth of the training institutions makes sense as many, developed and developing, look to more investment to benefit from the ever growing global market. With an increasing CAGR of 5.1% by 2025

1 CHAPTER ONE

1.1 Introduction.

The global furniture market size was valued at USD 480.7 billion in 2017 and is expected to grow at a CAGR (Compound Annual Growth Rate) of 5.1% from 2018 to 2025. The market is driven by various factors such as rising disposable incomes, growth of real estate and hospitality industries, and demand for luxury and premium furniture from certain consumer sections. Additionally, increasing government investments in infrastructural development is contributing towards demand for the residential and commercial sector can propel product demand in the near future.

This increased demand for furniture and furniture products therefore demands for a dedicated skill and development in the sector to compete favourably. This demand however calls for a given level of quality in the trade. Developing countries like Uganda, whose furniture quality is below world market standards are bound to face a decline in local furniture consumption and increased importation. In order to cope up with the quality demands, the government of Uganda has invested heavily in programs that empower carpenters through skilling and provision of machinery. Each year, these skilled graduates flood the market ready to work. However, there has not been a guideline on how to efficiently and effectively design workshops to help them kick start their furniture production journey with quality in mind.

1.2 Problem statement.

The quality of Ugandan locally manufactured furniture is below standard according to the world market report. The recent move by the government to ban the importation of furniture to promote local manufacturing strengthens Uganda's desire to tap into the growing furniture market. Despite this move, little has been done to improve the quality of the furniture. Some of the reasons for poor quality are attributed to poor material handling, lack of proper skilling, inadequate machinery and inadequate working space.

However, all these reasons can be attributed to the quality of the working space which affects the line of production hence the overall quality of the final products.

Much as there have been numerous efforts to educate and skill the craftsman, very little has been

discussed on the organization and design of the workshop where production happens. It is therefore critical to review the current workshop design in Uganda to better understand its contribution to the quality of the products in the local context.

1.3 Main objective.

To review the design of furniture workshops in Uganda.

1.3.1 Specific objectives.

1. Investigate the factors that influence the design of workshops in Uganda.
2. Analyze the different furniture workshop designs used.
3. To recommend the minimum design standards for the design of furniture workshops.

1.4 Research questions

1. What factors influence the design of furniture workshops in Uganda?
2. What furniture workshop designs can be employed to promote quality?
3. What are the possible recommendations for the designs of furniture workshops?

1.5 Significance of the study.

The ever-growing global furniture market (valued at USD 480.7 billion in 2017 and expected to grow at a CAGR of 5.1% from 2018 to 2025) has attracted a number of players in the recent years especially growing economies. This has increased competition among the players. The biggest factor however to gaining favour on the market has been driven by innovativeness and quality, with a special emphasis on quality. The quality of the final furniture product is determined by a number of factors including materials used, skill and knowledge, manpower and machinery as well as working environment. It is upon the basis of this argument therefore that the study seeks to review the design of furniture workshops in Uganda as a contribution towards improving the quality of the products in the trade.

1.6 Justification

With the growing need for quality furniture products within the country and the global market, Uganda risks losing a lot of revenue especially from the residential and commercial construction sectors if the issue is not addressed. Also, architecture is bound to create a dangerous and unsafe environment as a result of poor-quality furniture in the interior spaces.

1.7 Scope of study

1.7.1 Time scope

The research will be conducted during the length of the semester, from March 2021.

1.7.2 Content scope

Much as there are a number of factors that contribute to the quality of the final furniture product, this research is focused on the design of workshops as a key contributor to the quality of furniture. It analyses the current workshop layouts and their effects to the final product.

1.7.3 Geographical scope

The study will focus on Kampala district with special interest in the Nsambya furniture workshop, in Nsambya, Makindye division and Bwaise furniture workshop. The district has been chosen because it's the heartbeat of development in Uganda.

1.8 Methodology

1. Literature Review.

Study and analyze existing literature, and any other available data to guide in the research study, recommendations and conclusions.

2. Sketching

On site sketching of existing workshops.

3. Case study

Study case studies of workshops to understand their layouts.

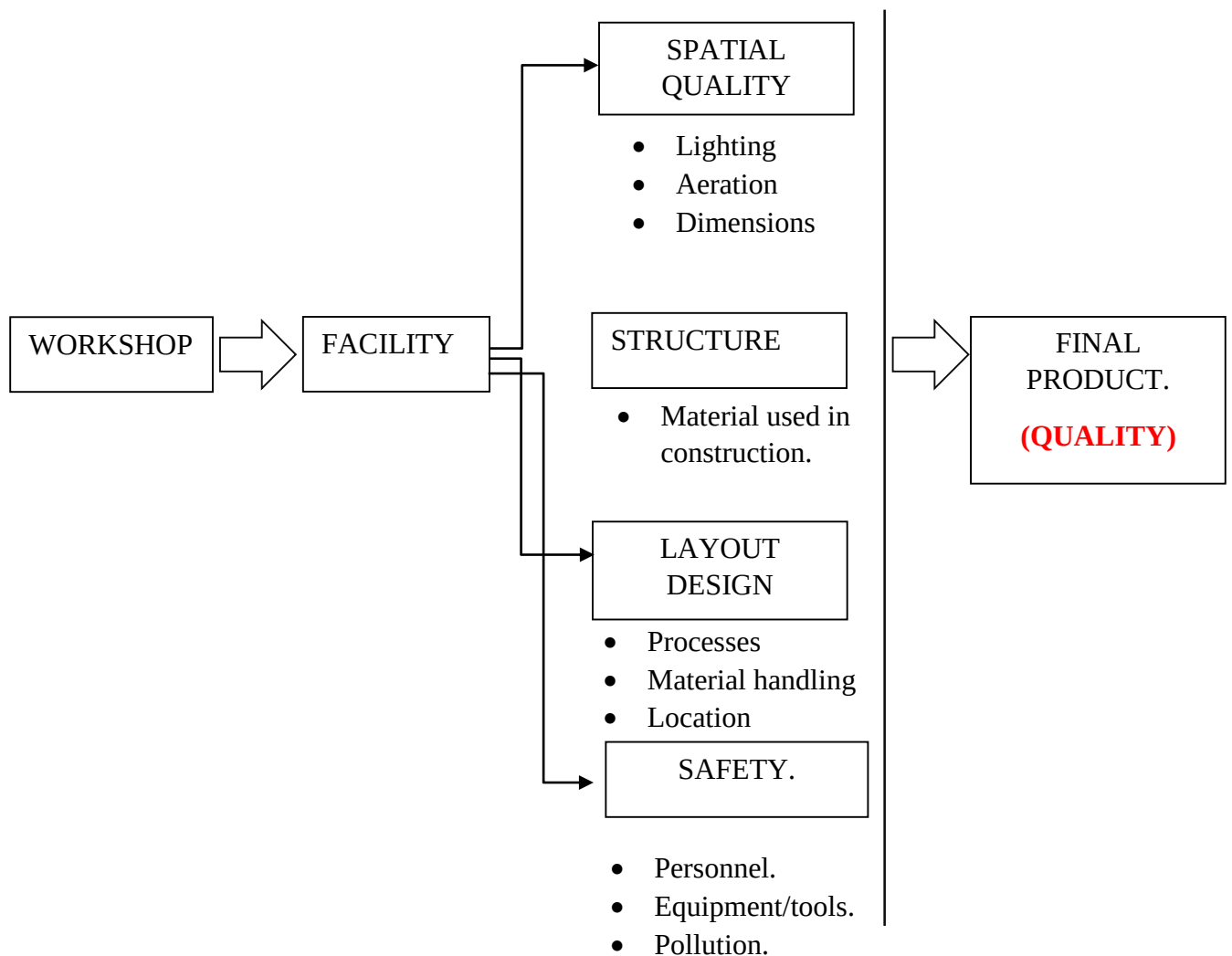
2 CHAPTER TWO: Literature Review.

2.1 Introduction

This chapter reviews relevant literature on the subject of furniture workshop design, evaluating the design layouts and spatial requirements for the ideal production so as to achieve quality in the final product.

2.2 Conceptual framework.

The conceptual framework below has been employed to tackle the issue at hand.



2.3 An overview of furniture manufacturing.

2.3.1 Major furniture producers

The world trade of furniture has grown over the years. Global furniture production was worth US\$420 billion in 2017(CSIL 2018). On the global stage, several countries have led the production of furniture due to several reasons. The figure below shows geographical regions and their furniture production on a global scale.

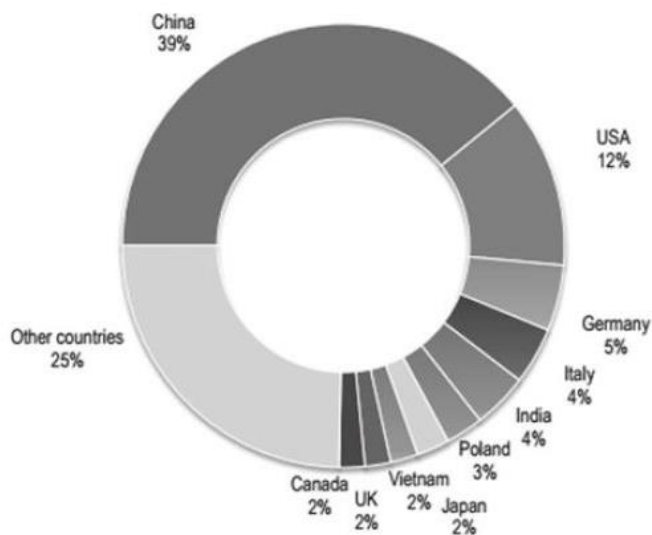


Figure 1: World leading furniture exporters. Source: Csanady, Kovacs and Magoss, 2019.

Over the last decade, China has witnessed an unprecedented growth within the furniture production globally making it the global leader in furniture production. This massive growth is owed to export-driven industrial production, foreign investment, abundant human capital among others (Csanady, Kovacs, and Magoss, 2019).

2.3.2 Manufacturing technology

Manufacturing technology for furniture production has faced advancements where computers and advanced machinery have appropriated craftsmanship and production, increasing design and production efficiencies of the furniture industry (Ratnasingam and Tanaka 2002). Among the foremost technologies applied within the furniture production field include software packages (CAD) and computer numerically controlled (CNC) manufacturing.

CAD software is a tool that helps a designer to visualize, to improve the precision of various designs, and enable them to produce 3D designs in the furniture industry (Ratnasingam et al. 2018). The application of CAD allows the ideas to be visualized before production allowing for quality and modification. This also ensures cost-effectiveness.

2.3.3 Manufacturing process

There are several stages or processes involved in the production flow of furniture. These are dependent on the type of furniture in production. These processes must be followed to get the maximum quality of the final product including quantity and durability (Ratnasingam et al. 2018). The process usually can be summarised; Lumberyard and dry kiln-to-rough mill-to-machining and sanding-to-assembly-to-finishing and finally packaging or shipping (Optimum design and manufacture of wood, 2019).

2.3.3.1 Lumber yard

The yard is a storage facility of raw materials, where the lumber is sorted into species, size, thickness, and length. During storage, the lumber is subjected to air drying. Kiln drying is also employed to attain optimum moisture content of 12 and 15% in the lumber. Kiln drying is a process of placing the lumber in a kiln where heated air is circulated with controlled relative humidity to reach the desired equilibrium moisture content (EMC) of the lumber.

2.3.3.2 Milling.

Milling is the process of converting dried lumber into dimensioned components. It involves planning, cutting gluing. The final product usually comes in a rectangular component with a specific rough dimension of length, width, and thickness.

A number of tools can be used in the milling process, including planer, saw, edger.

2.3.3.3 Machining and sanding.

Several tools can be used in the milling process, including planer, saw, edger. The sized lumber is then processed into components to achieve the required or specific shapes, profiles, and sizes for furniture manufacturing. These processes involve different machines such as molder, router, round end tenoner, and oscillation mortiser. Sanding is a process to smooth the

surface of the component for finishing. All components will be sent through the sanding process before assembling, once the construction manufacturing process of furniture is done.

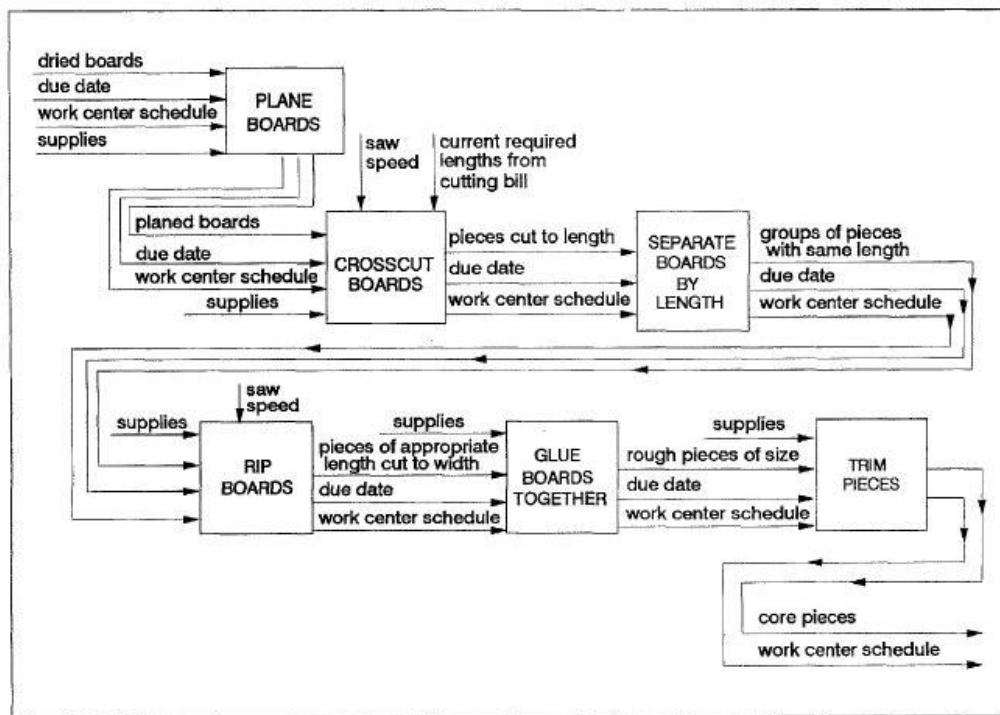


Figure 2: Summary of the machining process of a furniture piece(Kristen, Subhash and Bruce, 1992).

2.3.3.4 Assembly.

At this stage, the components are put together logically to achieve the desired design. Adhesives and joints are usually utilized in the assembly process. Adhesives commonly used include urea-formaldehyde (UF), phenol-formaldehyde (PF), polymeric diphenyl-methane diisocyanate (PMDI), hot melt and the polyvinyl acetate (PVAc). PVAc is the most widely used adhesive within the furniture industry (Bandel 1995). The common furniture joints used are the dowel, mortise-tenon joints and for flat panels, finger joints are increasingly popular. New techniques of joinery like edge-banding, overlaying with veneers and profile-wrapping especially in wood-based furniture have seen a rise (Bandel 1995).

2.3.3.5 Finishing.

This is when the assembled piece(s) are prepared for the ultimate look and feel. A range of coatings like stains, varnishes and other required materials are applied in a given order with a given measure

to attain the desired appearance. Cox (20013) defines wood finishing as the process of refining or protecting a wooden surface. This process enhances the beauty of the product in appearance while adding other properties such as being easy to clean (Gibbia, 1981).

The finishing material can be applied by dipping, roller-coating and spraying, with the spraying technique being the most common finishing application technique since it requires lesser time. In most furniture factories, finishing conveyors are in practice to scale back the handling time. Finishing is a crucial aspect to ensure the overall quality of the product as hence the success of furniture sales, as the appeal of the furniture through its beautiful appearance is the trigger for sales.

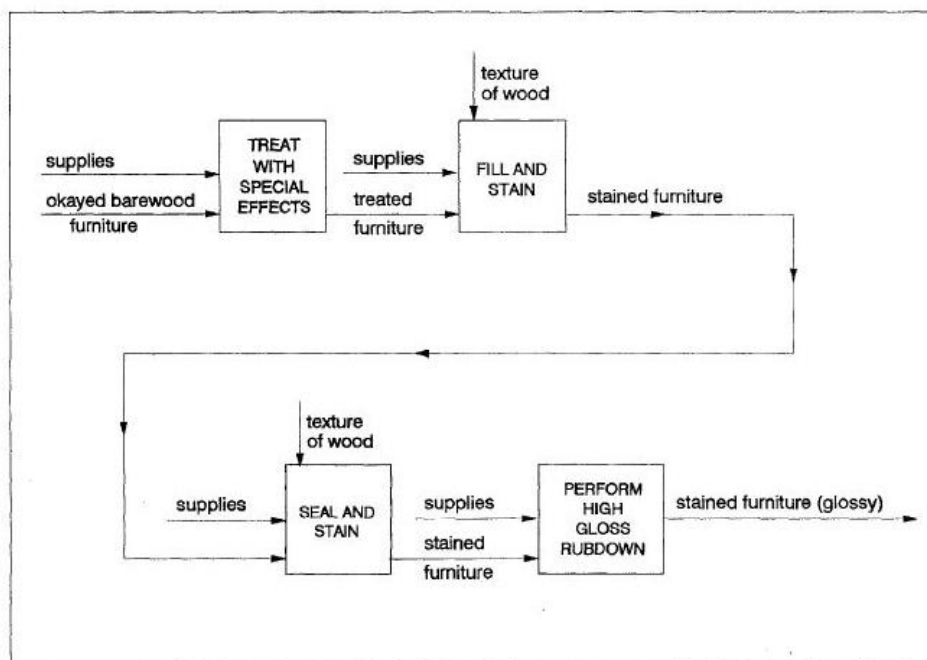


Figure 3: Summary of the finishing process of a furniture piece(Kristen, Subhash and Bruce, 1992)

2.4 Furniture workshop design.

2.4.1 The physical environment.

The physical environment is known to influence employee well-being and productivity (Dul, Ceylan and Jaspers, 2011) and the design of creative workspaces are often based on intuition rather than scientific understanding (Fayard and Weeks, 2007; Moultrie et al, 2007). Hence more research is needed to fully understand the relationship between spatial features, collaborative behaviors and innovative outcomes in the creative work environments. In particular, this applies

to a very specific class of workspace, the furniture workshop. Furniture workshops are equipped with an abundance of tools and materials which facilitate the design and production of furniture. A combination of the different materials and tools calls for a changing combination of spaces to efficiently and effectively manufacture furniture. This can be enabled or defined by the workshop concept and the spatial patterns which directly impact on the quality of the final product. Thoughtfully designed furniture workshops are key enablers of this; matching process and turn space into a valuable support tool for quality products.

2.4.2 The influence of the physical environment.

The physical environment includes all the material objects and stimuli, such as buildings, furniture, equipment and ambient conditions as well as the arrangement of these objects and stimuli (Elsbach and Pratt, 2007).

A study by Weinberg et al (2014) reveals and confirms that access to raw materials and spatial divisions influence creative teams thus the final product. People thus should be able to create spaces that facilitate and stimulate the creative manufacturing process (Asimov, 2014). Given the versatility of the activities that occur during the manufacture or even the design thinking process, workshop spaces need to fulfill various spatial requirements, giving the individual the ability to create and adopt space to meet the changing requirements (Weinberg et al, 2014).

2.4.3 Facility design and planning.

Facility planning cares with the planning, layout and accommodation of the people, machines and activities of a system or enterprise within a physical spatial environment. Several papers have been published, each presenting an analysis on different setups and suggesting improvement solutions. Take for example, Wilston and Shayan (2007) presented a model and analysis for furniture facility layout using formal analysis. They analyzed the application of different heuristic approaches to a real facility layout problem at a furniture manufacturing company. They concluded that formal layout modeling approaches can be effectively used on real problems faced in the industry and can lead to significant improvements. Shukla and Waghmare (2016) presented a study handling a layout of a bamboo furniture manufacturing facility. They indicated that furniture manufacturing unit layouts are usually revised thanks to several reasons including low production capacity, conventional machine tools, motion and work-study, erroneous materials processing, wrong

workflow directions, lack of engineering concepts and ergonomics. The authors addressed some major objectives in the design of bamboo furniture manufacturing units as a layout design based on modern engineering, contemporary machine tools, skilled manpower, ergonomically designed utilities and scope for future flexibility and these have improved the productivity and can be applied to other manufacturing systems.

2.4.4 Layout design.

The layout can be described as a schematic arrangement of systematic and Organised setup of the various departments and the various equipment that are to be used to achieve efficiency and effectiveness (Singh, 2006).

Increasing competition with rapid changes in consumer demand lead manufacturers to design or redesign their facilities and other organizational structures to satisfy the needs of the different product groups and styles. Several advanced manufacturing and decentralized and autonomous production systems have emerged in recent years to improve efficiency. Nevertheless, one of the key issues for organizing manufacturing is to select the best approach that will meet the needs best and appropriately.

2.4.4.1 Classification of Layouts.

The design of part of manufacturing workshop can be classified into two basic layout types,

- i. Functional manufacturing layout.
- ii. Cellular manufacturing layout.
- iii. Hybrid manufacturing layout.

2.4.5 Layout design, considerations.

Layout design in furniture manufacturing industry is affected by a number of factors and characteristics (Paavola, 1989);

- i. Wide assortment of products
- ii. Lot sizes tend to become small over time
- iii. Furniture, just like in the clothing industry, is affected by trends and fashions
- iv. Advanced technology created a variety of materials for production (solid wood, plastic, metal, upholstery)
- v. Also a variety of production machinery.

2.5 Human-centric design.

The physical work environment (workspace), in this case, a workshop, constitutes to the second largest financial overhead after human resources for many organizations (McCoy and Mitchell, 2005), however, the impact of workplace design stretches beyond the production of goods and services. Evidence on the subject shows the impact of the design of the physical workplace onto the users in addition to job performance and individual wellbeing (Veitch and Newsham, 2000; Vischer, 2007; Leaman and Bordass, 2005).

Whilst a well-designed environment may or may not have beneficial effects (dependent on other factors such as job design etc.), a poorly designed environment will have a negative impact (Marberry, 2004).

2.6 Architectural space.

In the rapidly changing world of technology and infrastructure, there is a need for engaging and interactive design assignments of spatial arrangements for the workplaces. Designs need to take into account the physical space, the furniture, the growing technology and the activities that will take place within the workplace. The complex tasks of shaping the modern workplace need a new design process with the active participation of users and different stakeholders (Duffy 2001).

The quality of architectural space is affected by several characteristics such as the size, lighting, aeration and sound.

2.7 Productivity.

2.7.1 Definition.

Productivity is that the efficiency of the assembly of products and services expressed by some measure. Measurements of productivity are often expressed as a ratio of aggregate output to a single input (Kaliska and Burton, 2001). Production has been discussed by several researchers, indicating factors that affect its quality and quantity. The need for privacy, status and control is basic to people's psychological comfort at work and has been some of the factors (Vischer, 2004). People see, hear and feel their environment differently depending on psychological processes such as expectations, memories, social influences as well as on physical stimuli.

2.7.2 Comfort and productivity.

Productivity is a broadly-defined general term applied at various levels of economic analysis. It ranges from population-wide measures of labor pool performance, like gross domestic product (GDP), to profit and loss statements and shareholder profits of individual corporations, right down to the scale of the individual worker or machine, like producing more widgets or reducing the time for widget production. Workspace design has a demonstrable effect on the performance of teams, workgroups and individual workers, and thereby on an organization's productivity. In order to measure organizational, team and individual productivity in terms of the effects of workspace on users, using the term 'performance' provides us with the key.

2.7.3 Lighting quality and productivity.

Lighting has been studied and proved to do more than just illumination. It can enhance form and function, improve safety and security and create flexible spaces that can adapt to the task at hand. Energy-efficient lighting solutions for the industry can reduce environmental impact and save on costs while increasing quality and productivity (Kralikova and Piňosová, 2016).

Ambient lighting is essential for optimizing visual performance and visual comfort, especially with an aging workforce. With better lighting, performance can be improved by speeding up tasks and reducing failure rates.

It may also influence cognitive performance and problem-solving ability by interfering with physiological factors like circadian rhythms (Juslen & Tenner, 2005), impact on mood and interpersonal relationships, therefore, job satisfaction (Boyce, 2003).

2.7.3.1 Definitions.

i. Quantity of light.

Quantity of light can simply be defined as the amount of light reaching the human eye. The quantity of light or Luminous energy, is a product of the luminous flux emitted multiplied by time.

ii. Light uniformity.

Is the ratio of the minimum lighting level to the average lighting level in a specified area. It's a quality parameter for the overall illuminance distribution.

iii. Illumination.

The use of light sources(Wikipedia). The sources can be natural or artificial.

iv. Illuminance uniformity.

This is the human perception of how evenly light is distributed with in a space or area.

v. Light color.

The light colour describes the colour appearance of the light.

vi. Glare.

Glare is the loss of visual performance or discomfort produced by an intensity of light in the visual field greater than the intensity of light to which the eyes are adopted. It occurs when too much light enters the eye, interfering with the eye's ability to see.

Types of glare.

i. Distracting glare

This results from light being reflected when it moves from one optical medium to another. This results in some of the light being reflected off the surface, or internally reflecting within a spectacle lens. This type of glare can also be experienced at night, forming “halos” around headlights and streetlights.

ii. Discomforting glare.

Results from direct or reflected glare caused by bright sunlight conditions, causing visual discomfort. The unprotected eye will usually respond by squinting and constriction of the pupil.

iii. Blinding glare.

Blinding glare results from light being reflected from smooth shinny surfaces such as water, reflective glass or polished metal. Reflected light is polarized thereby creating blinding glare.

2.7.3.1.1 Types of lighting

a) Natural lighting/ Daylighting

Natural light is the best and cheapest source of illumination utilizing the readily available source of light, the sun. Its efficient utilization however depends on a number of factors (Juan, 1998). Juan explains that for workers to benefit from daylight considerations such as floor area ratio to openings should be considered, with a minimum of a third of opening area.

However, a lot of care should be taken as these openings (windows and skylights) also allow the entry of heat in hot weather or points of leakages in cold weathers and the variations with the different seasons.

b) Artificial lighting.

Artificial light, in contrast to natural light, is one that is man-made from sources like fire, candlelight, electric lamps. However, this term in this context is used to refer to light as a result of electric mechanism i.e. electric lamps. The term 'lamp' refers to a light source typically comprising a light emitting element contained within an outer container (bulb or tube) which emits radiation within the visible spectrum (designing building wiki). Unlike natural light, artificial light can easily be manipulated to achieve the desired quantity and quality (colour, design, etc.). sources include incandescent, fluorescent, LED and these can be used to achieve ambient, task or accented lighting. The type of lighting used is dependent on the type of space the lighting is for, the quality and type of light required for the space and the energy consumption of the lighting fittings.

2.7.3.2 Light quality factors.

lighting quality can be defined as the extent to which the installation meets the objectives and constraints set by the client and/or the designer such as enhancing performance of relevant tasks, creating specific impressions, generating desired pattern of behaviour and ensuring visual comfort (Boyce, 2004).

Lighting quality depends on a number of factors from individual to individual. Other factors that are potential contributors to lighting quality include e.g. illuminance uniformity, luminance distributions, light color characteristics and glare. There are many physical and physiological factors that can influence the perception of lighting quality (Kralikova and Piňosová, 2016). Lighting quality cannot be expressed simply in terms of photometric measures nor can there be a single universally applicable recipe for good quality lighting (Boyce, 2004).

Light quality can be judged according to the level of visual comfort and performance required for a given task and the pleasantness of the visual environment and its adaptation to the type of room and activity.

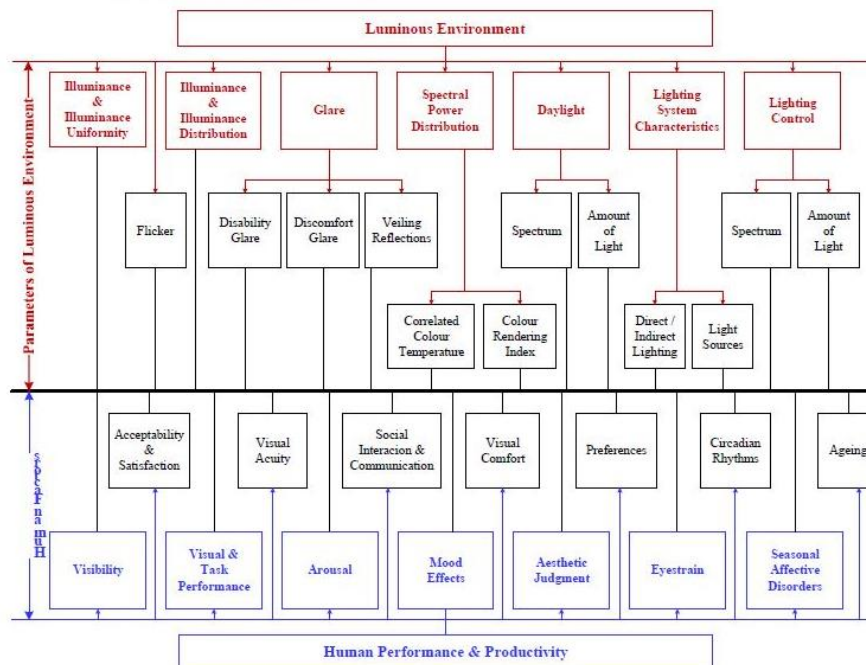


Figure 4: Luminous environment and human performance. Gligor,2004.

2.7.4 Pollution and productivity.

Research has revealed several ideas concerning air quality and productivity. Fanger (2002) suggests that to enhance productivity at workplaces, better indoor air should be promoted, unnecessary indoor pollution should be avoided, individual control of the thermal environment should be provided.

Poor IAQ is associated with many phenomena such as the Sick Building Syndrome (SBS), Building Related Illness (BRI) and Multiple Chemical Sensitivity (MCS), and they all are proven to have major effects on productivity.

The figure below shows the performance as a function of dissatisfaction with IAQ.

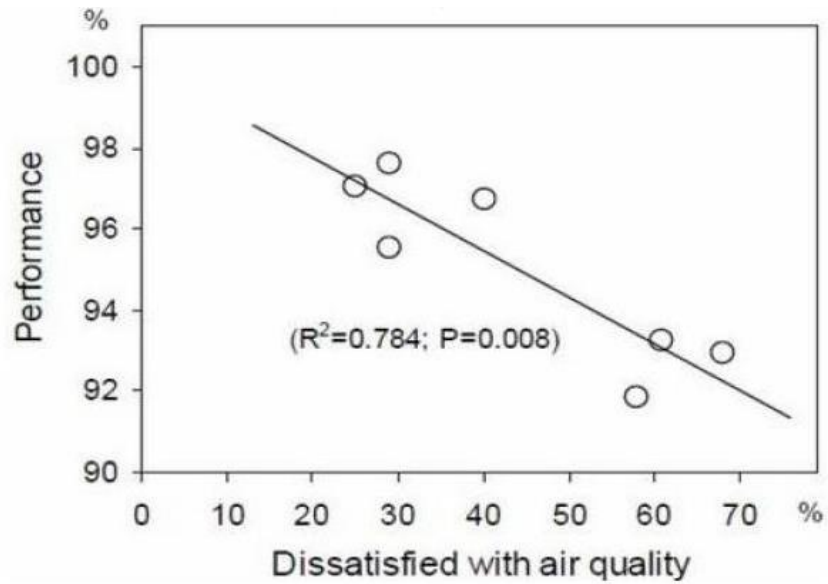


Figure 5: Performance against dissatisfaction with air quality. Source: Wargocki, www.inive.org

2.7.4.1 Definition.

The national geographic encyclopedia (2021) defines pollution as the introduction of harmful materials into the environment called pollutants. These can be natural or caused by human activity.

2.7.4.2 Sources of pollution.

Pollution in the furniture manufacturing industry is due to the operations such as drying, sawing, waxing, sanding and finishing wood or furniture products. These operations emit pollutants like hazardous air pollutants(HAP) and volatile organic compounds (VOC)(EPA). The vast majority of air emissions are generated from the coatings used in the wood finishing process (NEWMOA and NESCAUM, 1997). In the manufacture of partitions and fixtures and other sorts of wood furniture products that involve covering a material core with a wood veneer or laminate, the adhesives used can generate significant air emissions. The quantity of coatings or adhesives used, and therefore the emissions generated, also correlates with the application equipment used (NEWMOA and NESCAUM, 1997). Some air emissions also arise from the use of solvents to clean spray guns, spray booths and other equipment. Therefore, the more coating layers applied, the greater the air emissions and solid and/or hazardous wastes generated.

a) Wood Surface Finishing

There are generally two types of wood surface finishing processes, a long sequence and a short sequence. High-end furniture manufacturers use a long sequence where seven or more different types of finishing materials are applied to the wood, with several types applied more than once. Medium-and low-end manufacturers often use a short sequence consisting of three application steps: stain, sealer and topcoat (NEWMOA and NESCAUM, 1997). The relative percentage of total VOC emissions from the finishing process contributed by each of the typical application steps in the long and short sequences is shown in Table 1. All percentages refer to percent by weight.

Application Type	Short sequence(%)	Long sequence(%)
Stain	32	26
Washcoat		4
Filler		3
Wiping stain		8
Sealer	32	18
Highlight		1
Topcoat	36	40
TOTAL	100	100

Table 1: Relative VOC emissions in percentage (EPA, 1995).

Types of surface coating finishes

1. Nitrocellulose Coatings

Nitrocellulose sealers and topcoats are widely used in the furniture industry because they are easy to apply and repair, they quickly dry and familiar to the industry, providing a final product appearance that consumers are accustomed to (NEWMOA and NESCAUM, 1997). However, nitrocellulose is highly flammable; requires the use of solvents that are toxic and volatile, creating large quantities of potentially harmful emissions; and the dried finish is not highly durable - it is easy to damage, is ruined by water, and turns yellow when exposed to sunlight (EPA, 1994).

2. Catalyzed Coatings

Catalyzed coatings are used for sealer and topcoat applications, typically in the manufacture of

kitchen cabinets and high use furniture such as office desks and casual dining sets. Catalyzed coatings are more durable than traditional nitrocellulose coatings, with greater resistance to moisture, and physical and chemical damage. Acid-catalyzed topcoats are commonly known as conversion varnishes. Acid-catalyzed coatings typically have a lower VOC content and a higher solid content than nitrocellulose coatings.

Acid-catalyzed conversion coatings emit VHAPs that are different than those emitted by nitrocellulose coatings such as formaldehyde (Heltzer, 1995). Inhalation exposure to formaldehyde can result in eye, nose and throat irritation, and respiratory problems; studies have linked formaldehyde with increased cancer risk (NCI, 2021).

b) Adhesives.

Furniture manufacturers use contact adhesives for securing a laminate to an underlying wood substrate. The laminate is commonly a form of vinyl, polyvinyl chloride (PVC), coated paper, melamine or wood veneer while substrates are typically particleboard or MDF ((NEWMOA and NESCAUM, 1997). Contact adhesives can be applied with manual spray guns or brushes, or an automated system, particularly at large facilities.

The seven general categories of contact adhesives used by the wood furniture industry are solvent-based, epoxy resin, urea-formaldehyde resin, hot melt, heat seal, aqueous-based and PVA. Solvent-based, urea-formaldehyde resin and some epoxy resin adhesives contain VHAPs and/or VOCs and can generate significant air emissions. Hot melt, heat seal, aqueous-based and PVA adhesives do not generate significant air emissions at wood furniture manufacturers and are considered alternatives to solvent-based adhesives.

c) Housekeeping

Even though much of the air emission in furniture workshops is due to the active production of furniture, there are other potential sources of air emission in a wood workshop. Many of these result from "housekeeping" practices. Such practices include material storage and distribution, the maintenance of the facility and equipment, including routine cleaning. In addition, housekeeping activities at facilities generate several solid and/or hazardous waste streams.

3 CHAPTER THREE: METHODOLOGY.

3.1 Introduction

In this chapter, the researcher focuses on the research methods used to address the research questions identified in chapter 1. It starts by unveiling the methodology used which was the case study method. This is followed by the design of the study that embodies selection of cases and data collection techniques used.

3.2 Research design.

MacMillan and Schumacher (2001) define research design as a plan for selecting subjects, research sites, and data collection procedures to answer the research question(s).

The study will mainly be a qualitative approach where various tools will be employed to get the information needed. The researcher will seek to find what exists on ground in regards to the concept of furniture workshop design. A qualitative approach will be utilized in the research.

3.3 Choice of Research strategy

This study uses a qualitative methodological tradition. This is because qualitative methods are best suited for carrying out social science research as they focus on understanding the society and manner in which people behave and influence the areas around them. This research deals with a real life situation and therefore intends to understand the experiences and people's perceptions about the location, emergence and design of furniture workshops in Kampala. The method is also aims to answer the research questions of what, why or how that had been raised in this research (Patton M. Q., 2002).

3.4 Study area

The research will be carried out in Kampala city, the capital city of Uganda. It focuses on selected workshops, Bwaise and Nsambya furniture workshops.

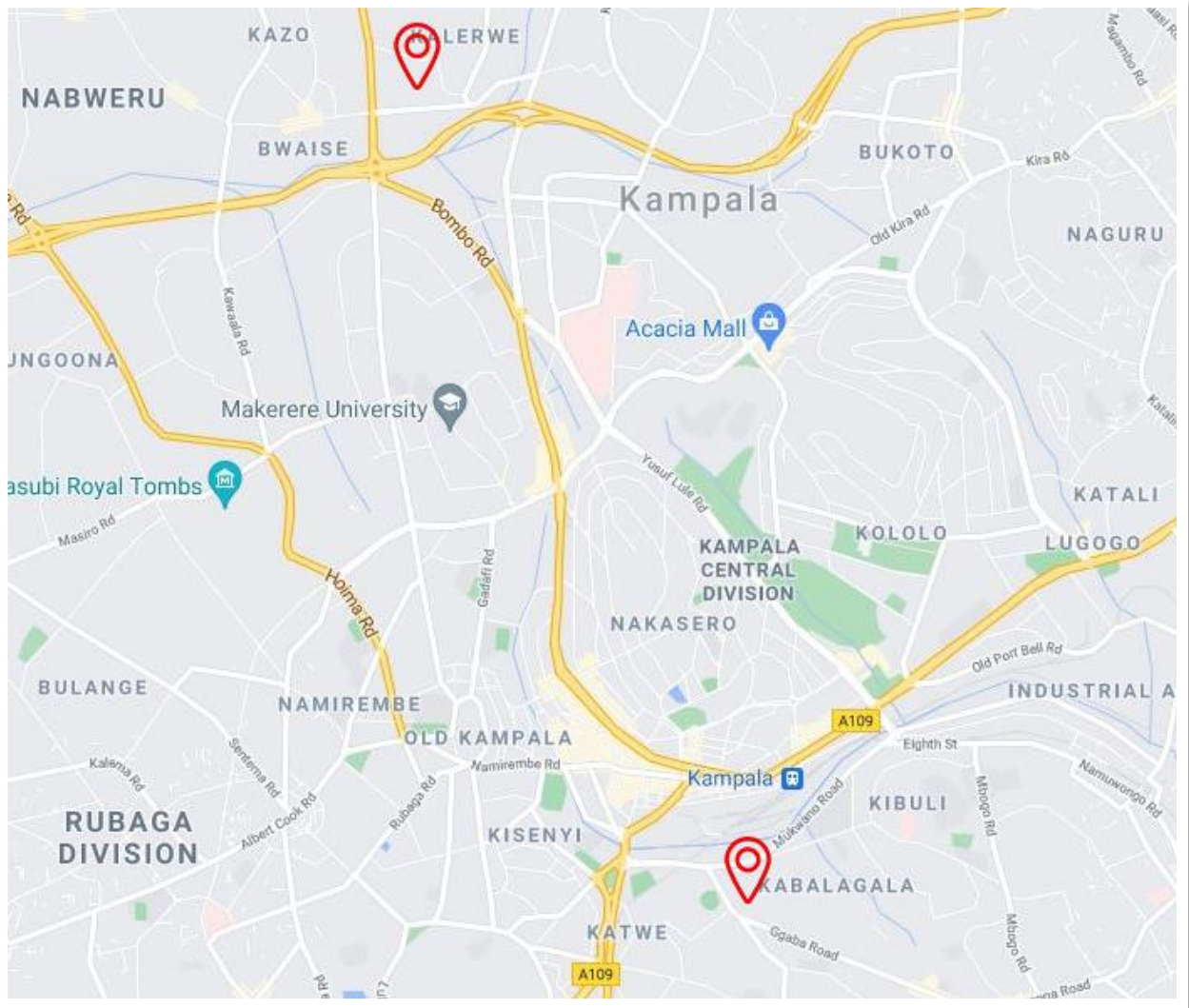


Figure 6: Map pinning areas of study. (Source: Google maps. Edited by author)

3.5 Criteria for selection.

This study examines two prominent furniture workshops, Bwaise and Nsambya furniture workshops. The study will focus on the design of the workshops, that is the design layouts, spatial qualities, materials of construction.

Bwaise furniture workshop is the largest woodworking SME agglomeration in Kampala, located in Bwaise a Kampala slum followed closely by Nsambya furniture workshop.

Nsambya furniture workshop is located south-southeast of Kampala, along Ggaba road.

3.6 Data collection methods and tools.

Qualitative method was used to carry out the research, and the following data collection methods will be used to conduct the research;

3.6.1 Case Study Method

Case study method enables the researcher to closely examine the data within a given context by selecting a small geographic area or a very limited number of individuals or objects as subjects of the study. Yin (2009) defines a case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries of phenomenon and context are not clearly evident and in which multiple sources of evidence are used.

The study will also involve reviewing the information obtained from other scholars to get an understanding of what is known on the subject matter. successful projects on the subject matter will also be reviewed to see how others have tackled the concept of furniture workshop design.

3.6.2 Literature review.

An evaluation of existing literature on the subject will be done to supplement the data collection methods as well as be able to compare the findings with those of other studies that have already been done on the subject.

3.6.3 Interviews.

A research interview involves an interviewer, who coordinates the process of the conversation and asks questions, and an interviewee, who responds to those questions (Easwaramoorthy and Zarinpoush, 2006). Interviews will enable me collect in-depth information on people's opinions, thoughts, experiences, and feelings.

3.6.4 Participant observation.

Gillham (2000), participant observation method involves describing what you see and explaining it. This tool is gives the researcher firsthand information which will be analyzed and conclusions made.

During observation, workshop operators will be observed to understand their behavior as they maneuver through workshop space during operations. The researcher will also analyze the circulation spaces to get an understanding of the user's behavior and notes will be taken.

While observing, the researcher will use sketches and camera to capture photographic evidence and where need be approach the users to ask questions

3.7 Data recording tools

The following data recording tools were used;

i) Photography

Photography to provide graphical evidence of some of the situations at hand and these photographs will facilitate analysis and will also be used for future reference. The main instrument used here will be a camera. Still photos will be captured as a way of accurately storing factual information during the research and these will be subsequently studied and analyzed at a more convenient time.

ii) sketches

Sketches and drawings will be used to analyze and explain different scenarios using a sketch pad and pencil as the main instruments.

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4 CHAPTER FOUR: DATA PRESENTATION AND FINDINGS.

4.1 Introduction

Data presented in this chapter was mainly obtained through literature review, observation and interviews with furniture workshop operators as well as the final furniture consumers.

The study focused on mainly two workshops, that is; Nsambya furniture workshop and Bwaise furniture workshop. These methods used to collect data sought to;

1. Investigate the factors that influence the design of workshops in Uganda.
2. Analyze the different furniture workshop designs used.
3. To recommend the minimum design standards for the design of furniture workshops.

The findings were focused on the spatial qualities (Lighting, aeration, comfort), Facilities available (storage, processing, health) and the layout of the workshops.

4.2 Case 1: Nsambya Furniture workshop.

4.2.1 Location

The Nsambya furniture workshop is located in Makindye division in Kampala along the Ggaba road, about 515m off Mukwano road and 530m before the American embassy.

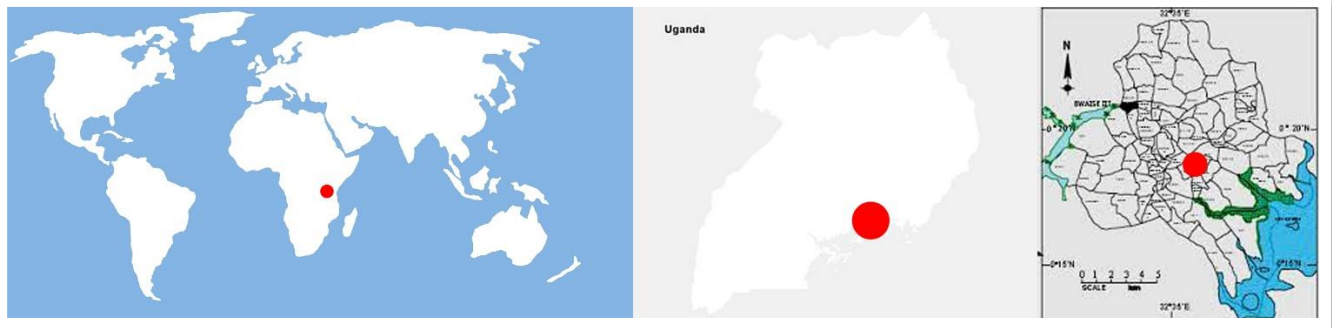


Figure 7: Location of Nsambya(Africa, Uganda, Kampala district).Source: internet images edited by author.



Figure 8: Nsambya furniture workshop location. Source: Google maps, edited by author.

4.2.2 Layout

The Nsambya furniture workshop extends along the shoulders of Ggaba road. It extends along the road with the location of the operation machines being the source of spread. The heavy machines orient the surrounding groups of workers. These heavy machines are supplemented with individual machinery and tools/equipment found in the small working groups.

Due to limited resources in machinery, the process layout is one characterized of central

4.2.3 Structures

The workshop structures are characterized by rough structures made from a combination of a number of materials. These include plastics, old wooden pieces, iron sheets and fabric.

4.2.3.1 The roof

The main roofing material is the HDPE tarpaulin. This is due to its waterproof properties, easy weight on the structure and cheap to acquire. The tarpaulin is secured onto the structure using ropes, nails, weight from old furniture that are laid on top.

The roof coverings come in different colours from structure to structure; with a single structure having more than three colours.

The roof level of different structures is at different heights, depending on the purpose of the space below. The height gradually reduces as a result of accumulation of wood waste, machinery, raw material and finished products. Multiple layers of roofing materials are used to offset the impact of weather elements, for example when iron sheets are used, a 'layer' below of old furniture is used to keep the heat at bay.



Figure 9: A display of different colours from the different roofing materials(Source: Author, 2021).

4.2.3.2 The walling.

The main walling material is old wood, sometimes protected from the elements using HDPE tarpaulin. The structure is supported by unfinished wooden poles and beams nailed together for reinforcement.

4.2.3.3 The flooring

The floors are generally of rammed earth. The workshops located at lower end of the Nsambya workshop are of marram. The workshops where processes such as dimensioning, machine sanding and milling happens, the floor is covered with wood waste. The floor level is the site level, which facilitates the flow of storm water into the workshops. To reduce the impact of storm water,

channels have been created around some workshops by individual effort. Stones have also been used to control wash away.

4.2.3.4 Observations.

From the images presented in the section above, it is very clear that the construction of the workshop structures is one that is guided by intuition, workshop size and available resources. The non-uniform level of roofs not only causes the lodging of rain water which in the end penetrates into the workshop affecting the raw materials, production processes and the finished products, it also affects the quality of working area. With reduced working height (contributed to also by accumulation wood waste), maneuverability of material, machines and human power becomes difficult which in turn affects the quality of the final product. It also poses a threat to the workers especially in areas where dangerous machines are used.

4.2.4 Spatial qualities.

4.2.4.1 Lighting

The operations in the spaces heavily depend on the use of day light. This penetrates through the roofing material (as the tarpaulin material used is translucent) and gaps left in the walling and roof.



A void in the roof
allowing in daylight.

Material translucence
illuminates the space
below.

Figure 10: Lighting patterns in the workshop. Source: Author, 2021

Artificial lighting is also used in some spaces. It is however limited due to the numbers of the lights available and their sizes. The lights are supported by boards and other materials made on site and are connected at non-uniform heights. The lights don't provide uniform light.

Interviews.

From the interviews, a great number of carpenters agreed that the lighting conditions within the workshops was bad, given the fact that it mainly depends on the sun and that its way of utilization, if the weather is clear. In the event that the weather changes, work comes to a standstill as there is no or little to carry out the tasks accurately and safely. Prolonged working durations in these conditions has affected some carpenters, causing sight related disorders while others said they were used and there was little impact of light conditions on their productivity. On the other hand, however, some carpenters especially those working in open spaces didn't have any light-related issues as they had abundant natural light on clear days.

The chart below summarizes the responses to light from the correspondents.

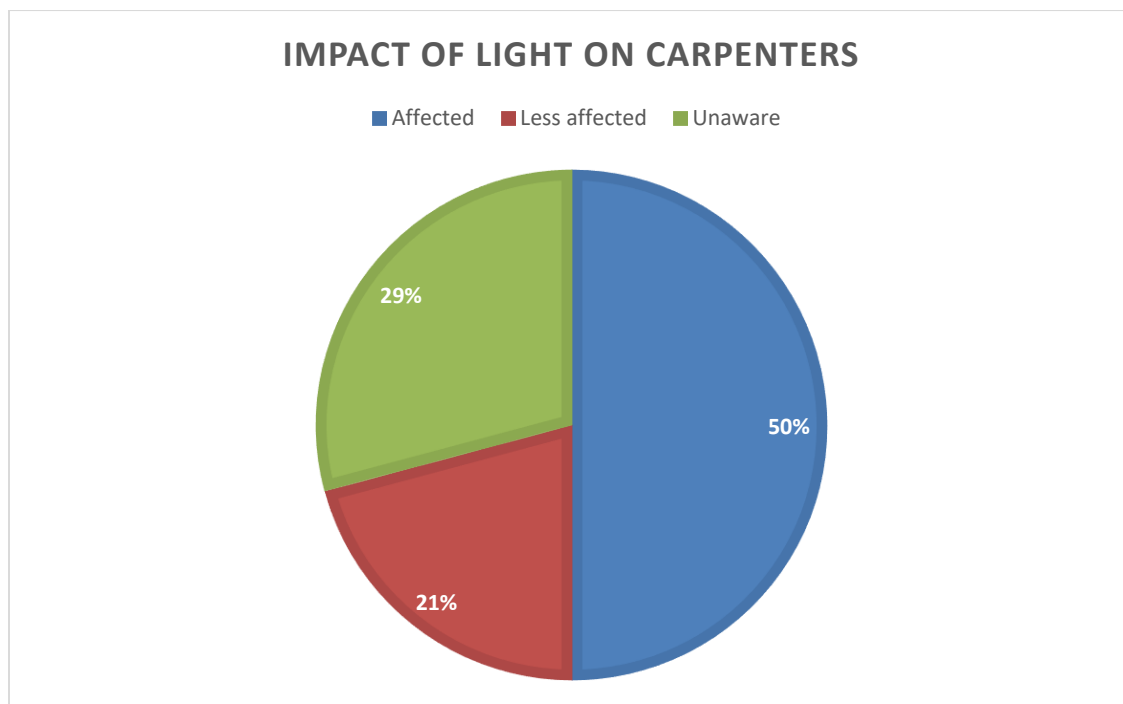


Figure 11: Impact of lighting. Source: Author, 2021.

4.2.4.2 Aeration.

Wood workshops are known for the immense saw dust particles in the air which consequently affects the quality of air. Processes such as sanding, milling and dimensioning that produce a lot of saw dust are in the open, with spaces such as displays and kitchens. Particles therefore freely move and circulate the air.

Materials in the workshops obstruct the free movement of air, keeping the internal air circulated with saw dust for longer times. Areas with heavy production of dust are enclosed using tarpaulin. However, some particles are able to escape through the cuts and opening in the material.

Below is a summary of the aeration and lighting situation of the workshop.

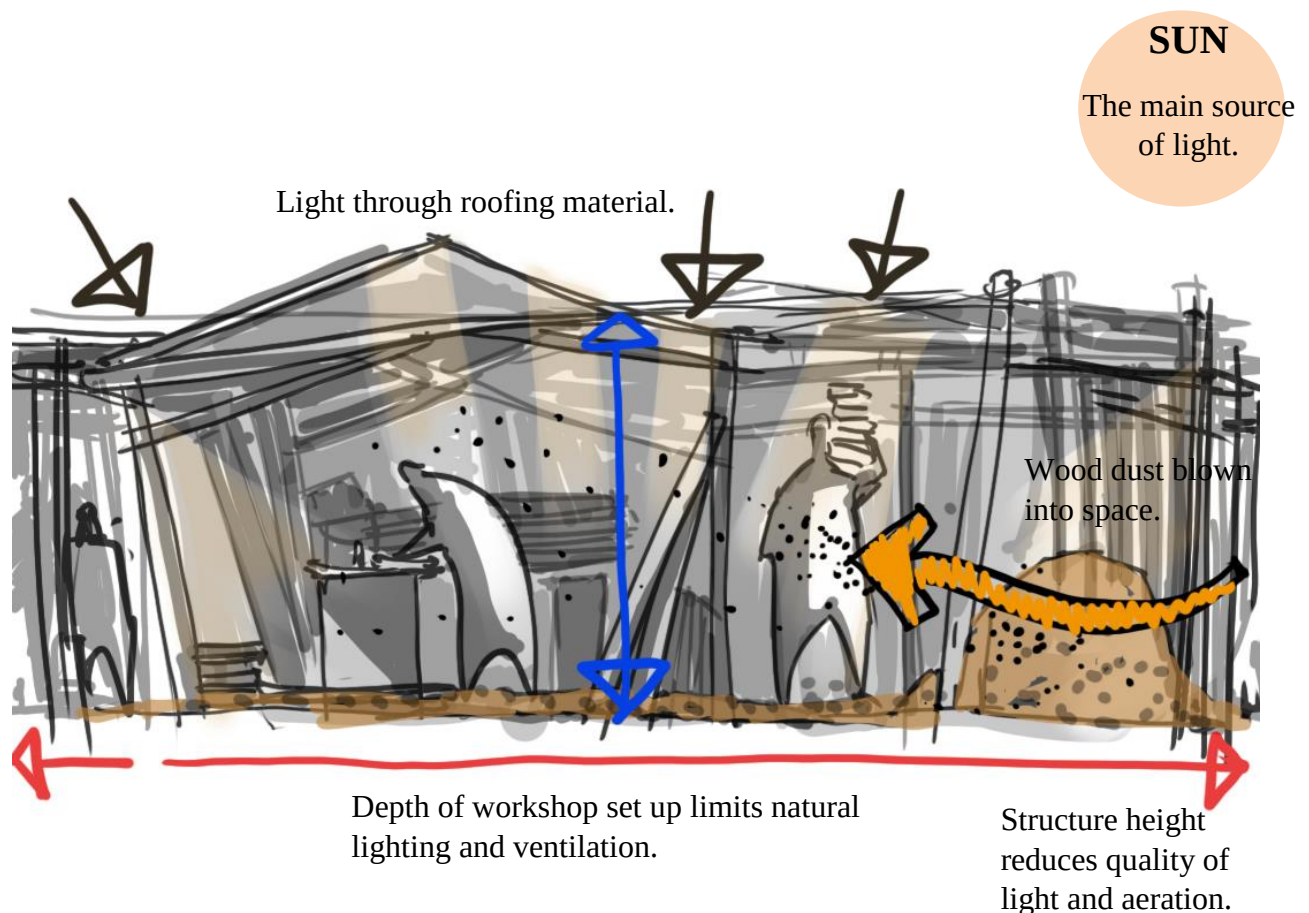


Figure 12: Summary of the interaction of space activities with lighting and aeration. Source: Author, 2021.

4.2.5 The design of facilities.

4.2.5.1 Storage of materials.

1. Raw materials.

Nsambya furniture workshop heavily relies on already or semi processed raw materials. The timber is mainly acquired from the Bwaise furniture workshop. The finishes such as finishes and vanishes are bought from different suppliers.

Nsambya furniture workshop doesn't have a dedicated timber storage facility therefore only timber needed for a given task is bought to minimize waste and need for storage. When there is need for storage, the working area works as the store for the timber. The structure, especially the roof occasionally turns into a storage space. The timber pieces are also kept in piles along the sides of the structures.



Figure 13: Dimensioned timber leaning against the structure of a workshop(Left). Timber pieces on the roof(Right). Source: Author, 2021.

2. Products

Produced product parts are kept within the working area. This is usually close to the machines or tools where carpenter works. They can be kept on the floor for the heavy parts and the roof for the light parts. Heavy parts are also leaned on the walling of the structure. Finished products, especially small ones like bed stands, are kept in sacks within the workshop.



Figure 14: Bed components temporarily kept on the roof before assembly. Source: Author, 2021.



Figure 15: A stack of bed parts ready for assembly(left). Furniture stands kept in a sack(right). Source: Author, 2021.

On the other hand, products still under production (WIP) are covered with tarpaulin in the open space. These are placed on the ground, exposing them to rain, storm water, Pests and other organic elements.



Figure 16: Unfinished products partially covered with old tarpaulin(Left). Craft material and old furniture piled in a corner in a workshop (Right). Source: Author, 2021.

3. Personal belongings.

Carpenters keep their personal belongings within their respective workshops of work. Personal belongings include working tools, changing clothes and bicycles. These are kept on the rooftops, hung up on the interior of the structures, kept in tool boxes in the workshops or hidden inside the workshops. This reduces the working area, poses a threat to the lives of the carpenters from injuries as well as to the structure.



Figure 177: Tools hung in the workshop(Left) and changing clothes kept in plastic bags within the working area.

Analysis of the data.

The lack of proper storage facilities doesn't only compromise the quality of the final product; it also increases the time of production. This is because the carpenters usually do not have enough materials within easy reach to produce a complete product. They thus have to incur time and financial costs in transporting the materials from sources such as Bwaise. The transportation of these materials exposes them to damage from poor handling.

The currently used methods of storage on site on the other hand expose the products to elements of weather, further compromising on the quality. These methods of storage also reduce working space within the workshop, creating unsafe spaces for both the products and the carpenters.

4.2.5.2 Furniture processes.

1. Drying timber

Nsambya furniture workshop lacks the timber drying facility. Therefore, the carpenters dry the timber along the walkway on Ggaba road. This exposes the timber to physical damage from the passersby. Also, without

regulation of heat, there is a great risk of uneven drying, which directly affects the quality of the timber and thus the quality of the final product.

It also exposes the timber to the element of rain should the weather change drastically. This increases the moisture content in the wood, attracting fungi and other wood organisms. Drying timber on the street poses a threat to the public, with a potential of fatal injuries.



Figure 18: Pieces of timber drying along the road. Source: Author, 2021.

2. Finishing products.

The products are finished along the walkway, close to the finished products. This includes painting, vanishing or adding final ornamental touches such as buttons or upholstery. This is done manually or using the spraying machine. The process of finishing a product takes place in the open area, exposing both the worker and the product to the elements of weather. This affects the quality of the product. Take for example vanishing, the final look is affected by the dust as a result of the moving traffic along the road.

4.2.5.3 Health facility

1. Injuries.

The workshop accommodates a number of tools and heavy machinery. These, among other purposes, are used to cut, smooth, drill and join pieces during the production process. These use sharp spinning blades, electricity and are heavy. However, the workshop does not have a health center to administer first aid and later on be able to contain a healthy emergency. It relies on the Nsambya hospital for all the major injuries such as cuts. The hospital is about 600m from the workshop.

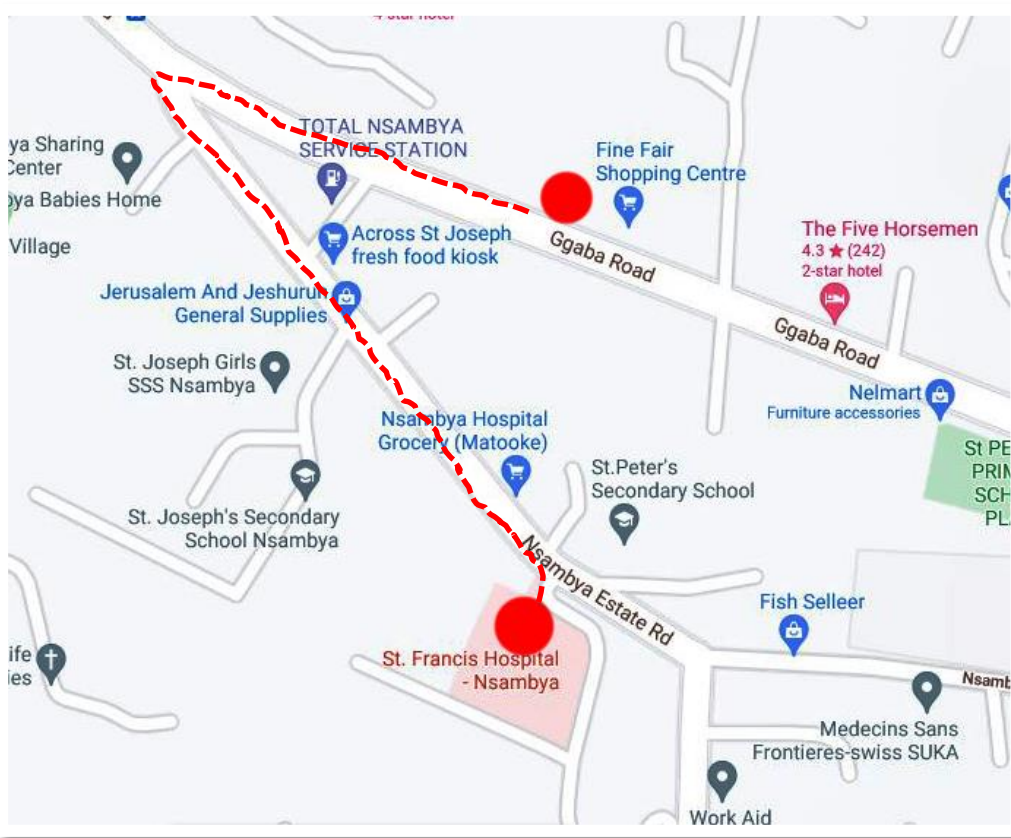


Figure 19: Location of St. Francis Hospital Nsambya from the workshop. Source: Google maps, edited by author.

2. Toilets, urinals and showers.

The workshop doesn't have well-designed facilities. Carpenters rely on the public facilities in the neighborhood especially those located on the showroom building and the commercial building still under construction across the road. The facility available doubles as a urinal (used by men) and a shower. The walling is of old corrugated iron sheets on two sides of the structure nailed to wooden poles. The floor is made up of rough stones and concrete blocks. The structure is 1.5m (the covered height) as shown in the figure below. The footprint 1.2m X 2.2m.

The structure is surrounded by piles of saw duct, with workshops on the other end



Figure 20: Urinal on site. Source: Author, 2021.

4.2.5.4 Children spaces

Some workers, especially women, carry children of the ages between 6-8 years to the workshop. The children don't have a playing ground so end up playing in the delivery trucks. This exposes the children to injuries from cuts from sharp elements. It also exposes them to health problems as a result of poor hygiene.

The “play grounds” for children border a zone of the workshop generally dominated by women. The activities in this zone is mainly sanding of the furniture components especially beds. Its proximity allows mothers to partly monitor the children as they go about their work. It is however an unsafe environment for the children. It also affects the time and effort input into the furniture as it has to be shared between watching the children and work.



Figure 21: Children seen in delivery trucks playing. Source: Author, 2021.

4.2.5.5 Food facilities.

There is a designated place for cooking and serving food to the carpenters. The restaurant is composed of different service providers, each with a space of 7square meters to 9 square meters. This area is inclusive of the working area, serving area and the dining area. Cooking also is done in some workshops on a smaller scale.

The restaurant structures are mainly made up of wooden materials, wooden poles forming the truss system and the supporting system. The walls are a wooden cladding nailed to the wooden poles. The wall is also made up of old tarpaulin material while the roof is composed of mainly old iron

sheets nailed onto the trusses. The roof system is supported by intermediate wooden poles at about 4 meters apart. The floor is of uneven rammed earth. This gives an uneven working surface for the cooking activities and thus creating dangerous spaces.

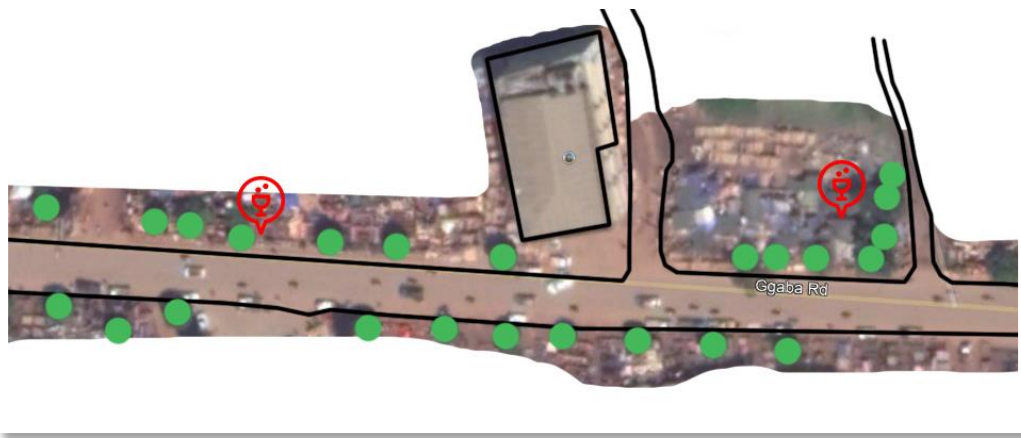


Figure 22: Location of restaurants. Source: Google earth, edited by author.



Figure 23: Cooking area in the restaurant. Source: Author, 2021.

The state of the restaurant poses a threat to the safety of the occupants. The cooking spaces being close to highly flammable timber cladding and wooden poles is a fire risk. The sources of energy, which are firewood and saw dust, pose a great health risk to the users of the spaces due to smoke

and dust particles since the spaces are not sufficiently ventilated. The uneven floor surface poses a great risk for burns from food as a result of loss in balance.

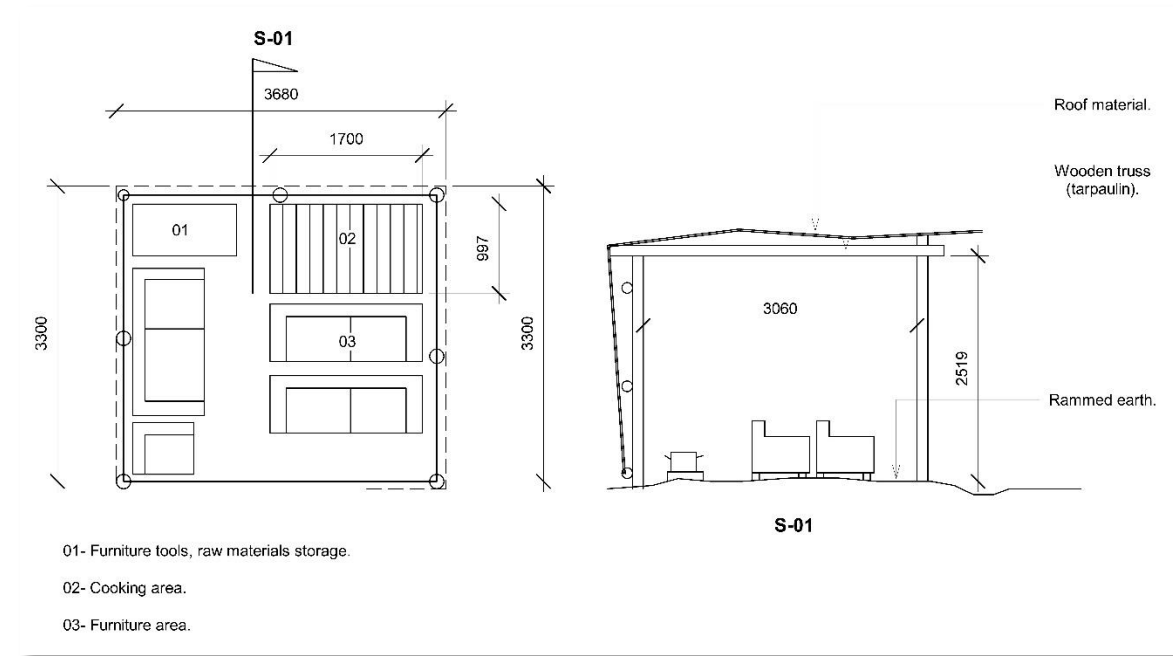


Figure 24: Cooking area layout. Source: Author, 2021.

4.2.5.6 Showrooms.

The main form of display at the workshop is along Ggaba road, along the walkways. The final products are displayed to the public in the open space, exposing the furniture and crafts to the elements of weather. Ggaba being a busy road, with heavy motor traffic, furniture is exposed to fumes and dust. The products are also exposed to damage from physical contact by by-passers. The display also happens within workshop area, especially those with well-defined structures. The structures are made up of wooden poles with a cladding of tarpaulin, which also doubles as the roofing material.

**GGABA
RD**



DISPLAY

WALKWAY

Figure 25: Location of furniture display. Source: Author, 2021.

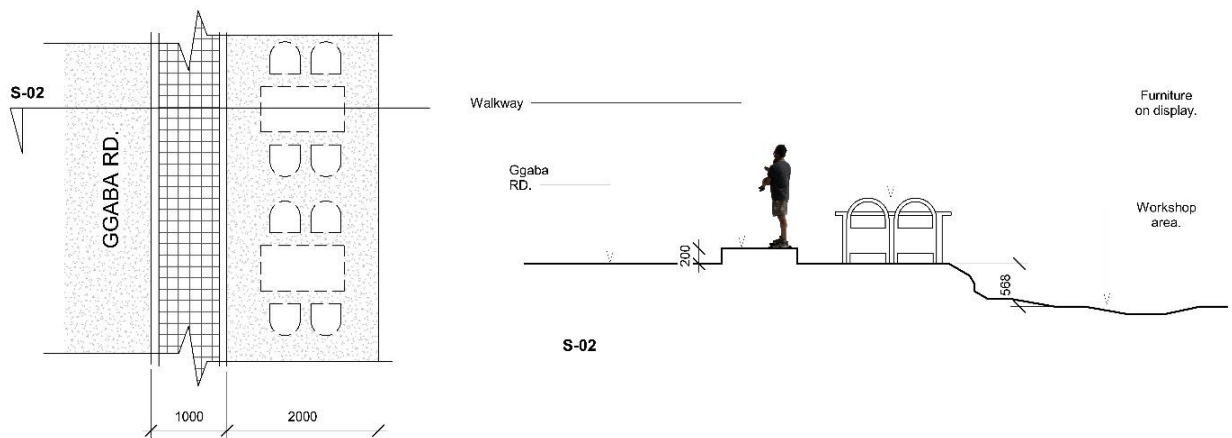


Figure 26: Drawings of the display area. Source: Author, 2021.

During display, furniture goes through constant cleaning (including dusting and vanishing). This is done by hand as shown in the image below.



Figure 27: A gentleman seen dusting furniture. Source: Author, 2021.

4.2.5.7 Power supply.

The workshop relies heavily on 3-phase electric power supplied by the UMEME. This is as a result of the heavy machinery used in the production of furniture at the workshop. Power is delivered to the machines through cables that run within the workshop. These cables run along the roof trusses, poles and in the open area to machines and lighting.



Naked wire connections in the open, exposed to elements and the structural elements.

Figure 28: Power connections in the workshops. Source: Author, 2021.

Exposed power cables pose a danger to the workers due to electric shocks. Also, it can lead to fires as a result of short circuits.

In case of power shortages, some workshops relay on generators that can supply 2.5KVA of power. This power can run a few hand equipment such as the electric hand saws.

The absence of complementary power supply leads to slow productions as tasks have to manually be done if deadlines have to be beaten. This directly affects the quality of the final product. Also, the use of independent power sources in the workshops increases the risk of fire, should there be mishandling of any of the generators and the generator fuels.



Figure 29: Generator in one of the workshops. Source: Author, 2021.

4.2.5.8 Delivery of materials.

Delivery of raw materials, especially timber, happens mainly along Ggaba road. The workshop has a delivery point, which doubles as a parking space for small delivery trucks locally known as “enyongeza”. Delivery of big volumes of material usually happens along the road, causing traffic jams. The offloaded materials are packed along the walkway, where they are picked from to the final site of production. This exposes the timber to physical damage and injuries to the pedestrians.



Figure 30: Timber delivered by truck along Ggaba road.

4.2.5.9 Fire fighting

The available fire suppression system is one that uses water supplied NWSC. The water is drawn from the tap using a hose pipe in case of any fire. There are 2 taps located at different points. These taps however are located within and at the borders of the workshops. This makes it difficult to fight a fire should it start around the tap area. Also, the size and location of the taps makes it very hard to recognize.



*Figure 31: Tap that doubles as a fire suppression system.
Source: Author, 2021.*

The location of the tap affects the smooth operation of the workshop as a result of flood water, which washes to the location of raw materials and finished products.

4.2.6 Summary.

Nsambya furniture workshop has a trained and committed workforce of skilled carpenters. It is committed to being innovative in their designs and way of productions evident from the locally made equipment and tools of production. However, the skill set coupled with unfavorable working conditions for quality furniture products has disadvantaged the carpenters of Nsambya furniture workshop. The issues of workshop space planning, design, lighting among others have greatly contributed to the poor quality of the workshop's furniture.

4.3 Case 2: Bwaise furniture workshop.

4.3.1 Location

Bwaise furniture workshop is the largest woodworking SME agglomeration in Kampala, located in Bwaise, a Kampala slum. It is an area incorporating commercial, industrial and residential infrastructure. Bwaise borders Kawempe to the North, Kyebando to the East, Mulago to the southwest, Makerere to the South and Kasubi to the southwest. The site is about 5km from the central business center.

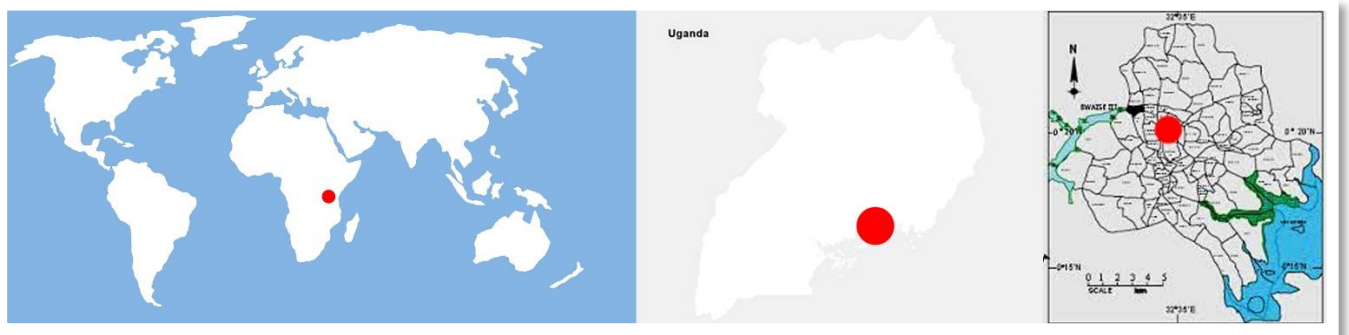


Figure 32: Location of Bwaise. Source: Images from the internet edited by author.



Figure 33: Location of Bwaise furniture workshop. Source: Google earth edited by author.

4.3.2 Layout

Bwaise furniture workshop is an amalgamation of many independent and private workshops, located on different plots. The make up the Bwaise industrial area.

4.3.3 Workforce.

The workshop is composed of a young workforce mainly composed of males. The data is summarised as below. Men are in the intense fields such as loading and offloading, delivery of materials, workshop management while women are in the catering, sell of finishing materials such as upholstery, chemicals.

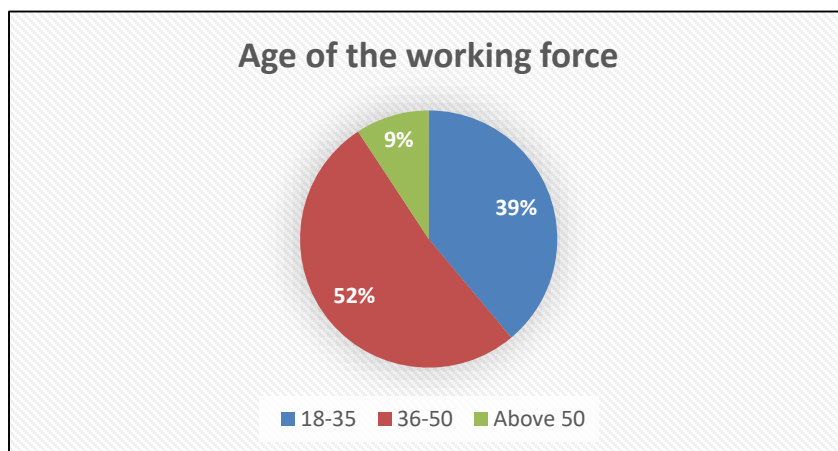


Figure 34: Working age. Source: Author, 2021.

4.3.4 Structures

The workshop structures are characterized by a combination of a number of materials. These include iron sheets, timber and plastics.

4.3.4.1 The roof

The roof covering is mainly made up of corrugated roofing iron sheets nailed onto wooden poles forming the truss system. The truss system come mainly in two variants, one of natural wooden poles and the other of sawn timber. The roofs are generally at 4m to 5m high supported by wooden poles. Most of the iron sheets used look new and in a good condition.



Figure 35: The roof system. Source: Author, 2021.

4.3.4.2 The walling.

The walling materials of the workshop include iron sheets, timber and wooden poles. Some workshops are open and exposed on the sides. Other workshops on the other hand are only covered due to proximity with the neighboring workshops.



Figure 36: Iron sheets and poles used as walling material. Source: Author, 2021.

4.3.4.3 The flooring

The floors are generally of rammed earth. The workshop floor area is mostly covered up with timber waste (sawdust timber chip particles) and raw materials (mainly timber). The floor level is the site level, which facilitates the flow of storm water into the workshops. To reduce the impact of storm water, channels are created during flooding. These also end up filling with timber chips.



Figure 37: The floor covered in waste and raw materials. Source: Author, 2021.

4.3.5 Spatial qualities

4.3.5.1 Lighting

The workshop relies heavily on both daylighting and artificial lighting. The natural light penetrates through the spaces in the walls, the huge entrances. Artificial lighting is bulbs, generally about 3-4 bulbs per workshop.

The lighting modes, in the current state, don't provide sufficient lighting as evidenced by the uneven lighting and shadows in the workshops. Sometimes both lighting methods are employed at the same time to provide illumination. In the event of change of weather, operations in the workshop, especially those requiring precision come to a standstill due to insufficient lighting.



Insufficiently lit
working area.

Relatively sufficient
lighting.

Figure 38: Workshop lighting levels. Source: Author, 2021.



Figure 39: Dependence on natural light. Source: Author, 2021.

4.3.5.2 Aeration.

The huge openings (mainly entrances) allow the free movement of air throughout the workshops. The walling of the different workshops regulates to some extent the movement of saw particles from one area to another. However, the mass production of saw dust in the different workshops, which are limited in size, circulates the air with dust particles.

4.3.6 The design of facilities.

4.3.6.1 Storage of materials

1. Raw materials.

Bwaise furniture workshop is a supplier of timber to a number of workshops in and around Kampala, including Nsambya furniture workshop. The timber is kept in dedicated storage structures, roofed with corrugated iron sheets and open on the sides. The open structure allows the free movement of air, which keeps the timber ventilated. It also exposes the timber to elements of

weather such as rain, also exposes the timber is to physical damage from delivery trucks and people as they are located close to the delivery routes. The timber is laid on the floor, exposing it to ground water and fungi.

People are seen sitting and standing on top of the timber, exposing it to deformation among other defects. This is during resting after delivery of timber to trucks or delivery of timber from trucks.



Timber in contact
with the ground.

Figure 40: Storage of timber. Source: Author, 2021.

2. Storage of products.

Bwaise furniture workshop is mainly composed of equipment and processes that turn wood into timber and therefore furniture production is on a small scale. Production of furniture happens on the shoulders of the industrial area. The furniture is kept in the workshops where it is produced, being brought out for finishing or display. Products still under production are kept in the open space, exposing them to the elements of weather.

4.3.6.2 Health facilities

1. Injuries.

The workshop accommodates a number of tools and heavy machinery. These, among other purposes, are used to cut, smooth, drill and join pieces during the production process. These use sharp spinning blades, electricity and are heavy. However, the workshop does not have a health center to administer first aid and later on be able to contain a healthy emergency. It relies on clinics around the industrial area for minor injuries. Mulago hospital is relied on for major injuries. the hospital is about 3.3 km from the industrial area.

2. Toilets, urinals and showers.

The Bwaise industrial area has a number of public toilets which are paid for. These are located at different points within the industrial area, proving to be sufficient and convenient. These are strategically located along access routes, making them easy to locate.

3. Food facilities.

There is a designated place for cooking and serving food to the carpenters. The restaurants are private owned, composed of different service providers, each with a space of 9square meters to 12 square meters. This is dinning area. Cooking takes place in the open space, exposing the cooks to the elements of weather. The restaurant structures are mainly made up of wooden poles forming the truss system and the supporting system. The walls are a wooden cladding nailed to the poles. The wall is also made up of old corrugated iron sheets while the roof is composed of mainly old iron sheets nailed onto the trusses.

4.3.6.3 Power supply.

The workshop relies heavily on 3-phase electric power supplied by the UMEME. This is as a result of the heavy machinery used in the production of furniture at the workshop. Power id delivered to the machines through cables that run within the workshop. These cables run along the roof trusses, poles, walling material and in the open area to machines and lighting.

Exposed power cables pose a danger to the workers due to electric shocks. Also, it can lead to fires as a result of short circuits. Power is delivered to each workshop through a circuit board, which is

the main power management system. On a number of occasions, the workers are seen interacting with the unit, repairing or attempting to repair electrical issues.



Figure 41: Electrical box(Left), attempts of electrical repairs by the workers(Right). Source: Author, 2021.

4.3.6.4 Resting facilities.

The workshop is a busy place, involving load and offloading materials, tools and equipment, processing of timber and its products as well as coordinating the activities for smoothing running. All these activities are intense and often cause energy grain. This usually calls for short naps between activities. Workers nap in the workshops, usually on the furniture products, timber or even logs. These are usually located close to active equipment and in dusty areas.

Facilities that promote resting and relaxation are in place in a specific area. These engage the participants actively and passively in the different activities. These activities include pool table, movie theatres



Figure 42: Passive and active resting. Source: Author, 2021.

4.3.6.5 Flooding

Bwaise is prone to flooding due to the fact that it's in the valley, between Kawempe, Mulago and Makerere hills. This equally subjects the Bwaise industrial area to the floods affecting not only the day to day running of the workshops but also the materials for furniture production and the final products since there are no well-designed facilities for storage.



Figure 43: A worker creates a way for storm water. Source: Author, 2021.

4.3.7 Summary

4.3.7.1 Architects' response on the design of furniture workshops.

This aspect provides feedback on some of the opinions and suggestions of the different architects on the subject matter and could some of the major limitations as to why many architects have not been involved on such projects

4.3.7.1.1 Reasons why architects don't get involved in furniture workshop projects.

One of the reasons why architects have not considered designing furniture workshops is the fact that such places get established informally, with individuals setting up their own small work space and eventually turns into an industrial area. (Registered architect, 6.05.2021).

The challenge of limited resources, especially finances have not attracted architects to this kind of field. Many choose high end projects for financial reasons. They have to pay bills. (Registered architect, 6.05.2021).

Many architects only seem to be informed about the social housing needs and small house hold income generation of the population and have ignored the production and economic factors. That explains why locals initiate and 'design' such projects. (Registered architect, 8.05.2021).

Such workshops are usually small, housing a few carpenters in very small areas. Very few graduate to be prominent such as Bwaise and Nsambya. No architect wants to spend time on such a project size. (Registered architect, 8.05.2021).

The local carpenters have not yet understood the value of design and the employment of an architect for that matter. They see us as expensive professionals. Many also think they can do what we do and therefore turn to their knowledge to implement the projects. (Registered architect, 8.05.2021).

4.3.7.2 Local furniture manufacturers

Architects ignore us, they are looking for fancy projects from the rich people who can offer big monies. (Carpenter, 12.05.2021)

Our finances and setups don't happen all at once. You can only plan for what comes in and what you can manage, you risk bankruptcy anything beyond that. That is why you see the structures

only develop where there is need for example when an equipment comes in that requires protection from the elements then we have to erect a shelter for it. (Carpenter, 12.05.2021).

We have lost many clients simply because of lack of the proper facilities for manufacture and display. Those that pay take the products at a very low price. (Carpenter, 14.05.2021).

Our leaders, those that have the political power don't usually air our views as should be. For example, the new workshop location is designed for modern facilities and way of production, something we can't afford. It's more of modern display than local production. (Nsambya Carpenter, 12.05.2021).

5 CHAPTER FIVE: DISCUSION OF FINDINGS.

5.1 Introduction

This chapter presents the findings from the case studies (Nsambya and Bwaise workshops). It focuses on the interpretation of the design of a workshop, analyzing the space and way of life of the workers in the workshops, which in the long run impacts on the quality of the products. The analysis is based on the local context and compared to the data in the literature review section. The discussion further addresses the objectives and the research questions as started earlier in chapter one.

5.2 Production.

5.2.1 Layout for production.

A very powerful point in successful production guaranteeing safety, accuracy and speed of layout has been presented by a number of researchers like Singh (2006) and Shukla and Waghmare (2016) among others. The different layout classifications aim at the systematic movement of a product in a linear manner. These systems however assume that there is a single management that over sees the acquisition and management of the systems, dictating placement and thus the order of flow of production.

In our local context however, workshops and their management is entirely based on the owners. However, it is very crucial to understand the origins of the workshops in the first place. The Nsambya furniture workshop for example started as a small coffin workshop, attracting different people from different walks of life especially the less educated. This has seen a transformation over the years which have turned it into a famous and busy production hub it is now. This background clearly throws light on the resources that the carpenter can acquire in their individual workshops. Because of this, individual workshops can't afford equipment for full furniture production process thus sharing resources becomes the inevitable and immediate solution. Independent workshops then become individual production units that feed and get fed through the entire production line.

The origins and growth of many local furniture workshops has in the same line sidelined the involvement of professional services in the construction industry such as architects. It is no wonder very few architects have been involved in the redevelopment of such specialties.

5.2.2 Spaces for production

The design of production space has been entirely based on the levels of output rather than a thoughtful integration and coexistence of machinery and human labour. This is witnessed, for example at the Nsambya workshop, where machinery is given first priority of space and protection rather than the carpenter or the duo incorporation. This doesn't only create a weak connection between the carpenter and the production line due to the factors of weather among others, it also fuels inaccuracies in production. Unfinished or poorly designed workshop floors that are always full of timber waster, finished products and raw materials create navigation problems during and after production. The choice of construction materials and techniques employed have greatly contributed to the issue of poor furniture quality. Take for example roofing, the roof height of about 3m of many Nsambya workshops limits free air circulation, natural light and vertical working area. This has a direct impact on the maneuverability during furniture production and hence the final quality. Inadequacy of space has greatly contributed to the faulting in working standards. Sec. 110-26 of the American national electrical code (2016) talks about 3ft clearance in front of all electrical equipment, a 30 in-wide working space in front of equipment operating at 600v or less and a minimum headroom clearance of 6ft of the height of the equipment.

5.3 Related facilities.

The argument of the impact of the physical environment beyond the streamlined production line is undeniably one of great impact to the quality of production (Dul, Ceylan and Jaspers, 2011). The ability for workers to enjoy and modify the spaces and element around them have proven to be one of the great mechanisms that feeds into quality assurance as explored by (Elsbach and Pratt, 2007). This therefore calls for design of spaces with the everyday-user in mind. Take for example women that take part in the production at Nsambya and Bwaise furniture workshops, those that have children get caught between dividing their attention between the safety of their children and work. This doesn't only affect the quality of work but also increases the time of production for a single furniture product.

The other facilities that are of great secondary value as noted from Bwaise industrial area recreational areas. These engage the participants both actively and passively, helping them to regulate tire, stress and improve focus. The users of such spaces argue that taking off time from

the active production schedule relieves stress, helps you get energized and focused while getting you connected to a wider pool of possible resource providers. This is possible due to their location away from the production noise in an isolated zone we can refer to as a “cool off” zone.

6 CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS.

6.1 Conclusions

With an ever growing population in Africa there is an increasing need for home and office furniture. Furniture such as beds, seats, tables, wardrobes among others have been at the forefront of home furnishings. Africa is fast emerging as an important market for furniture on the global market with total imports mounting to more than US 5billion dollars in 2018. By 2050, the world population is projected to be 2.4 billion people more with 1.3billion expected in Africa. This is a very great opportunity for Uganda to invest in the design and manufacture of furniture. The investment in skilling and educating local carpenters and fabricators through vocational and technical schools is a good initiative in the right direction of tapping into the local and global market. Also, government funding some workshops in the form of providing equipment promotes more efficient means of production. There seems to be however a missing link between the acquired knowledge and skills and the places of execution with regards to quality. An understanding of the design of the primary and secondary or supportive spaces of productions. These, as reviewed and discussed in the previous chapters have a very significant impact on the carpenters and furniture. Therefore, there is great need for designers, especially architects to get involved through the provision of their expertise in space design and planning if we are to benefit from furniture production.

There is need to focus on the design of spaces where production happens with a special consideration of costs of running the workshop. This calls for measures that incorporate and utilize natural mechanisms such as lighting and ventilation in the design. Also, an investment in local construction material will not only result into cheaper costs but also help in the mindset challenge. It will help as a medium of mind transformation to both the architects and the carpenters, wholly appreciating good design without it taking on the fancy facet.

Production setups move hand in hand with human labour. This always, if not properly Organised and regulated has led to the growth and development of slums. It is therefore important for research and investigations into the impact of local furniture workshops to the community.

6.2 Recommendations

The concept of furniture workshop design is a mindset issue the public and especially the immediate stake holders, the carpenters, need to be educated about on the need for professional services from architects. However, much as the architect can be seen as the educated designer, local design knowledge is important. These two forms of knowledge should collaborate, working hand in hand with the experienced workmanship to achieve functional and aesthetic design.

There is also need to re-align the mindset of both the carpenters and the designers about the concept of design. Good design doesn't necessarily mean fancy forms or materials. Good design should be able to utilize the available resources within the given constraints to achieve functionality, aesthetics, costs and durability.

The public (mainly the immediate stake holders in the trade) must also be ware of other aspects of workshop operation for example catering for the special needs for children and mothers in the design of furniture workshops.

Anybody is a candidate for Disability especially in workshops where heavy and dangerous equipment is run. Therefore, with such a thought, there is need to incorporate inclusive design, catering for people with disabilities. Designing for people with disabilities should be incorporated in the design school curriculum (in technical and vocational institutes) as a way of making the public more aware of the need to design for all users.

Health and safety should be given a major boost. Onsite first aid should be readily available, administered by a qualified person. This calls for a well-designed health facility to handle common injuries. Major injuries should be referred to major health centers.

Taping into technology is very key. The most utilized material in the furniture industry is timber or wood. However, it is also the most wasted material in the workshops in the form of saw dust. There should be ways of salvaging saw dust into boards that can be reused. This would help with clearing workshop floor area in addition to creating additional material options.

Passive design should be highly invested in. With the alarming conditions of the economy and the abundant and conducive weather conditions, passive design is a sure solution to economical architectural design, tapping into the use of daylight, natural ventilation and insulation. This is

specifically beneficial to local furniture workshops given the fact that there is always limited funding for their smooth operations.

One of the contributors to poor quality furniture has been related to storage of personal belongings in addition to the storage of both raw materials and the finished products. The absence of safe and well planned storage spaces means that personal belongings are kept within spaces of operation or on the roof structure as it is the case at Nsambya furniture workshop. This not only infringes on the already inadequate working space but also affects the products through physical damages.

Informed feedback drives innovation. A very critical and perhaps the most important piece of the furniture production puzzle is the design of the furniture itself. There is therefore need to accommodate spaces that facilitate the initiation and review of furniture designs at the workshop. This ensures quality and sustainable production by ensuring waste minimization and invention of new methods of working. Design review spaces are particularly important given the fact that many of the designs on the local market are foreign, mainly sourced from the internet. The production of such products without their review on the local context as a result of ignorance or lack of facilities to aide in the process has greatly affected the quality of the final furniture products.

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8 APPENDIX.

8.1 INTERVIEW GUIDE.

With architects:

1. Have you designed a furniture workshop in your career as an architect?
2. If yes, what was your approach when designing for?
 - a. Lighting
 - b. Aeration
 - c. Comfort
 - d. productivity
3. If no, why?
4. Have you been involved in planning a furniture workshop before?
5. If yes how did you approach the design from a planning perspective, in other words, what strategies did you put into consideration?
6. What is your opinion on the current situation on the planning and design of furniture workshops in Uganda?
7. To what extent has the absence or presence of designed furniture workshops affected your architecture practice?
8. What do you think are the limitations of designing furniture workshops in this country?
9. How can these limitations be overcome?

With local furniture manufacturers:

1. How long is the production process?
2. What factors contribute to the time of production?
3. Which facilities do you often use while at the furniture workshop?
4. Which facilities should be incorporated in the design?
5. On the scale of 1-10, how would you rank the following facilities?
 - a. Meeting facilities
 - b. Collaboration facilities
 - c. Resting facilities

- d. Eating facilities
 - e. Health facilities
6. What are the working conditions with regards to?
 - a. Lighting
 - b. Aeration
 - c. Sound/Noise
 7. Do these condition affect your productivity?
 8. How do they affect your productivity?
 9. Do you feel safe in the structures at the workshop and why?
 10. Have the working conditions impacted on your health?
 11. How have they impacted on your health?

The public

1. How often do you visit a furniture workshop?
2. What are the reasons for your visit?
3. Do you use local furniture?
4. On a scale of 1-5, what is its quality?
5. What do you contribute its quality to?
6. What do you consider nuisance from the furniture workshops?
 - a. Sound pollution
 - b. Air pollution
 - c. Both
7. Do furniture workshops pose a threat to the public sphere and why?

8.2 General observations

Age of workers

Age(yr)	Below 18	18-35	35-50	Above 50
number				

Sex

Sex	Number
Male	
Female	

Injuries

Body part	Classification	
Head		
Ears		
Eyes		
Nose		
Chest area		
Hands		
Legs		

m- Minor injuries

M- Major injuries