DESIGN CRITERIA FOR THE PRODUCTION OF UPHOLSTERED LIVING ROOM FURNITURE FOUNDED ON ASANTE TRADITIONAL STOOL

By

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MASTER OF PHILOSOPHY IN INTEGRATED ART (WOOD WORKING TECHNOLOGY)

Faculty of Art

College of Art and Built Environment

DECLARATION

I hereby declare that this submission is my own study towards Master of Philosophy in Integrated Art and that, to the best of my knowledge, it bears no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Asante traditional stool is nothing but a wooden seat of artistic design for practical use. The introduction of chairs by the Europeans have taken over the popularity of the Akan traditional stool which every Asante (Akan) had many of these seats (stools) for use in his house, have lost its dominance to the European chair because of its modification according to the current living conditions, customs, needs, tastes and even the simple functional beauty of contemporary furniture and interior design which is in harmony with our scientific age in which emphasis is placed on precision and the accuracy of shapes, contours and proportions. This existing situation brings about a way of broadening the scope of developing the skills of designing new forms of living room upholstered furniture from the Asante traditional stool and further more enlighten users on the meaning and significance of Adinkra symbols incorporated in the upholstered living room furniture. The researcher employed qualitative research using the descriptive and exploratory (studio/ practice based) methods; the descriptive method was used to describe the procedures and processes of constructing the upholstered living room furniture founded on the Asante traditional stool. The purposive sampling was used to select the sample size. The researcher used interview guide and observation as data collection instruments for the study. In light of this, the researcher observed that Akan traditional stools are exhibited flashily; others, though superficially similar, were so sacred that they are concealed from all but selected few. It was also observed that ordinary stools (nkondwa) were used by common people and the king. Chief's stools tend to be large; women's stools are smaller than men's; and a spirit-medium stool were covered with white Kaolin. Finally, educative programmes, seminars and workshops are recommended to be organized frequently to educate designers and furniture practitioners on the need and the standards of quality design and the materials to be considered before transforming the Akan traditional stool into living room upholstered furniture.

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This is the introductory part of the thesis which describes the Background to the Study, Statement of the Problem, Objectives, Research Questions, Delimitation, Definition of Terms, and Importance of the Study, and Organization of the Rest of the Text.

A stool is defined as a seat without back or armrest. Stools in Ghana come in different shapes, sizes, designs, and purposes (Dagan, 1988).

Asante traditional stools have crescent- shaped seats, flat bases and complex support structures, which exist in many designs with symbolic meaning. Asante traditional stools are mostly carved out of block of wood and are not upholstered (Dagan, 1988).

1.2 Background to the Study

Today's competitive industrial market has created a highly challenging environment for product development. Companies are under increasing pressure to create and sustain competitive advantage by reducing product development time and cost, while maintaining a high level of quality. These needs drive companies to focus more than ever before on streamlining their product development process (Ulrich, 2000). Asante Traditional stool is one of the more ever-present types of carving in Ghana, and it is especially common in Asante, although there are many types of Asante stools, most can be classified as being either rectangular or circular, according to the shape of the seat and base (Dagan, 1988). The circular stool is the most common and widely distributed in West Africa, and historically it is the earliest in Asante-Ghana. European records and indigenous oral traditions indicate that it preceded the

rectangular stool by about one hundred years. Nonetheless, it is the rectangular stool that is associated with Ghana and identified with its largest ethnic group, the Akan (Dagan, 1988).

Generally, among Asante, a stool has cultural significance beyond its domestic and utilitarian functions as a seat, and there are rules and taboos concerning its usage. Symbolic motifs in the carved decorations determine its ritual or domestic category and who is entitled to own it. (Warren and Andrews, 1977)

Indeed, designers have never lived without Shapes, Forms, and symbol and there is a lot of beauty in these elements, especially those in the traditional stool which incorporates with symbols called Adinkra. This research was chosen as a way of broadening the scope of developing the skills of designing new forms of living room upholstered furniture from the Asante traditional stool and enlightening customers on the meaning and significance of Adinkra symbols incorporated in the traditional stool.

1.3 Statement of the Problem

Sarpong (1971) considered concretely, the Asante stool is nothing but a wooden seat of artistic design for practical use. Before the introduction of chairs by Europeans, every Asante had many of these seats for use in his house. However, based on these assertion the researcher found that the trend whereby the The introduction of chairs by the Europeans have taken over the popularity of the Akan traditional stool which every Asante (Akan) had many of these seats (stools) for use in his house, have lost its dominance to the European chair because of its modification according to the current living conditions, customs, needs, tastes and even the simple functional beauty of contemporary furniture and interior design which is in harmony with our scientific

age in which emphasis is placed on precision and the accuracy of shapes, contours and proportions

1.4 Objectives of the Study

The main objective of the study is to develop upholstered living room furniture using the traditional Asante stool as a model.

1. To identify the socio-cultural concept of Akan traditional stool and design criteria for product development.
2. To ascertain the significance of the selected traditional symbols, local wood species and upholstery materials for the production of living room furniture.
3. To utilize design criteria for the manufacture of upholstered living room furniture founded on Akan Traditional Stools.

1.5 Research Questions

1. What are the socio-cultural concept of Akan traditional stool and design criteria for product development?
2. What are the significance of the selected traditional symbols local wood species for the production of living room furniture?
3. How can Upholstered Living Room furniture be manufactured with design criteria founded on Akan Traditional Stools?

1.6 Delimitation

This research is limited to the design development and construction of living room furniture using the traditional Asante stool as a model.

1.7 Definition of Terms

- **Traditional Ashanti Stool** – is a carved wooden seat used to denote the office of the chief or king in Asante's tradition.
- **Living room** – is a room in a residential house for relaxing and socializing.
- **Furniture** – is a mass noun for the movable objects intended to support various human activities such as seating (e.g., chairs, stools, beds and sofas)
- **Design** – is a plan within the framework of art, That is, layout, pattern, motif, sketch, draft, form, and arrangement of line.
- **Developing** – processing a photosensitive material in order to make an image visible
- **Upholstery** –a piece of furniture such as a chair with stuffing, cushions, leather, fabric and other materials

1.8 Significances of the Study

- The thesis will serve as a reference material for art students, furniture designers, wood work researchers, and product design educators in Ghana.
- Enlighten our chiefs and traditional leaders to adopt the designs in their palace
- The results would broaden the knowledge about traditional stools and their related functions and customs.

1.9 Organization of the rest of text

Chapter two focuses on a review of some relevant literature in connection to this study; Chapter Three, Methodology; Chapter Four, Results and Discussion; Chapter Five, Summary and Conclusion; Chapter Six, References

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

The researcher reviewed related literature under the following sub-topics: History of the Traditional Asante stool, Modernity of the Traditional Asante stool, Ceremonial stools, Material Used for Making Asante Traditional Stools, Types of Asante Traditional Stools, Owners of Stools, Samples of Traditional Asante Stools, and Symbolisms of Designs on Asante Traditional Stools Construction, Design Principles, and Furniture Materials.

2.2 History of the Traditional Asante stool

According to Cole and Fraser (2004), the word stool has two-fold meanings. It signifies the actual shape of the stool (the seat) and the office of the chief. Stools in general are wooden seats that have been used since ancient times. They are actually one of the most ubiquitous types of woodcarving in Ghana. According to Ross (2002) and Arthur (1998) stools are monoxylous in form or carved from a single piece of wood. Arthur (*op cit*) and Rattray (1927) assert the stool represents the seat of the owner's soul. They affirm that when the stool is not being used by its owner it is turned on its side or leaned against a wall especially at night time in order to avoid other souls (persons or spirits) passing by having access to it.

Stools have multiple forms, functions, and meanings (Cole and Ross, 1977). They range in significance from everyday domestic furniture to the spiritual essence of its owner or user.

According to Sarpong (1971), in Ashanti and other Akan societies, the stool is considered synonymous with its owner as an extraordinary intimacy is believed to exist between a person and his or her stool. He contends that the stool follows a

person from birth to death, while ritually punctuating major segments of his or her life.

2.2.1 Modernity of the Traditional Asante stool

With time the shape of Asante indigenous stools changed from the *dufua* varieties, which were cylindrical in form, to round stool varieties and later to a more sophisticated rectangular form (*as s dwa*). They comprised a crescent top, a middle portion and a rectangular base (Cole and Ross, 1977; Arthur, 1998). According to Sarpong (1971) rectangular Asante stools are synonymous with female principles and notes that the crescent top is popularly known as *baatan awaamu* meaning the warm embrace of a mother. The crescent shape of the stool facilitates comfortable sitting and easy carrying on the back of the neck (in the case of stools used by chiefs) during ceremonial processions. Conversely, stools of queen mothers (*ahemaa*) are carried on the head (Ross, 2002).

The middle portions of rectangular Asante's stools are considered the most important part as they carry distinctive motifs and designs from which the names of stools are derived. The motifs and designs are mostly obtained from various geometric and abstract designs, animal and human motifs. They embody lots of proverbial or symbolic messages, and suggest or reinforce the status, authority and beliefs of the owner or user, the worth of the stool, and the kind of stool it is. Some of the stool names serve to evoke, record, and communicate some aspects of Ashanti beliefs, history, social values and cultural norms (Rattray, 1923; Sarpong, 1971). Stools with symbols and geometric designs in the middle are designed to achieve a horizontal or symmetrical balance when halved. A few however with animal motifs may have asymmetrical balance (Edusei, 2003).

2.2.2 Ceremonial stools

Ceremonial stools (*Adamu dwa*) function in the Asante political system as symbols of authority and legitimacy. These stools are usually handed over from one ruler to another and others may be commissioned when a new chief assumes office. Ceremonial stools are crucial political objects that feature when new chiefs are being enstooled by being placed three consecutive times on the stool as a sign of their enstoolment. They are also used by chiefs when they sit in state or are performing rites connected with ancestral cult (Kyerematen, 1964).

2.3 Material Used for Making Asante Traditional Stools

There is a traditional choice in the species of wood for carving; and only a few trees are considered proper for it. Yet it can also be said that the choice of wood is made on practical grounds, since whatever is carved is expected to last for a long time, and should be light enough to be carried about. But more predominant in the choice is the religious reason. The wood is chosen because of the intrinsic supernatural character it is believed to have. "The chief kinds of wood used by the Asante wood-carvers are the osese (Funtumia sp.) and the 'Nyarne dua (Alstonia gongensis), from one or other of which stools are made" (Rattray's 1959, p. 271).

2.3.1 Types of Asante Traditional Stools

Considering the materials used for stools, we can divide them thus:

1. The ordinary white stools, that is, those stools carved from the wood mentioned above and left intact without anything being done to them besides the normal periodic washing and white-washing, which Ashanti decency and self-respect demand.
2. The silver stools, white stools which have been entirely plated with silver. These are very few indeed.

3. Still fewer are the golden stools. As far as Rattray's (1959) knowledge and information go, there is only one genuine golden stool. Rattray (1959) gave a more elaborate account of this stool later on, because of the prime importance attached to it by every Ashanti. It is believed to be all gold, but prefer to see it as a wooden stool covered entirely with pure gold leaf. There are other stools which are also called golden stools because they are made on the model of this famous one, even though no gold is put on them.

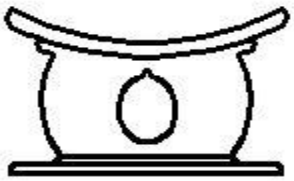


fig. 2.1

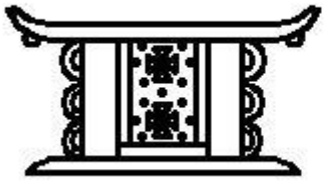
fig. 2.2

fig. 2.3

Fig. 2.1: Ashanti Stool

Fig. 2.2: Asika dwa kofi "Friday's Golden Stool"

Fig. 2.3: Ahemmaa dwa Queen's Stool



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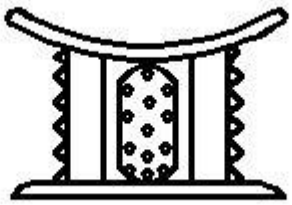

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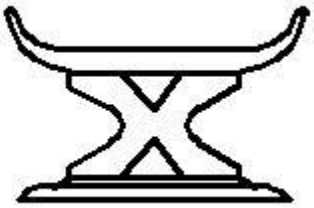


fig. 2.6

Fig. 2.4: Mmarima dwa "Man's Stool"

Fig. 2.5: Mmaa dwa "Woman's Stool"

Fig. 2.6: Osram dwa "Moon Stool"

Priests have their special stools with single centre supports, and so have certain attendants at the chief's house, e. g. the padlock stool is used by the chief's spokesman (fig. 2.1). A further division of stools is provided by the names given to them. There are special types of stools which more or less serve as the patterns for the carvers. There may be slight modifications or elaborations on the set and acknowledged types, but these latter are so varied that to invent a completely original model would require a prodigy of a craftsman to do. Rattray (1959, p. 272 f.) has enumerated some of these types; but they are certainly not comprehensive of the types as he himself admits. "These may not exhaust all the designs known in Ashanti stools, but they are sufficient to show their graceful lines, and the technique and beauty of their design" (p. 273). Suffice it to make mention of five of these stool-models : The Porcupine stool upon which sit the members of the chief's council (fig. 2.7) ; the Moon stool, used by ordinary people of either sex (fig. 2.6) ; the Draught-board stool, the Amu- let stool and the Leopard stool.

2.3.2 Owners of Stools

Every Asante person can possess a stool, irrespective of his sex, age, position in society, economic situation and marital rites. Many parents are wont to buy little stools for their small children. In fact, any self-respecting person has several stools in his house so as to be able to provide seating facilities for visitors. Our purpose here therefore is to examine which stools can be owned by whom. For it is not everybody who may buy any stool. Rattray (p. 271) observes that "many of the stools shown here were the 'copyright' of the Asante king, and might not, on any account, be sold in the open market". The unique authentic golden stool, of course, belongs to the king of Asante. He alone may possess the Elephant stool (esonodwa, fig. 2.8) and the Leopard stool (*osebodwa*). The Circular Rainbow stool (*kontonkurowidwa*, fig. 2.9) was once

used by him alone. As an act of honour, in the past, he received other stools which he gave out as presents to chiefs whose services pleased him. Those who own silver stools are the queen mother of Ashanti and the paramount chief of the Mampong State. The latter is the chief who takes over the traditional administration of the nation during the king's absence or when he is indisposed, and presides over the national council of chiefs. The chief of Techiman too has a silver stool which he uses on special and specified occasion. The Cross stool (*mmaremudwa*) is used only by the king of Ashanti and the greater *amanhene* (paramount or State chiefs), with his permission. The Porcupine stool (*kotokodwa,* fig. 2.7) is for the king and his council. A sub-chief uses a *mmomiwa* (a stool with two side supports). The shrines of the gods rest on the Crocodile stool (*denkysmdwa,* fig. 10) during public performances. Priests use the *sakyi-dua-korodwa* (the stool with only a single central support, fig. 2.11). Apart from the women's stool, those of the fair sex utilize also the *me-fa- asa-dwa* "my-half-is-finished stool", i.e., half of my family is dead. But, like the *owo-foro-adobe-dwa* "Snake-climbs-t he-raffia- tree stool", the Moon stool (*osram dwa,* fig. 2.6), and the *mframa-dan-dwa* "House-of-the-wind stool" may be used by both men and women. This shows that - in the past at least - the Ashanti were particular about the use of their stools. We have not been able - in fact it is impossible - to enumerate all the possible offices, and the kind of stools associated with each. As regards silver stools, many more chiefs are rumoured to possess them than we have mentioned, or are in a position to know about, for those who possess them do their best to conceal the fact for fear of being severely reprimanded for going beyond their rightful limits. Perhaps it ought also to be pointed out that the rigidity with which the Ashanti once regarded the question as to who should possess what stools, has these days given way to a great deal of elasticity, especially in regard to the distinction between men's and women's stools. Now practically nobody would make any fuss about what sort of stool is offered him

to sit on. We ought to explain too that it was inferiors who were restricted in the right to possess stools designated to or appropriated by superiors and not vice versa. A chief could acquire any stool his subjects were allowed to have. The king of Ashanti could have any stool he chose to have. For this reason it is in royal circles that one encounters a whole array of stools.

2.3.2 Samples of Traditional Asante Stools

Figure 2.7 Ashanti Golden Stool throne.

Figure 2.8 Akan (Asante)

Figure 2.9 Queen mother's stool, state treasury of Mampong, Asante, Ghana.

Figure 2.10 Porcupine stool

2.3.3 Symbolisms of Designs on Asante Traditional Stools

In Ashanti traditional life a stool symbolizes the soul of society. The seat which, as we remarked at the beginning of this chapter, is in the oval form of a crescent moon, symbolizes the warmth of a mother's embrace. The *obi-te-bi-so- dwa* "some-one-sits-upon-another stool" is carved in such a way that one stool is standing on top of another. The symbolism is not hard to find. It means that in any society there is a hierarchical order among the citizens; and even among chiefs, priests, elders and the

like, there is an order of precedence to be observed for the good running of the community.

The central portion, besides determining the name of the stool, is the object of diverse motifs. In the Circular Rainbow stool, used by the King of Ashanti alone, it is the figure of the rainbow. It is the reproduction in wood of the well-known proverb *kontonkurowi, eda amansan kon mu* "the rain- bow is around the neck of every nation". The symbolism is twofold. One inform- ant told us that it reminds the king that death is the lot of everybody, including himself, powerful as he is, and that therefore he should not be puffed up with pride by reason of his high position on earth. Another thinks it depicts the power which the king has over everybody in Asante. Then there are the *esono* stool and the *osebo* stool, the middle parts of which are the figures of the elephant, and the leopard respectively. They are the symbols of the great powers of the king of Ashanti, for the animals are considered to be the strongest and most feared in Asante. The maxim says: *wodi esono akyi a hasuo nka wo* "when you follow the elephant you do not get wet". To follow the owner of the stool with the figure of the elephant there- fore, is to be free from any unlawful provocation and aggression. The description of the Asantehene as the elephant is very succinctly put in the laudatory poetry about the chief of *Kokofu*, one of the greatest paramount chiefs of Ashanti: *esono uni wura mua anka ekoo ye bopon* "but for the presence of the elephant in the bush, the buffalo would be a huge animal". In other words, it is only because of the exalted position of the king of Ashanti that the prominence of the chief of *Kokofu* is not noticed.

2.4 Design Principles

Walton (1974) defines design as the intentional planning or inventing and making of an article for a particular use. The term “design” refers to the article itself as well as

the planning of its construction, operation and appearance. It may be made by hand or machine and is influence by the materials, shape, structure, use and appearance.
A design is not a copy of the work of another, it must be original. It is a purposeful creation, the result of intentional constructive thinking (Walton, 1974).
New designs are necessary to fulfil the needs of man in our changing living and social conditions. New shapes are required for new purposes often using new materials and new methods of manufacture. According to Walton (1974), states that when designing, the designer must take into consideration numerous aspects, each one playing either a major or minor part in the final production. If well designed it will be efficient in use and pleasing to look at.

2.4.1 Design Fundamentals

The two main elements governing design are;

1. Efficiency – combining all the practical aspects necessary to produce an article which is functionally sound and skilfully made of suitable materials.
2. Appearance – the aesthetic or external visual aspects which are produced by skilful and honest use of shapes, surface textures, colours and decoration.

The final result depends on the careful consideration of these aspects and the skill of the designer to integrate their relative values according to the use, beauty and quality of the article. The fundamentals of design are not dependent on any style or fashion but are aspects which are flexible and can be applied to any creative activity at any time. They are influenced by what people think is beautiful and suitable, and in harmony with our constantly changing living conditions and environment.

2.4.2 The stages in Development, Planning and Construction of a Design

Walton (1974) states that an object is being designed from the moment it is thought of or conceived. The first thoughts are generally concerned with the intended use of the article. The particular need for it creates some form of mental picture of the article; what it will look; what it is made of; and perhaps a picture of it in its surroundings. Walton (1974) continues by adding that unless the article is of very simple design it will be almost impossible to make it without wasting time, energy and materials due to errors in calculating sizes, etc. hence it is necessary to develop and record the mental picture by means of sketches and drawings. This will give a much better idea of its construction, general appearance, proportions and accommodation.

2.4.3 Anthropometric/ Ergonomic design

Anthropometrics are the measurement of the size and proportion of the human body. Kilmer & Kilmer (1992) define ergonomics as the study of the relationships between human beings and their function in the environment. It is the application of anthropometrics for optimum human/environment relationships

The goal and a challenge of a good design was to address all design types simultaneously in order to obtain ultimate outcome the furniture product which would be aesthetically pleasing, user friendly, durable, easy to manufacture, will support the user and would be environmentally responsible

An example can be seen in figure 2.11

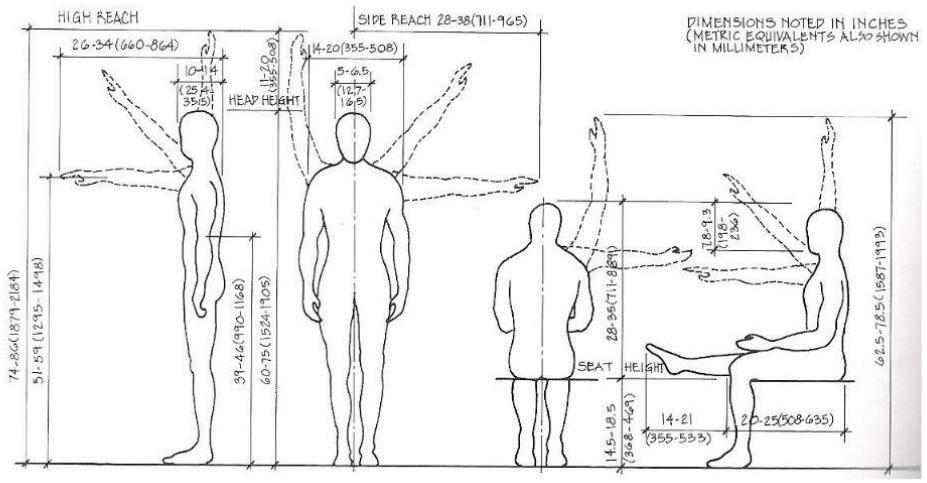


Figure 2.11 Anthropometrics: Body Measurements

(Kilmer & Kilmer, 1992, p. 190)

2.5 Furniture Materials

The first step in an evaluation of furniture is to check the type and quality of the material used. Of the variety of materials used in the construction of furniture, the most common are wood, metal, plastic, and glass. These materials may be used alone or in combination. (Sherwood, 1990)

2.5.1 Wood

Wood is a ubiquitous bio-material obtained from certain woody plants. Oteng-Amoako et al, (2006), advocate that, wood is the principal strengthening and water conduction tissues of the stems and roots of mainly trees. In relation to this the World Book Encyclopaedia states that, “wood is the tough inner portion beneath the bark of trees, shrubs and certain plants”. As in other literature the difference between the two definitions is the fact that one is based on the physical appearance of the material and the other based on the scientific function of it as part of the parent tree. Wood is

heterogeneous, hygroscopic, cellular and anisotropic and may also refer to other plant materials and tissues with comparable properties (http://en.wikipedia.org/wood, 2014).

However, the material engineers who look more into the composition of materials describe wood as a natural composite (composition of other materials) - (Van Vlack, 1973).

These account for the fact that different people interpret the nature of the material differently and hence its varied applications that include extraction of raw materials from it, engineering of the material to suit different purposes and also its application also in building and decoration of forms. This also implies that information of wood available to the various areas of wood specialisation contribute to the success of the respective areas. This necessitates the organisation of information relevant in the intercommunication of wood and metal in the case of this research for the assurance of its success.

2.5.2 Wood source and classification

Wood is varied in appearance, behaviour and structure owing to the fact that, it is obtained from different plants that grow in different environments under different conditions. It is also necessary for the artist to have a fair knowledge of the sources and characteristics of wood and its parent tree in its natural environment. This is because the artist apart from sourcing labelled wood from the timber market might for one reason or the other want to also obtain wood from the natural environment. Also apart from the general classification of wood species and their behaviour, different parts of the wood or trees behave differently, hence the essence of the in-depth 26 knowledge of this to make it possible for the artist to make the right choice at the right time. The trees from which wood is obtained can be designated into one of two groups

in the plants classification. These are Endogens (monocotyledons) and Exogens (dicotyledons)-(Chapman, 2001).

Chapman also elaborates on the two categories as follows: *Endogens (monocotyledons):* these are trees in which most of the growth takes place inwardly in a hollow stem. Examples he gave include bamboo, palm, yucca and tree ferns. According to him, this species has little or no commercial value which is not the case in today's economic terms: looking at what is happening in China in relation to bamboo and in Malaysia in relation to palm.

Exogens (dicotyledons): these are outward growing and increase in size by adding new tissues in their growing season in the form of individual layers of concentric growth rings. The valuable exogens are divided into two classes; these are angiosperm well known as deciduous trees and gymnosperm also well known as coniferous. Moreover both the class liliopsida (monocotyledon) and magnoliopsida (dicotyledon) belong to the angiosperm group of vascular plants known as the division anthophyta (flowering plants)-(Crosby et al., 2007).

2.5.3 Hard wood and soft wood

Woods from exogenous plants are classified into two main groups depending on the tree from which they come. Woods from broad-leaved trees are called hardwoods, and wood from coniferous trees are called softwoods, regardless of their actual hardness

(Redmond, 2007).

Figure 2.12: An exogenous plant

Source: Microsoft® Student 2014

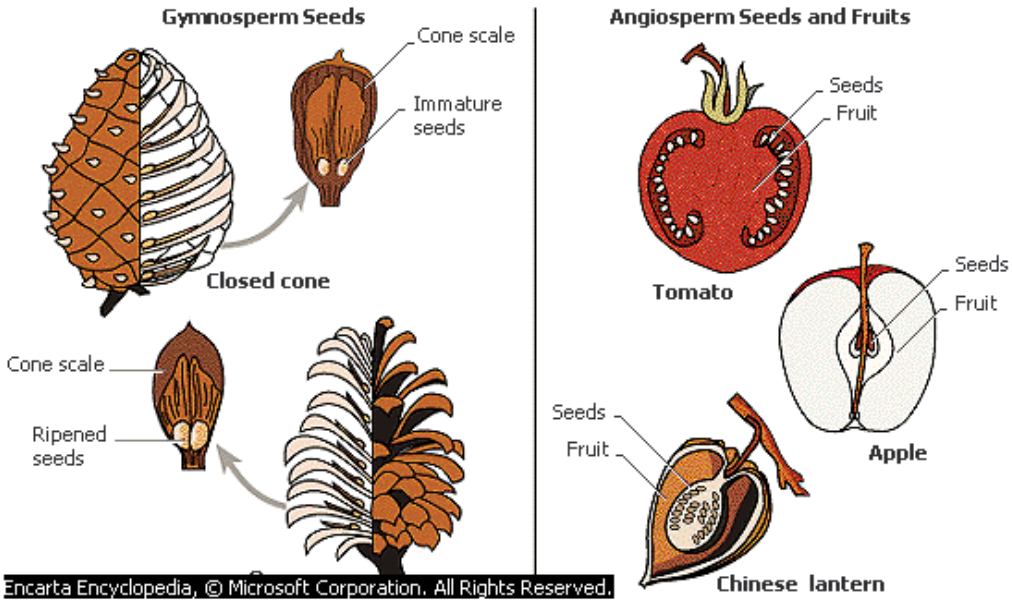


Figure 2.13: Gymnosperm seeds and angiosperm seeds in contrast

Source: Microsoft® Student 2014

Other wood writers and scientists such as Bridgewater A. and Bridgewater G. (2007) also advocate the general classification of wood under hardwood and softwood. They state that, *hard wood* are obtained from broad leafed deciduous trees that drop their leafs annually and soft *woods* are obtained from coniferous or cone-bearing evergreen trees that retain their foliage though there are exceptions. But the fact remains that softwood are fast growing than hardwood. Also softwood contains more sap in them than hardwood. This also means that apart from identifying wood by the kind of flowers, seeds or fruits from the parent tree, the amount of fluid that comes out by cutting the back of a tree can assist the wood artist in determining whether the wood is soft or hard.

2.5.4 Components of wood

The component of wood can be best understood by its *basic chemical composition.* According to Tsoumis (1991), the elementary composition of wood is such that there are no important differences. He mentions the principal chemical element of wood as Carbon (C), Hydrogen (H), Oxygen (O) and Nitrogen (N) in small amounts. Also he states that the chemical analyses of a number of species (hardwood and softwood) show the proportions of the element in percent of the oven dry weight to be approximately as the following:

- Carbon (C) = 49% to 50%
- Hydrogen (H) = 6%
- Oxygen (O) = 44% - 45%
- Nitrogen (N) = 0.1% - 1%

Tsoumis (1991) also gives accounts of certain amount of mineral element that exists in wood ash that are seldom 0.2% or higher than 1% of oven dry weight of wood. These are principally calcium (C), potassium (K) and magnesium (M).

Organic components of wood: according to Tsoumis carbon, hydrogen and oxygen combine to form the principal organic components of wood structure namely: cellulose, hemicelluloses, lignin and small amount of pectic substances. According to him:

Quantitatively, cellulose and the other chemical constituents are contained in wood in the following proportions (in percentage of the oven-dry weight of wood): cellulose 40–50 percent (about the same in softwoods and hardwoods), hemicelluloses 20 percent in softwoods and 15–35 percent in hardwoods, lignin 25–35 percent in softwoods and 17–25 percent in hardwoods, and pectic substances in very small proportion. In addition, wood contains extractives (gums, fats, resins, waxes, sugars, oils, starches, alkaloids, and tannins) in various amounts (usually 1–10 percent but sometimes 30 percent or more). Extractives are not structural components but inclusions in cell cavities and cell walls; they can be removed without changing the wood structure.

These confirm the composite nature of wood and dealing with it means dealing with multi materials, hence the essence for the consideration of relevant factors.

Cellular composition of wood: the cellular structure of wood is a result of specialised cells capable of division. These cells compose the so called generative or meristematic tissues responsible for the length growth (optical growth) and diameter growth (secondary growth) of the tree: the optical growth influenced by the optical meristems and the secondary growth influenced by the lateral meristem. However, results of these quite vary between softwood and hardwood.

This growth system results in two categories of cells: the ray cells and the longitudinal cells summarised below in figure 2.14.

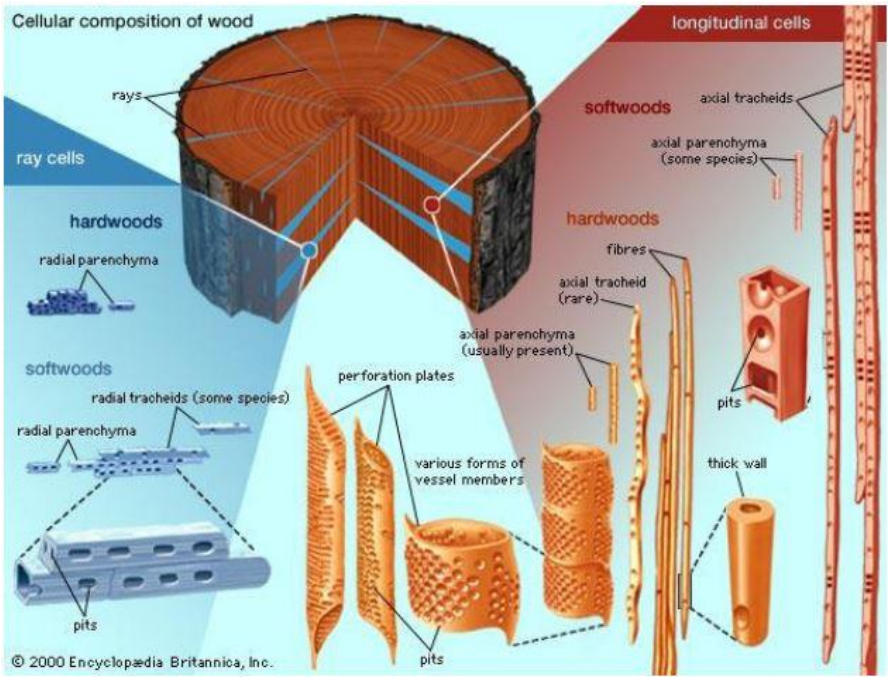


Figure 2.14: Cellular composition of wood

Source: Encyclopaedia Britannica, Inc. 2014

The summary above illustrates the differences in cell structure which has a direct relation to the behaviour of the wood as well as the variation of behaviour in different species. The direction of the pores shows the direction of moisture movement in the wood. The thick cell walls of the hardwood giving a clue to why they are denser than softwood in most cases. The pits on the tissues also indicate the wood's ability to hold water and not draining off easily. The vertical and horizontal arrangement of the cell explains the strength distributions within the structure. The variations in cell distribution between the radial and axial also explain why the wood is stronger when sawn in certain directions than others. The cross nature of the cells and the wavy nature of the cells explain the looks of figure in wood. These among others explain the relevance of the cellular structure of wood to the artist with limitless ideas.

2.5.5 The structure of wood

The structure of wood is the architectural organisation of the wood that comprises the nature and arrangement of the physical (macroscopic, microscopic, ultramicroscopic) and chemical building components (Tsoumis, 1991). By this statement it means that the structure of wood comes in two categories, those aspects that can be seen with the naked eyes and/or in conjunction with an eye aid: such as lenses and the other aspects that have to do with the chemical composition of the material.

2.5.6 The physical structure of wood

To Chapman and Peace (2001), the usefulness of various sections of wood can also be determined by their roles played in the mother tree before they are harvested. This they capture under a broader topic- *growth and structure* as follows:

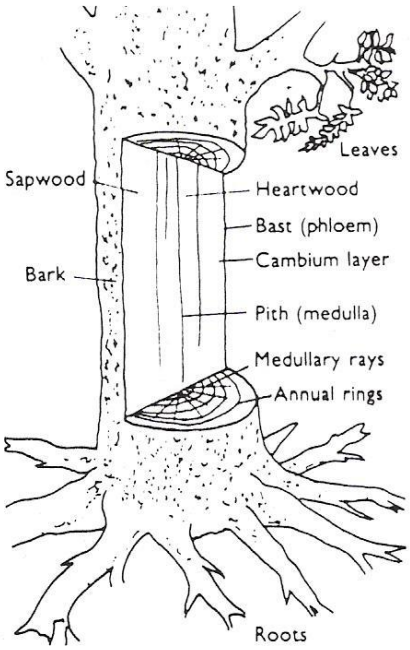


Figure 2.15: The physical structure of woody tree

Source: Chapman and Peace, 2001

According to them although hardwoods and softwoods have different types of cells and differ in the formation of tissues, their growth and overall structure are sufficiently similar to allow a combined study of how a tree grows. For that matter, as shown in figure 2.15 above is the structure of a typical tree, together with the cross-section of its trunk. The function of each labelled part is given as follows:

***Roots*:** The root structure begins to grow as the seed sprouts and continues to develop through the sapling stage. Roots serve two basic purposes:

1. Root hairs absorb water and dissolve mineral salts to make crude sap.
2. They support and anchor the tree.

***Sapwood*:** Sapwood is the newly formed wood made up of xylem cells. Sap water and mineral salts are carried through these cells up the tree by suction pressure to the leaves, where they are manufactured into food.

Often light in colour and quite soft, it is least resistant to decay and is prone to attack by insects and fungi. In the young tree, all the stem and branches are required for conveying sap, but as the girth of the trunk increases the proportion of sapwood becomes progressively smaller.

***Heartwood*:** Heartwood was once sapwood, which has matured and become inactive. Heartwood is made up of lignified (hardened) cells which serve to give strength and support the tree and provide storage for waste products such as resin.

It is much harder, stronger and often darker in colour than sapwood, and provides the most commercially useful part of the tree.

***Pith or (medulla)*:** The pith is the centre of the trunk. It is the remains of the earliest growth of the sapling and is often soft. It is to be found throughout the length of the tree, forming in the crown or leading shoot as it extends upwards.

***Medullary rays*:** These thin sheets of tissues or rays extend from the cambium to the pith (medulla) like the spokes of a wheel. They conduct and distribute waste products horizontally for storage, in the mature cells. They vary considerably in thickness and visibility, forming figure or silver grain, in some wood.

***Leaves*:** Leaves take in carbon dioxide from the atmosphere and sunlight is absorbed by the chlorophyll (green pigment) in the leaves. The energy from the sun is used to Synthesis organic compounds (in the form of sugars and starches) from carbon dioxide 'and water. This complex chemical reaction is known as photosynthesis.

The leaf surface has tiny vents or pores (stomata). Oxygen and carbon dioxide enter and leave through the stomata, and water vapour is also lost through the stomata, a process known as transpiration.

During daylight hours, when photosynthesis is taking place, carbon dioxide is absorbed and any excess oxygen is expelled. At night when photosynthesis stops, excess carbon dioxide is expelled through the stomata. In this way trees help to maintain the. delicate balance of oxygen and carbon dioxide in the atmosphere.

***Bark*:** Bark is a skin or protective coating which prevents transpiration from the trunk and serves to protect the tree from damage and the extremes of temperature. It is made from the outer layers of bast or phloem as they die, and expands as the tree grows, with the outer, corky layer becoming hard.

***Bast or phloem*:** Bast or phloem is the inner bark made up of living tissue (phloem cells) which carries food in the form of sugars, amino acids to make up proteins, and

hormones which control growth. These are mainly carried downwards from the leaves to other parts of the tree.

Cambium layer: This completely surrounds the sapwood and is where growth takes place by cell division. New wood cells (xylem) are formed on the inside and, to a lesser extent, new phloem (bast) cells on the outside.

Annual rings: These are commonly called growth rings, because they represent one season's growth. Each ring or band is made up of two distinct layers, the spring wood and the summer wood. The inner most spring wood consists of large, soft, thin-walled cells which help the flow of sap. In summer, with less sap, the cells are smaller, thicker walled and denser. It is this density which often accounts for darker variations in colour and texture. Viewed in cross-section, this growth cycle gives distinctive bands, by which the age of the tree can easily be determined. By contrast, some tropical timbers show no visible annual rings because growth takes place uniformly throughout the year.

Cork cambium: Royal Forestry Society 2010 highlights the cork cambium. This is a zone of actively dividing tissue near the outer surface of a tree that produces cork. This is more significant in trees noted for cork production like the cork oak. This can be identified in fig. 2.16.

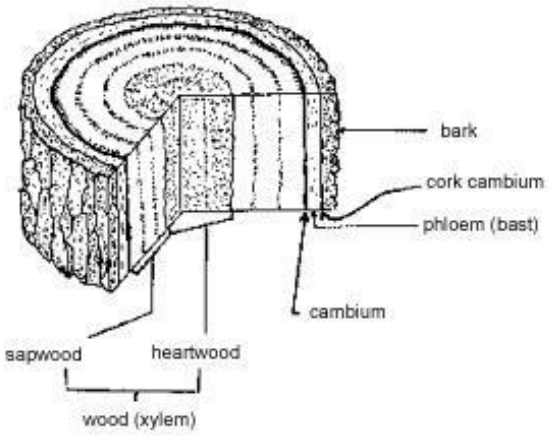


Figure 2.16: The structure of a corky wood

Source: © J. Jackson –Royal Forestry Society website

In spite of one exception or the other as shown in Figure 2.16, Chapman and Peace (2001), advocate that wood cells vary in size shape and function. According to them "this permits a botanical distinction to be made between hardwoods and softwoods based on the arrangements and types of cells". This they do by the consideration of the unique cells components of each category and also the differences that exist in the common cells.

2.5.7 The structure of softwood

The structure of softwood is more primitive than hardwood. The main types of cells are:

a) Tracheid
b) Parenchyma
c) Resin canals

Tracheid – in softwoods the tracheid form the bulk of the timber. They are thin, elongated tubes sealed at the ends and spliced together in the direction of growth. Communication between the cells for the passage of sap and food takes place through small openings in the cell wall known as the *pits*. As they age the cells harden and serve to support the tree. They form in radial rows and it is the direction in which these cells lie that makes the grain of the wood.

Parenchyma – these are smaller than tracheid, with simple type pits, making up the remaining cells. These include *rays*, which in the case of softwoods are usually thin, only one or two cells thick. Rays are almost invisible, but they are a reliable means of identification between species when magnified.

Resin canals – these occur in most conifers (softwood trees) and are indication of the function of the rays, thus the means by which resins and gums (waste products) are carried (Chapman and Peace, 2001).

2.5.8 The structure of hardwood

This is characterised by *Fibres, Vessels* or *pores* and *Parenchyma.* See figures 2.17 and 2.18.

Fibres – unlike softwood fibres make up the bulk of hardwoods. They can be compared to the tracheid in conifers, but they are very much smaller and sharper, giving mechanical support to the tree. On the contrary to tracheid, they do not also carry sap and are not arranged in any form or pattern.

Vessels or pores – these are found only in hardwoods, they provide a positive means of identification. They form ducts or tubes and extend in the whole length of the tree with the primary function of carrying food. They are numerous and often clearly visible, and appear in two different forms dividing hardwoods, into two groups:

1. *Diffuse porous* - when they are equally spread throughout the tree (examples are tropical hardwoods like ebony and mahogany).
2. *Ring porous* - when they appear somewhat large in the early spring growth and considerably smaller in the summer. However, when the pores are only slightly larger than those produced later, they are called 'semi-ring porous' (e.g. walnut).

Parenchyma –apart from existing in softwood, these are also found in hardwoods, forming radially in the rays which are often more outstanding. In oak especially, they can be 20 to 30 cells thick, producing the familiar silver grain. In some timbers these cells mark the end of each season's growth. Much rarer, in Burma teak, they form at the start of the growth ring (Chapman and Peace, 2001).

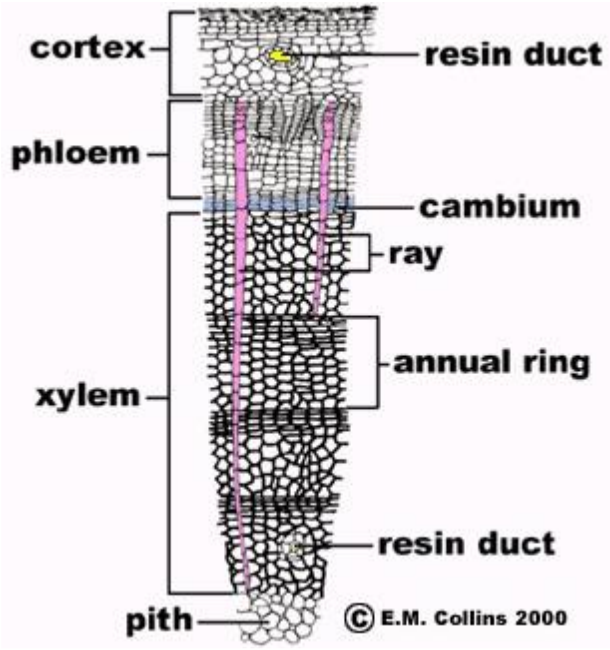


Figure 2.17: Softwood -microscopic view

Source: Collins, 2000

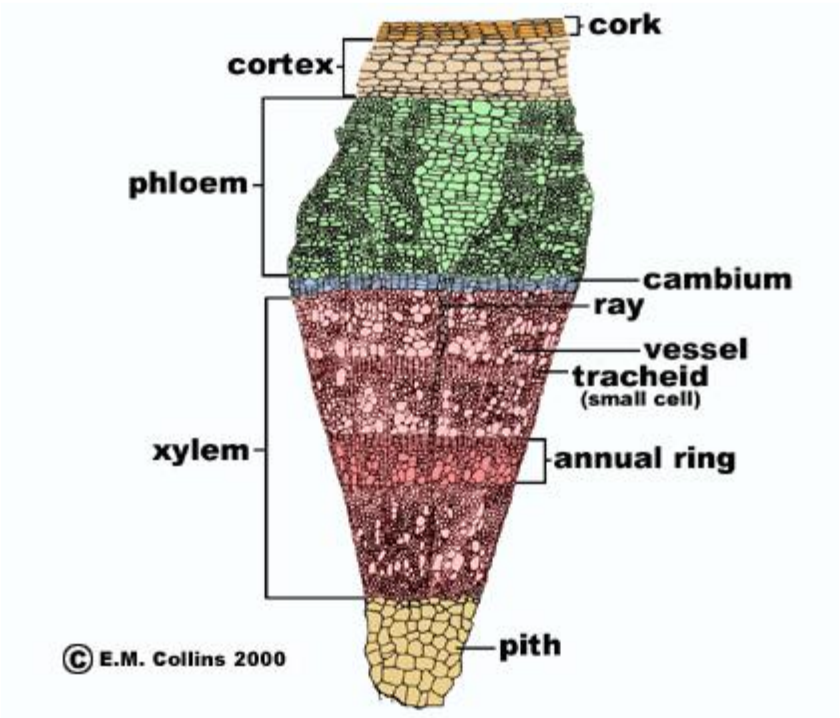


Figure 2.18: Hardwood -microscopic view

Source: W.P. Armstrong 1999

2.5.9 Processing of wood into good lumber

Bridgewater A. and Bridgewater G. (2007) opine that selecting solid wood is exciting, but one must avoid making expensive mistakes, such as the wrong type of wood, a poor quality wood. The best way of ensuring that one finishes up with wood that is good for its purpose is to know something about conversion, seasoning, grain and faults.

2.5.10 Conversion of wood

With reference to various available literature, wood conversion is the process of cutting wood into usable piece which cannot be achieved without considering the nature of wood in relation to its physical anatomy as shown in Figure 2.19. This is because the angle at which the saw meets the growth ring determines the behaviour, figure and strength of the wood.

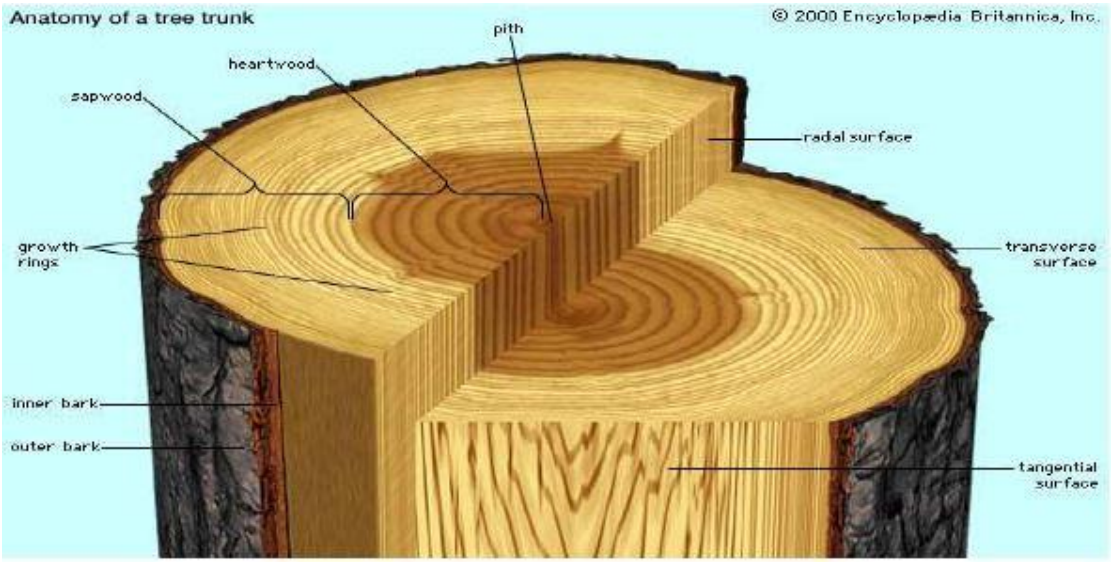


Figure 2.19: The anatomy of a tree trunk

Source: Encyclopaedia Britannica, Inc. 2008

The size, shape and grain pattern of timber as purchased from the supplier are determined by the way the tree is sawn (converted). There are many traditional ways of

converting a tree. It can be plain sawn to make a stack of planks, radial or quarter sawn, modularly sawn etc. The conversion method, and the resultant angle at which the growth rings within the tree meet the sawn face, are the factors that shape the grain as they appear on the finished lumber (A. Bridgewater and G. Bridgewater, 2007).

Conversion is the term giving to sawing the log into marketable timber. Many factors affect how this is achieved. Some of these are: the type of timber, market requirement and eventual use. It can also promote features like grain pattern and figure and also an increase in stability in use.

In some cases the conversion is done without stripping off the back in order to prevent rapid drying unlike most exported timbers that are debarked before shipping to avoid insect contamination. Bulk of timber is also sometimes produced which involve only the removal of the sapwood. However two basic methods are used in conversion, these are: Slab, plain or through and through sawing and Quarter (radial) sawing (Chapman and Peace, 2001).

Apart from the varied suitable conversion methods, Hilton (1980) also emphasises conversion as an effective means of production management. According to him conversion based on the intended use of the wood ensures that the required shapes and sizes of the material are always made available to avoid extra work by managing extraneous materials. This case he establishes as follows:

The sawing of logs, or breaking down into various shaped and sized pieces for specific purposes, is known as conversion. There are very few firms which take the logs in the round state. Timber is purchased mostly cut through and through, quartered or squared and carried out at the place of shipment in the case of softwoods. Purchasing timber in this way does mean that the buyer is able to select his material with the finished product

in mind noting the quality, texture, grain, colour, etc., thus avoiding having to handle unsuitable materials often occupying valuable yard or floor space.

There are several ways of converting a log: Through and through or tangential sawing and Quarter or rift sawing. The term radial or tangential refers to the surfaces of the wood secured by the cut of the saw in relation to the growth rings of the tree. (Hilton)

2.5.10.1. Through and through or tangential sawing

This is the same as slab or plain as described by Chapman and Peace (2001). This is the straight forward cutting of the log into any required thickness without any regard for showing particular grains but with a minimum of waste. This plain method is usually the cheapest form of conversion. "In this method most of the boards will be flat sawn which means that the growth rings meet the face of the board in any part of an angle of less than 45 degrees"

Tangential sawing is adopted for timber types having clearly defined growth rings. In this method the through sawing happens such that boards have their faces tangential to the growth rings. When converting softwoods for floor joists and the like, where strength is most important, the lengths of timber must be tangentially sawn (Hilton, 1980).

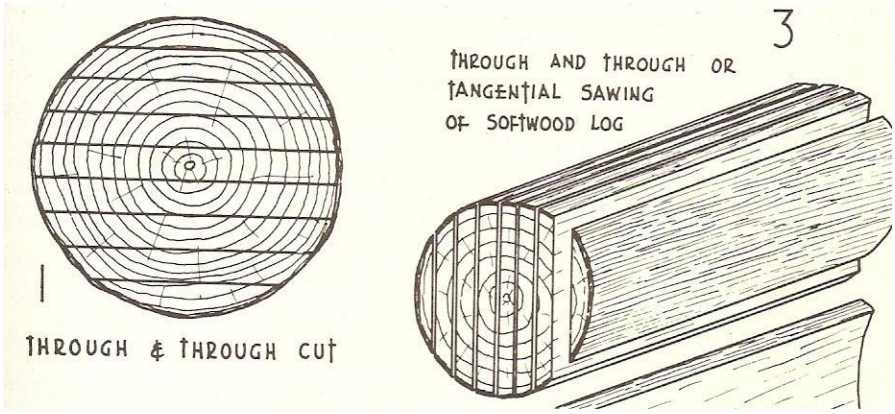


Figure 2.20: Through and through or tangential sawing

Source: Hilton, 1980

Though the through and through method and the tangential method of sawing appear to be the same and are used interchangeably, they are not. This is so because in tangential sawing the sawing is always through but in the through and through method the face of the lumber will not always be tangential to the growth rings especially when it is either running through the pith or taking place in wood without clearly defined grains.

2.5.10.2 Quarter or rift sawing

Quarter or rift sawing also known as radial sawing is a method of conversion in which the growth rings meet the face of the board at an angle of not less than 45 degrees. In achieving this, certain percentages of the log is lost or wasted in the process making quarter sawn lumber more expensive in relative terms with the plain methods. Though quarter sawn woods are expensive they carry the advantage of less shrinkage and also the provision of a more even ware in terms of figure and structural variation

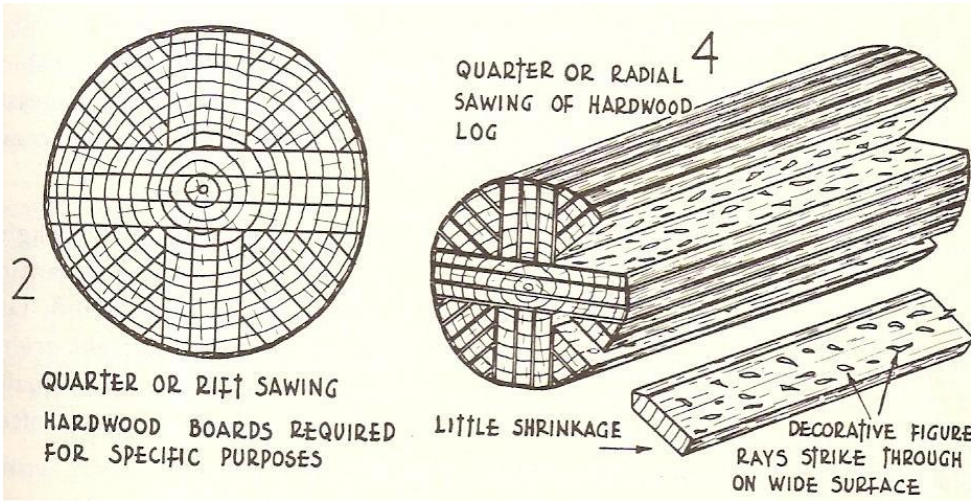


Figure 2.31: Quarter or rift sawing

Source: Hilton, 1980

2.5.10.3 Operations in conversion

Further breakdown of wood is accomplished in one or more operations. For example, a combination of circular and frame saws, or two frame saws in series, may be used. The first saw removes slabs (the outside pieces cut from a log) and, in certain cases, some boards. The piece produced is then turned 90° and introduced to the second saw, which converts it into boards (cant sawing). The second operation may be considered as re-sawing. In general, re-sawing consists of either dividing thick boards into thinner ones or producing boards from slabs. Ripping, or edging, is the removal of wane (edge areas with bark or some missing wood) from the sides of boards, frequently done by passing the board through a machine that has two small circular saw blades mounted on a shaft. One blade is stationary and the other can be moved sideways to set board width. Edging can also be done by chipping in a simultaneous sawing and chipping operation, with the chips directed to pulp, fibreboard, or particleboard manufacture. (Some valuable furniture woods are not edged in the sawmill.) Finally, certain boards are crosscut with trimmers to square their ends and remove defects.

Other examples of combinations of machines used for breakdown include two band saws (used as head saw and ripsaw), followed by edger and trimmer, or a series of double band saws with chipping edges. In some sawmills (and other wood-using industries) computers are employed to regulate positioning of logs and other operations (Tsoumis, 2010).

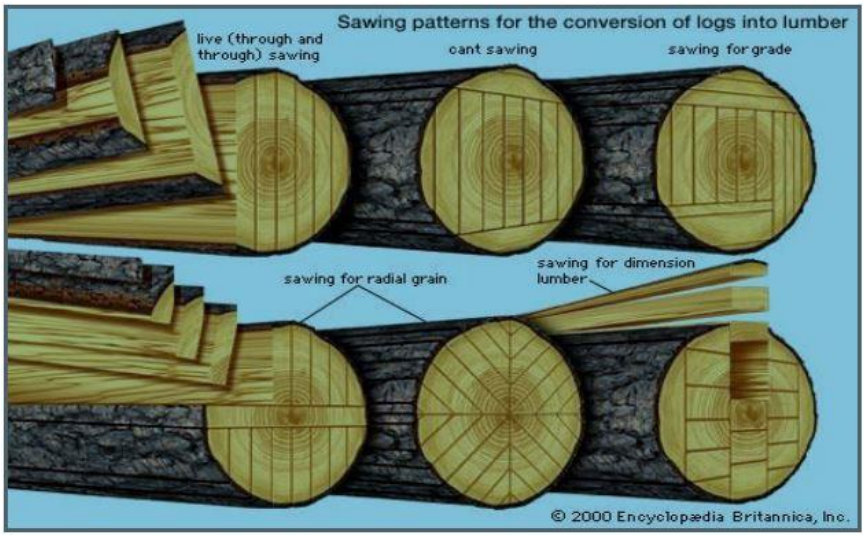


Figure 2.32: Basic log-sawing patterns

Source: Encyclopaedia Britannica, Inc. 2008

From figure 2.32, live and cant sawing may be done with a frame saw for simultaneous sawing. In cant sawing, two slabs on opposite sides of the log are removed first, producing a cant for the frame saw. Sawing for grade, done with a band saw, involves turning the log after each cut according to revealed wood quality. Sawing for radial grain enhances the figure of some species and reduces distortions due to shrinkage and swelling; the lumber so produced is sometimes called quarter sawn, especially when the logs are quartered before being sawn into boards.

2.5.11 Seasoning of Wood

Another area of concern is the fact that excessive water content of lumbers makes them fail in many instances. Many works by wood researchers emphasise the fact that-the drier the wood the stronger it becomes. In other words, the strength of wood is largely dependent on its moisture content. Apart from this, wet timber is also prone to bacteria attack, fungi growth, other biological degrading agents that may destroy its colour, grain pattern and other desirable properties. Excessive water may also react chemically

with any complementary material that may be used in conjunction with the wood negatively.

"A growing tree contains more than its own dry weight in water" the objective of seasoning is to remove excess, unwanted sap and moisture from the timber (Chapman and Peace, 2001). Timber is a hygroscopic substance, thus gives off water to the dry environment but absorbs water from the damp or wet environment or atmosphere. Consequently dry wood swells in damp environment and shrinks in a dry environment. Wet wood when used in products tends to shrink and poses problems like leaving gaps at joints, poor finishes among others. Seasoning therefore must ensure that the moisture content at the end is less than 20% (Chapman and Peace, 2001).

Chapman and Peace like other wood writers and researchers advocate that, there are two basic methods of seasoning. These are air seasoning and kiln seasoning.

2.5.11.1 Air Seasoning of Wood

Planks that are seasoned by air drying method are stacked on spacer battens at least 450mm apart. These air spaces between planks are essential to guard against mould or fungal attack. The stack is built in a dry shelter spot to allow air to circulate around it but protect it from rain and direct sunlight. It takes approximately one year to dry every 25mm (1in) of board thickness for hard wood and slightly less for drying soft wood. "With this method the timber can only dry to the ambient humidity-the humidity of the atmosphere it is drying in-which is generally about 15 percent". This is good for exterior use but if the timber is meant for interior use, then this must be reduced in the kiln where the extraction of the moisture can carefully be controlled or regulated (Simpson, 2001).

2.5.11.2 Kiln Seasoning of Wood

Kiln seasoning is more or less an artificial method of seasoning in which the timber are stacked and put in the dryer in a form of oven known as kiln in which temperature and humidity are carefully controllable. The woods are fed into the kiln on trolleys, then a mixture of hot air and steam is introduced then the humidity is slowly reduced to the moisture content required. The moisture content is normally 8 percent or less, after which the seasoned timber is stored in a controlled environment. If kiln seasoned wood is otherwise placed outside it will take moisture again. (Simpson, 2001)

2.5.11.3 Advantages of Seasoning

A well-seasoned timber has the following advantages that make it more applicable in production. Chapman and Peace (2001) put these under four tabulates as follows:

a) It makes it immune from decay and increases it resistance to rot.
b) It increases timber strength and stability.
c) It helps preservatives to penetrate (dry wood takes finishes easily).
d) It makes timber considerably less corrosive to metals.

2.5.12 Other Drying Methods

Apart from the orthodox seasoning methods available there are other unconventional methods. Hilton (1980) mentions four of such methods. These include:

a) Radioactive frequency heating
b) Temperature gradient method
c) Chemical drying
d) Second seasoning

2.5.12.1 Radioactive Frequency Heating

In this method the wood is placed between two metal plates to which is applied an electric current oscillating at a very high frequency. This high frequency current, unlike in kiln heating, causes the moisture in wood to heat up at a more or less uniform rate throughout till boiling point is achieved. The steam formed is able to escape freely depending on the power input. This process takes advantage of the water conducting tissues of the wood to eliminate water. The greater the power input the greater the drying rate.

Because of the even heating that takes place in this method, the wood dries at equal rate void of case drying that avoids tension in the wood structure that leads to splitting in most cases (Hilton, 1980).

2.5.12.2 Temperature Gradient Method

In this method of drying, the core of the wood is heated by radio-frequency and the surface deliberately cooled by moist air thereby inducing moisture movement from the hotter or centre to the cooler surface till the required water is lost from the timber. This process is likewise very expensive (Hilton, 1980).

2.5.12.3 Chemical Drying

In this process the surface of the timber in the green state is caused to absorb certain hygroscopic salts such as urea or even sodium chloride (common salt). This salt on the surface tends to keep the timber damp and inhibits shrinkage, but at the same time establishes an osmotic gradient that causes moisture from within to diffuse into the outer surface and then evaporate into the atmosphere. The seasoning in this method is not complete since it is always completed with either air or kiln drying. Another

disadvantage is the tendency of discolouring the wood that may be caused by the chemicals involved (Hilton, 1980).

2.5.13 Moisture Content in Wood

Though seasoning is aimed at removal of moisture, timber should retain some degree of moisture. Moisture content is the technical description of the amount of moisture contained in the wood which is expressed as a percentage of its dry weight. Seasoning aims to reduce the moisture content to below 18% for general outdoor use, falling to below 14% for indoor use, and to around 10% in centrally heated homes in cold region (Chapman and Peace, 2001).

Chapman and Peace among other works express the percentage of moisture content of wood as follows:

$$\% \text{ moisture content} = \frac{(\text{initial weight} - \text{dry weight}) \times 100}{\text{Dry weight}}$$

2.5.14 Movement of timber

Though the cutting down of trees ends their movement (growth of various parts of the tree), there are other movements that take place in the lifeless cell caused by the movement of water molecules in and out of the wood cells. This movement is normally seen as swelling and shrinkage that come with its own structural effect to the wood.

According to Chapman and Peace, (2001), "shrinkage is closely associated with seasoning. It occurs as the wood dries out. Wood cells contract, which often result in splitting and twisting". Similar work was also done by Hilton (1980). He talks about the variation of size and shape as a response to moisture content by wood and how they can be studied and compared by experiments. According to him the percentage of moisture movement may be calculated as follows:

$$\% \text{ moisture movement} = \frac{\text{increase in length} \times 100}{}$$

Dry reading

In the drying movement, maximum shrinkage occurs along the direction of the annual rings and tangentially, the medullary rays close like a fun. Some though minimal, shrinkage takes place in the radial direction along the grain which is about half that of the direction of the annual rings. However there is negligible shrinkage in length (Chapman and Peace).

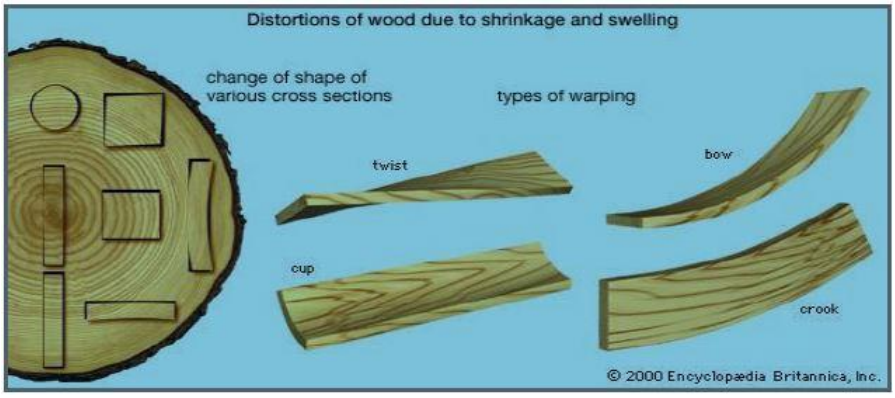


Figure 2.33: Distortion of wood due to shrinkage and swelling

Source: Encyclopaedia Britannica, Inc. 2008

2.5.15 Physical Properties of Wood

According to Bridgewater A and Bridgewater G, (2007) "wood is the most versatile of all materials", the reason being that, there are hundreds of colours, textures and grain patterns. One may wonder how a material could show so such numerous qualities.

According to Panshin and Carl de Zeeuw (1980), "basically all the physical properties of wood are determined by the factors inherent in its structural organisation. This he summaries under five headings. These are:

- The amount of cell wall substance present in a giving volume of wood.
- The amount of water present in the cell wall.

- The proportional composition of the primary chemical components of the cell wall and the quantity as well as the nature of the extraneous substance present.
- The arrangement and orientation of the wall materials in the cell and in the different tissues.
- The kind, size, proportion and arrangement of the cell making up the wood tissues.

Apart from a similar comprehensive work done by Tsoumis (1991) on physical properties, Negi (1997) also did a comprehensive work on the same subject. He opines that the physical properties include the properties connected with the physical state of the wood such as look or appearance, colour, density, weight and also the reaction of the wood to sound, heat, light etc. He goes on to state that physical Properties do not include those which appear under the influence of external mechanical or chemical factors on the wood. Under this he mentions nine important physical properties and three other properties he declares less important. These are:

i. *Colour*
ii. *Weight, density, and specific gravity*
iii. *Sound and wood*
iv. *Resonance*
v. *Light and wood*
vi. *Electricity and wood*
vii. *Heat and wood*
viii. *Permeability of wood*
ix. *Wood working and other properties*

2.5.15.1 Colour

Colour is the most common physical property of wood which varies in various species of wood. In many species of wood, the colour darkens on exposure to light. This is due to the chemical change that takes place on the exposed surface of the wood. Differences in colour also occur as a difference between heartwood and sapwood.

The *Lustre* of wood is also discussed as an important element so far as colour is concerned. This refers to the degree of the reflection of light from the walls of the wood cells.

2.5.15.2 Weight, Density, and Specific Gravity

Though these three: weight, density and specific gravity have to do with pressure exerted by gravity. The differences are made clear by the following:

Weight: the weight of a wood is the total weight of all the matter it contains. This includes wood substance, the mineral and non-mineral components as well as the water content of the wood.

***Density*:** the density of wood like most other substances is the mass of a unit volume of the wood. It may be expressed in kilogram per cubic metre.

Specific gravity: is the ratio of the weight of the wood to the weight of an equal amount of water at a given temperature.

2.5.15.3 Sound and Wood

Wood has different reactions to sound and these are important factors to consider when selecting wood for musical instruments. These reactions are known by others as wood's acoustic properties. Some of these properties with relation to sound as stated by Negi (1997) are:

a) ***Velocity of sound in wood.*** This is affected by the elasticity and density of the wood.

b) Absorption and reflection. As sound hits the surface of wood, part of it is absorbed and the rest reflected. These are affected by the following variables: the nature of the surface of the wood; orientation of the fibres in the wood; structure and arrangement of the cells; moisture content and specific gravity.

2.5.15.4 Resonance

There occur vibrations or resonance in wood when periodic sound acts upon it. These may be force causing mechanical vibration or sound. These vibrations are referred to as resonance vibrations and are of three kinds: longitudinal resonance, torsional resonance and transverse resonance.

2.5.15.5 Light and Wood

Wood responds to light also since the various colours of wood depend on the reflection and absorption of light by it. These are affected by the degree of smoothness of the surface; the plane surface-radial, tangential or transverse; the nature of tissues occurring in their surface and their comparison with the longitudinal tissues and the moisture content on the surface of the wood.

2.5.15.6 Electricity and Wood

There are two types of electric current that have varying effects on wood: the direct current and the alternating current. In relation to direct current the most vital property of wood is its resistivity. This is known as electric resistivity and is measured in ohms-cm. On the contrary the reverse of resistivity is conductivity. The following factors affect resistivity of wood to direct current: moisture content, temperature, density and direction of grains.

2.5.15.7 Heat and Wood

The reaction of wood to heat discussed in other works as thermal properties is put under six headings by Negi (1997). These are summarised as follows:

Thermal expansion: the ability of wood to increase in dimension in the presence of heat and constant moisture content.

Thermal capacity: the quantity of heat required by wood to raise its temperature by a specific amount. *Specific heat*: this is the ratio of the heat required to raise the temperature of wood by a given amount to that of an equal weight of water by the same amount.

Thermal conductivity: wood, to some extent, allows the passage of heat through it. The more the water content the greater the conductivity. For this reason very dry wood serves as good insulators of heat as used for the handles of equipment used for cooking and heating.

Combustibility: this is the readiness or ability of wood to catch fire and continue to burn until only ash remains. This also varies from one wood to the other which explains why some wood burn faster than others.

Calorific value: this is the heating power of wood or the quantity of heat emitted by a given weight of wood during the process of combustion. This is expressed in terms of the number of heat units obtained by complete combustion of a unit of wood mass. It is denoted in calories.

2.5.15.8 Permeability of Wood

The ability of wood to absorb liquid is known as its permeability. When wood is put in water it will absorb it till the cell cavities are filled. This may even cause the wood to sink. This absorption of water by the sapwood is faster than the heartwood. The end

grains also absorb faster than the tangential surface which is also faster in its absorption than the radial section.

2.5.15.9 Wood Working

This refers to properties based on which wood can be converted into finished products. Though it is not a direct physical property, it is very vital in deciding end use of a particular species of wood. Some of these include the following as outlined by Anon (1970) as cited in Negi (1997):

a) The qualities of species to machine operations like mortising, sawing, planing etc.
b) Qualities of species with regard to hand operations such as filing, chiselling, carving etc.
c) Finishing qualities of particular species with regard to the finishing agent or means in question

According to Anon (1970), the main wood working qualities of various species that may be taking into accounts are:

i. Feel on the hand of the worker during and machine operations.
ii. The kind of marks produced of the various planes of the wood.
iii. Exposed and deviated fibres
iv. Chipped portions that may remain at the sharp corners
v. Broken or continuous wood shaving that may be produced
vi. Wood may blunt the tool while it is being worked.
vii. Efforts for good finishing
viii. Capacity to retain polish or paint

2.5.15.10 Other Properties of Wood

Anon (1970), describes the following as other physical properties with lesser importance:

a) ***Porosity:*** "This is a measure of the relative size of cells and abundance of cell cavities known as lumen". Wood cells with thinner cell walls have larger cell cavities which make them more porous than those lying on the contrary: those with thicker cell walls and for that matter lesser cell cavities. This property is highly related to the degree of paint adhesion, floatation and preservation treatment of wood.

b) ***Odour:*** Characteristic smells are emitted by different wood species. These are more often perceived in green wood than in a well-seasoned wood. These scents are made possible by the presence of resins, oils and other chemicals that may exist in the wood. Odour in wood may be advantageous since they can serve as an insect repellent.

c) ***Taste:*** This characteristic of wood is felt by the tongue and even in the throat. This has a link with the odour of the wood and is well felt in the heartwood than in the sapwood.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter outlines the general plan of the study and strategies adopted by the researcher to resolve the problems of the study. These include the research design, research methods, research tools, population and sampling, research experiments, data collection and data analyses plan.

3.2 Research Design

Research designs are concerned with turning the research question into a testing project. The best design depends on the research questions. The research design has been considered as a "blueprint" for research, dealing with at least four problems: what questions to study, what data are relevant, what data to collect, and how to analyse the results (Creswell, 1994). The research design chosen for the study is qualitative research design.

Qualitative research is a method of inquiry employed in many different academic disciplines, traditionally in the social sciences, but also in market research and further contexts. Qualitative research aim at gathering in-depth understanding of human behaviour and the reasons that govern such behaviour. The qualitative method investigates the why and how of decision making, not just what, where, when. Hence, smaller but focused samples are more often needed, rather than large samples (Marshall, & Rossman, 1989).

Furthermore, it involves an interpretive, naturalistic approach to its subject matter and gives priority to what the data contribute to important research questions or existing information (Marshall, & Rossman, 1989).

From the explanations above, characteristics of qualitative research design made it suitable to be employed in the project. The design principles used in developing products. Again, it created an opportunity for investigating and exploring the possibilities of using the Asante (Akan) traditional stool models in developing the living room upholstered furniture. The study employs descriptive and exploratory methods of research based on qualitative enquiry for collection and presentation of data.

3.2.1 Descriptive Research

Descriptive research is a sort of research that is centered on presenting realistic and detailed explanation of people, events or works of art in details. The term "descriptive research" informs readers on the dual nature of this kind of academic paper. Again, descriptive research is written for the purpose of providing the readers with complete detail of events and emotions as they happen. Another function of descriptive research is to make an effort to present events, emotions, sentiments or ideas and images to the reader as realistically as possible (wiersma, 1995).

It is further explained that, the author of a descriptive research paper seeks to communicate to readers what they would see, hear, feel, think or even smell as if they were actually present in that environment. For this reason, a descriptive research makes use of strong and powerful adjectives which possess the ability to create pictures in the mind of the readers.

According to Knupfer and Mclellan (2001), description research method also emerges following creative exploration, and serves to organize the findings in order to fit them with explanations, and then test or validate those explanations. Many research studies call for the description of natural or man-made phenomena such as their form, structure, activity, and change over time, relation to other phenomena and so on. The

description often illuminates knowledge that might not otherwise be noticed or even encountered.

This research method was employed by the researcher to effectively provide complete details of the processes, the equipment, the accessories, the techniques, the materials and the developed living room upholstered furniture design samples produced. Additionally, this method of research assisted the researcher in the explorations and explanations of findings.

3.2.2 Studio/Practice-based Research Method

Practice-based research is a form of research that aims to advance knowledge partly by means of practice. This type of research is an original investigation undertaken in order to gain knowledge and understanding. It includes the invention of ideas, images, performances and artefacts including design, where these lead to new or substantially improved insights in the field of practice. Moreover, practice-based research is also a research where some of the resulting knowledge is embodied in the artefact. Whilst the significance and context of that knowledge is described in words, a full understanding of it can only be obtained with reference to the artefact itself (Candy, 2010).

The research was conducted in the studios of King of Kings Royal Production Works at Old Tafo, Kumasi. The production processes and the invention of ideas and explorations of the Living room furniture model of the Asante traditional stool design samples were executed solely in the studio, therefore this project is considered to be practice-based research and data was collected and recorded through observation during the exploration of the project.

3.3 Research Tools

Leedy and Ormrod (2005) say that, these are the specific devices or line of attacks the researcher uses to collect, manipulate or interpret data. Research tools as employed in this dissertation are as follows: the library and its resources; the computer and it software; statistics; the human mind and language.

3.3.1 The library and its resources

Apart from the empirical studies conducted the following libraries were also visited in search for relevant information for the study. These include some KNUST libraries

- The university library- KNUST, Kumasi.
- The Institute of Renewable Natural Resource Library, KNUST-Kumasi.
- The Department of Material Science Library, KNUST-Kumasi.
- Faculty of Art Library, KNUST-Kumasi.
- The Polytechnic library- K'POLY, Kumasi.
- The Department of Interior Architecture and Furniture Production Library, K'POLY-Kumasi.

3.3.2 The computer and its software

The personal computer and related software such as the Microsoft excel, Microsoft word, AutoCAD (2D/ 3D software) and Rhinoceros (3D software) were used and the word processing, data calculations, charts plotting, labelling, designing and modelling in the project. The Internet was also visited periodically to retrieve relevant information and new updates throughout the research.

3.3.3 Statistics

This is one of the ideal research tools typically used in fields such as education that presents data in a simpler manner. This has been adopted for the summary of the data which has made it less complicated and manageable.

3.3.4 The human mind

Though the scientific method of research has been adopted for the study, it has involved both the deductive and the inductive reasoning of the human mind. The research questions were developed based on the relationships that existed between design, development and construction (deductive logic) and the findings based on the observation of series of events that took place during the research (inductive logic). In summary, both the deductive and the inductive reasoning, critical thinking and collaboration with others were all keys to the project.

3.3.5 Language

The researcher's proficiency in English, Twi and Fanti was highly instrumental in the communication with different people from different parts of the country.

3.4 Population for the Study

Polit and Hungler (1999) refer to the population as an aggregate or totality of all the objects, subjects or members that confirm to as a set of specification. A research study population is a well-defined collection of individuals or objects known to have similar characteristics. The number of persons or objects covered by the study or with which the study is concerned is what Oswala (2001) refers to as population. In other words, it is a set of people or items under consideration in a study. The target population for the study is heterogeneous in nature and it was made up of Indigenous furniture produce, Furniture designers, Upholstery Merchants and Upholsters.

3.5 Sampling Technique

Babbie (2001) opines that a sample is a subset of the population being studied. It represents the larger population and is used to draw conclusions about that population. Sampling technique is used in the social sciences as a way to gather data about a population without having to measure the entire population which is not easy to access due to its heterogeneous nature. However, the researcher chose two sampling techniques to conduct the research.

Random Sampling: Members of the population stand an equal chance of being selected; hence, the traditional stools for the production of upholstered living room furniture were selected randomly.

Purposive Sampling: It was used to select the parts of traditional stool thus, the base, the middle portion, and the top on the design required for the upholstered living room furniture. This sampling technique was employed because of a particular purpose for the study.

3.5.1 Sample Size

Table 1: The results of sample size

Population	Places	Sample size
Indigenous furniture producers	Oforikrom (Kumasi)	4
Furniture designers	Old – Tafo (Kumasi)	4
Upholstery Merchants	Central Market (Kumasi)	15
Upholsters	Old – Tafo (Kumasi)	27
Total		**50**

Based on the above data, the researcher considered a sample size of 50 to be a representation of the total population.

3.6 Data Collection Instruments

Ashitey (2013), states that Data Collection Instruments are special tools used by researchers for the execution of plans towards the achievement of established goals. In this study, observation and interview were the main instruments employed.

3.7 Data Collection Procedure

In the process of collecting data for the study, interview guides and observational checklists (Appendixes 1, 2, 3, and 4) were prepared to assist the researcher to obtain reliable information from upholstery merchant, furniture producers and designers. The

questions were devised according to the research objectives and to identify the level of knowledge of these experts.

The interviews and observational checklists were composed of both open and close ended questions. Close ended questions were made to assist participants to choose from a list of possible answers. Open-ended questions, on the other hand allowed participants to express their reasons and understanding according to their level of knowledge.

The interviews were done face to face, which helped the researcher to observe whether or not respondents understand and know more about the field of study. Similar questions were asked but in different ways in order to verify the information given by the respondents and therefore assured validity and coherence of data.

The observations gave an opportunity to the researcher to have a direct contact with the settee produced and the upholstery leather on the market. The researcher had the chance to feel and compare the various types of upholstery materials (leather) and to gather various samples for the study.

3.8. Research Question One: What are the socio-cultural concept of Akan traditional stool and design criteria for product development?

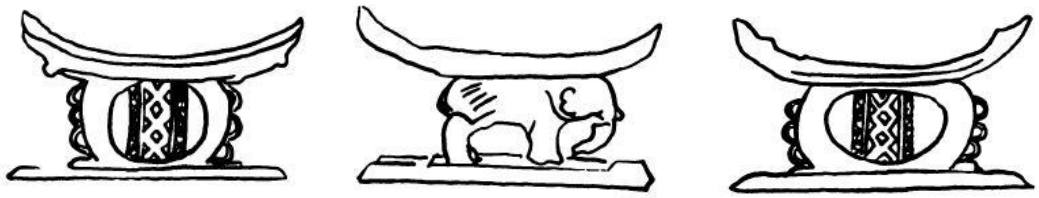
Designs of Traditional Asante Stools

The designs of Asante traditional stools, just like many other items used for special purposes are influenced by certain factors that are held in high esteem and these are passed on from one generation to another.

Stools basically are considered among the everyday household items, however, to the Asante there is distinction between these and those meant for special persons and special occasions. The purpose to a large extent helps the caver to determine the physical features required for each stool under construction.

PURPOSEFUL DESIGNS

From the point of view of the sex of the person who may possess certain types of stools, the researcher categorizes them into men's stools, women's stools (generally presented by a new bridegroom to his bride), and mixed stools, used by persons of both sexes (fig. 2.4, 2.5, 2.6). The social status of the persons who use stools for official purposes, affords still a third division of stools. We have the ahennwa "chief's stool", the ahemmaa dwa "queen's stool" (fig. 2.3) and the adammadwa (literally the "two-penny stool", i.e. the poor man's stool).

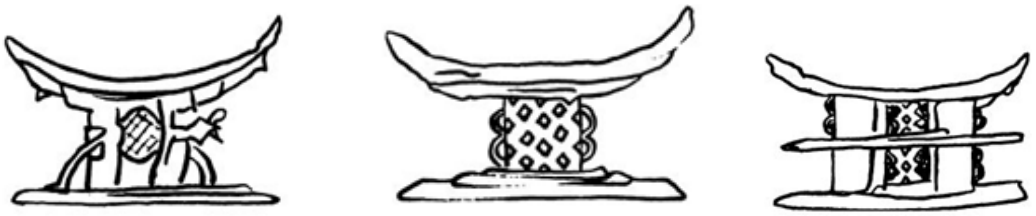


3.1 ***3.2*** ***3.3***

Fig. 3.1: Kotoko dwa "Porcupine Stool"

Fig. 3.2: Esono dwa "Elephant Stool"

Fig. 3.3: Kontonkurowi dwa "Circular Rainbow Stool"



3.4 ***3.5*** ***3.6***

Fig. 3.4: adenkysm dwa "Crocodile Stool"

Fig. 3.5: sakyi-dua-korodwa "Stool- with-one center-support"

Fig. 3.6: obi-te-bi-so-dwa "Someone-sits-upon-another stool"

3.8.1 Symbolisms of Designs on Asante Traditional Stools

In Asante traditional life a stool symbolizes the soul of society. The seat which, as we remarked at the beginning of this chapter, is in the oval form of a crescent moon, symbolizes the warmth of a mother's embrace. The obi-te-bi-so- dwa "some-one-sits-upon-another stool" (fig. 3.6) is carved in such a way that one stool is standing on top of another. The symbolism is not hard to find. It means that in any society there is a hierarchical order among the citizens; and even among chiefs, priests, elders and the like, there is an order of precedence to be observed for the good running of the community.

The central portion, besides determining the name of the stool, is the object of diverse motifs. In the Circular Rainbow stool, used by the King of Ashanti alone, it is the figure of the rainbow (fig. 3.3). It is the reproduction in wood of the well-known proverb kontonkurowi, eda amansan kon mu "the rain- bow is around the neck of every nation". The symbolism is twofold. One inform- ant told us that it reminds the king that death is the lot of everybody, including himself, powerful as he is, and that therefore he should not be puffed up with pride by reason of his high position on earth. Another thinks it depicts the power which the king has over everybody in Asante. Then there are the esono stool and the osebo stool, the middle parts of which are the figures of the elephant (see fig. 3.2), and the leopard respectively. They are the symbols of the great powers of the king of Asante, for the animals are considered to be the strongest and most feared in Asante. The maxim says: wodi esono akyi a hasuo nka wo "when you follow the elephant you do not get wet". To follow the owner of the stool with the figure of the elephant there- fore, is to be free from any unlawful provocation and aggression. The description of the Asantehene as the elephant is very succinctly put in the laudatory poetry about the chief of Kokofu, one of the greatest

paramount chiefs of Asante: esono oni wura mua anka ekoo ye bopon "but for the presence of the elephant in the bush, the buffalo would be a huge animal". In other words, it is only because of the exalted position of the king of Asante that the prominence of the chief of Kokofu is not noticed.

Figure 3.7 leopard stool

Figure 3.8 Turtle stool

Figure 3.9 Elephant stool

Figure 3.10 cock surrounded with chickens stool

Figure 3.11 Gye Nyame stool

Figure 3.12 Twin crocodiles joined at the stomach stool

Design criteria (sometimes called specifications) are a useful thinking and communication tool for the designer. Essentially the researcher list all the things that the product needs to feature to satisfy the user. Design criteria are like the bullet points on the side of a product's package – a list of the key benefits.

Design criteria are helpful in a number of ways. At an early stage in product development they are an aid to creative thinking because they focus the designer's mind on what the user needs and can be a spur to thinking of alternative, creative ways of meeting these needs.

Design criteria are helpful during the process of developing design proposals (especially where a team is involved) because they are an agreed starting point from which new ideas can be evaluated.

Design criteria are also helpful in product evaluation – a product is successful to the extent to which it fulfils the design criteria.

If 'the design process' were a linear sequence, then design criteria would be developed at an early stage and then fixed. In reality, as the designer learns more about the user and thinks about the product, new aspects of the design criteria will become clear. Depending on the situation, it may be possible to take account of these new insights, even at a late stage.

Sometimes even important criteria will have to be left to one side if it is too late to include them in the product. However, these ideas should still be recognised as valuable and included in the evaluation of the project.

It is important (and not always easy) to distinguish between design criteria and design proposals. In essence, design criteria say what a product must do; design proposals say how it will do it.

The design proposal might specify the circuit, the components, state that the current consumption. This objective aimed at answering the first, second and third research question.

In developing product, the design criteria should specify:

- Who it is for?
- What its main benefits are – what it must do for the user?
- What is special about it?
- Any constraints on its size or shape?

CAFEQUES and ACCESSFM are mnemonics used in this project to help the researcher undertake product analysis activities.

They may, however, also be used to help the researcher formulate design criteria.

Taking CAFEQUES as the example, the researcher produces a grid or table shown below:

CAFEQUES Questions to spark ideas Design

- **C**ustomer; who is the product intended for?
- **A**esthetics; what appealing features would it have?
- **F**unction; what are its functions?
- **E**rgonomics; how will the product relate to people's size, shape etc.?

- **Q**uality; what design and manufacturing features will ensure a quality product?
- **U**sability; how easy is the product to use? Will a user guide be needed?
- **E**nvironment; how will the product relate to the environment – recycling parts, materials used in manufacture, the manufacturing process.
- **S**afety; how will you ensure that the product is safe?

For each of these areas (C-A-F-E-Q-U-E-S) the researcher would develop a handful of design criteria for the intended product. The researcher can add in as many 'questions to spark ideas' to help the researcher formulate clear design criteria. These design criteria then also become the criteria by which the product is evaluated at various points through the designing and manufacturing process

Product possibilities based on the meanings and socio-cultural contexts,

Below are listed contexts for product and product possibilities that have come up based on the meanings and socio-cultural contexts specified for the selected Adinkra symbols, it is important to note, that in addition to the researcher's ideas, the researcher interviewed 24 persons with diverse ethnicity, culture and backgrounds: 1 Ewe, 1 Ga-Adangbe, 2 Mole-Dagbane, 2 Guan, and 18 Akan. Of these, there was 1 University Doctor (Leather) and 23 furniture design students, (18 Furniture producers, 4 Upholstery merchandisers, 1 Food & Nutrition). The interview sessions were structured as follows: first, the researcher asked interviewees of their impressions and associations to the Adinkra symbols.

Secondly, the researcher asked of the names the respondents would give to the Adinkra symbols;

Thirdly, the product contexts or areas, and what specific products interviewees would suggest;

3.9 Research Question two: What are the significance of selected traditional symbols, local wood species and upholstery materials for the production of living room furniture?

Finally, the researcher was told of the actual meanings of the Adinkra symbols in his culture and asked for contexts and product possibilities based on the actual meanings of the Adinkra symbols.

Traditional symbols generally have special significance to the culture of a people, and in Ghana they play major roles towards the understanding and sustenance of various cultures in the country among these are the Adinkra symbols. Adinkra symbols are used for different purposes which in turn provide the context for identification and use. The researcher identifies five types of *Adinkra symbols*.

These are shown below with their meanings and socio-cultural contexts;

Plate 3.1 BI NKA BI (No one should bite the other)

This symbol signifies the peaceful co-existence among people devoid of provocation, retaliation and strife. This symbol cautions people against social vices like back-biting, cheating etc. It therefore encourages fair play and cordiality which brings about peaceful co-existence.

Plate 3.2 AKOKO NAN (leg of a hen)

‘Akoko’- FOWL, ‘Nan’- LEG. ‘Akoko Nan tia ba, na enkum ba’; this literally means that, ‘the hen treads on its chicks, but it does not kill them.

This symbol signifies the protective, corrective and loving nature of mothers for their children. Children are reprimanded and punished when they go wrong. The symbol teaches the importance of nurturing children and warns against pampering them. It also encourages showing mercy to offender. This is a symbol of mercy and nurturing.

Plate 3.3 GYE NYAME (Except God)

‘Nyame’- God. (Except God) or (I fear nobody except God). God is regarded as the creator of the world and humanity and therefore must be reverenced and worshiped.

This symbol reflects the supremacy, power and dominion of God over all situations and creations. God is therefore regarded as the omnipotent, omniscient and omnipresent. This is a symbol of the supremacy of God.

Plate 3.4 SANKOFA (Go back and take)

‘Sanko’- go back, ‘Fa’- take. This means “Go back and take”. This symbol signifies the importance of returning in time to bring to the present useful past cultural values, which are needed today. It is believed that progress is based on the right use of the positive contributions of the past, which helps in building the future. It also teaches people to cherish and value their culture and avoid its adulteration. This is a symbol of positive reversion and revival.

Plate 3.5 HYE-WONHYE (Burn, you do not burn)

'Hye'- burn, 'Wonhye'- you do not burn. (That which cannot be burnt)

Some traditional priest were noted for their fire dancing abilities without burning their feet. In the same way, other individuals are able to endure and overcome all forms of difficulties. This symbol signifies the tendency to withstand pain and other hardships.

This is a symbol of imperishability and endurance.

3.10 Research Question Three: How can Living Room furniture be manufactured with design criteria founded on Akan Traditional Stools?

The researcher started the studio work by going through the product design process whereby basic design of the product were first made, these were intended to serve as a guide in the manufacturing process.

3.10.1 Preliminary Sketches

These are rough freehand pencil sketches usually in perspective. The aim being to determine the general form of a design which might be suitable for the purpose of the job, and at the same time have good appearance.

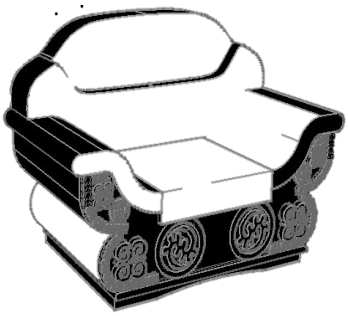


plate 3.6 Sketch 1

Plate 3.7 Sketch 2

Plate 3.3 Sketch 3

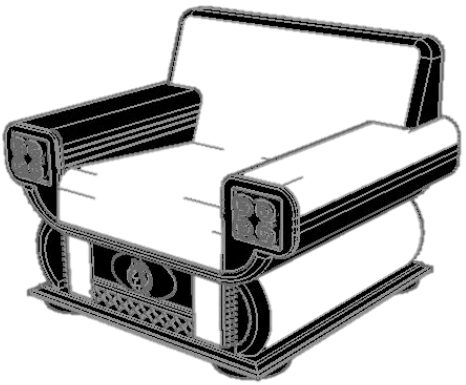


Plate 3.9 Sketch 4

3.10.2.1 3D Rhinoceros and AutoCAD Software Designs

Plate 3.10 3D Design Sample 1

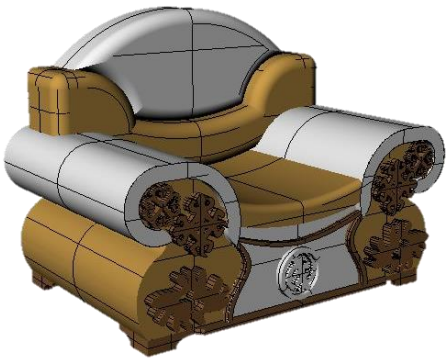


Plate. 3.11 3D Design Sample 2

Plate 3D Design Sample 3

Plate 3.13 3D Design Sample 4 (Selected Design for Development)

3.10.2 Development of the Selected Design

Further consideration was then given to the selected design which were developed into a final design. The development includes making value judgments on the shapes and sizes of the components, the appropriate materials to be used in constructing the parts together, the available facilities to be used for the construction, and the expertise required for making the whole product. With this factors in mind, appropriate modifications were then made to the various parts of the selected design. A full set of working drawings, exploded and detailed drawings embodying all the modifications were made and presented as a final design of the project.

Plate 3.13 Final Design Developed 1

Plate 3.14 Final Design Developed 2

Plate 3.15 Final Design Developed 3

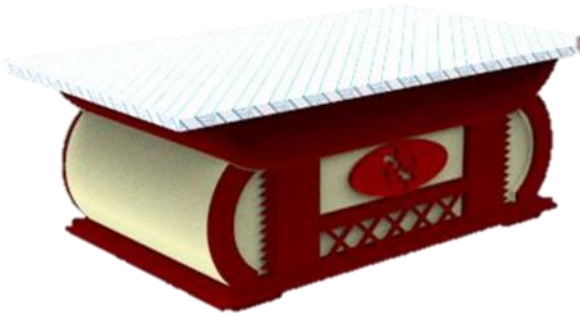


Plate 3.16 Final Design Developed 4

Plate 3.17 Final Design Developed 5

Plate 3.18 Final Design Developed 6

3.10.3 Making the Final Design

The design emerging as the final design was then be constructed as a prototype, preferably, full size and using the materials and the constructional methods specified on the working drawing of the design. These final drawings were accurately constructed drawings intended to give all the necessary information on the design of the object- the methods of construction, overall dimensions sizes and shapes of the various parts, and notes on the kinds of materials, fittings and finish needed.

On the other hand, special detail drawings were also illustrated, sections of members, shapes, mouldings, angles and joints were not different from accepted standard practice.

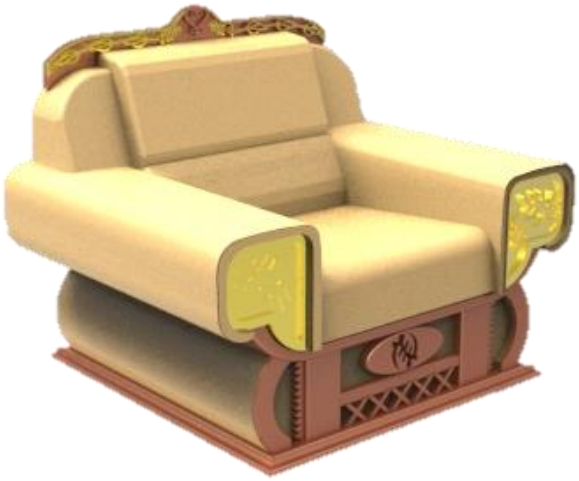


Plate 3.19 Final Design for Construction

3.10.4 Working Drawings

These are the most commonly used drawings in the workshop or studios, consisting of two or more separate face views of the job. Usually,

- A front view or elevation showing the shapes and sizes of the job.
- A side or End elevation showing the details as seen from one end.
- A plan (if required) showing the details of the job when viewed from the top. Other views may be required for special jobs.

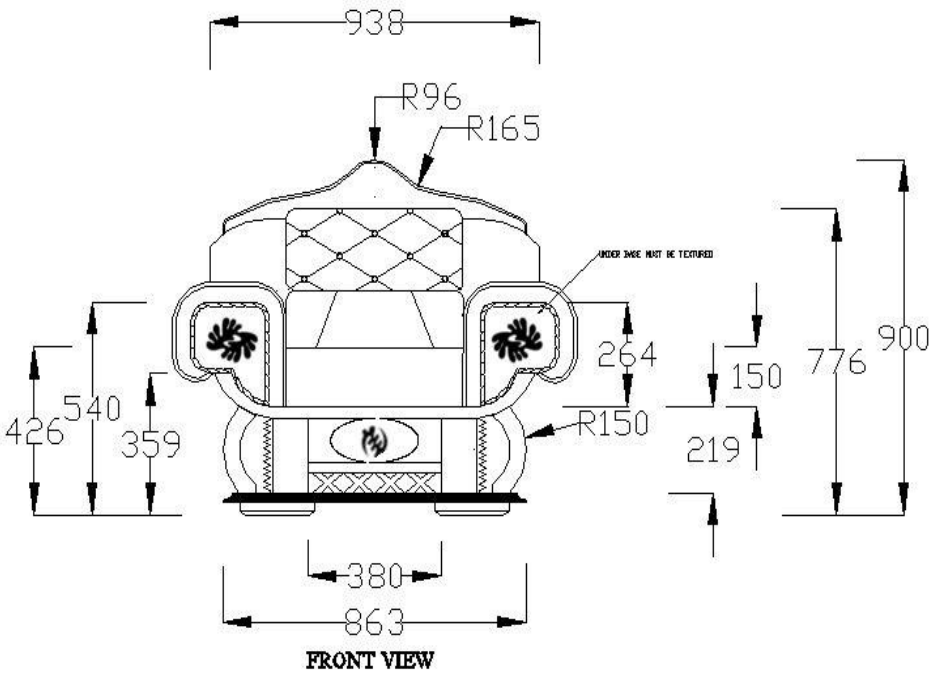


Plate 3.20 Front View

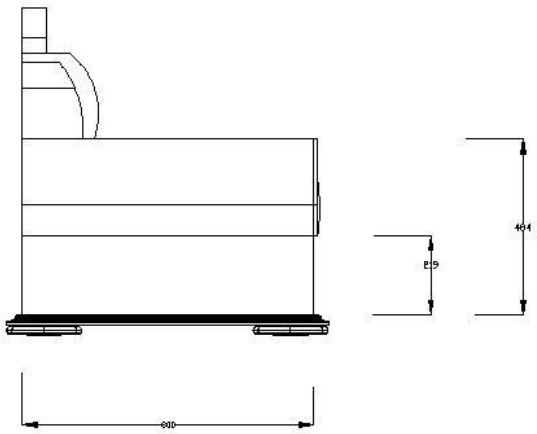


Plate 3.21 Right Side View

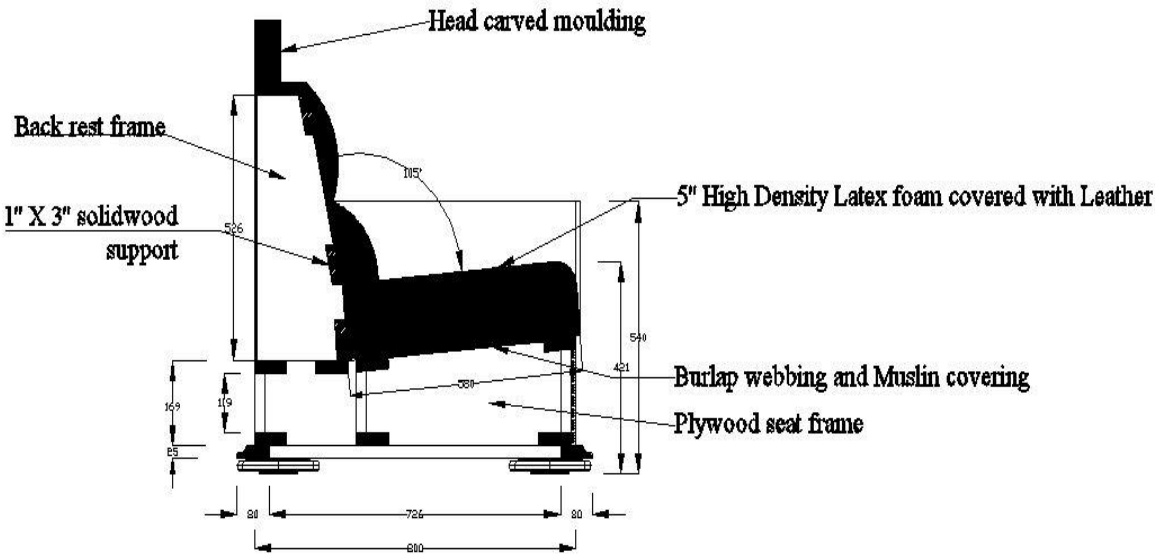


Plate 3.22 Sectional End View X-X

3.11 The Procedures in the Execution of the Project

This outlines the systematic working procedures the researcher went through in executing the living room lounge chair at the studio or workshop.

The most significant materials used for the production of the living room upholstered furniture are solid wood, plywood, leather, velvet fabric, webbing belt, tacking nails, P.V.A, contact adhesive, latex foam, and cellulose finishes.

3.12 Setting-out the Project

In producing any practical work, the artesian needs to identify suitable materials, tools, and equipment needed for the execution of the work.

3.12.1 Materials Preparation

3.12.1.1 Planing of solid wood

Solid wood (Teak and Mahogany) planks of size 25x80mm were planed with the thicknessing planing machine to a required thickness and squareness as shown below.

Plate 3.23 Planing of Planks with the Thicknesser Planer

After preparing the surfaces and edges of the solid wood plank, they were then ready for sizing it to the required specification as shown on the working drawings.

3.12.1.2 Cross-Cutting

The various components of the lounge chair were then measured on the work piece and cutoff as shown below;

Plate 3.24 Cross-Cutting with the Cross-Cut Saw

3.13 Setting out Templates on a Sheet of Plywood

The researcher introduce a preliminary full size drawing, where at this stage been decided on a suitable design sketch, makes it good idea to set out on a sheet of plywood or hardboard two fairly accurate full size elevations of the final design as indicated in fig. 3.17.

Plate 3.25 Template Setting out

3.13.1. Cutting–Out Templates

The researcher sets-out a portable jig saw machine to cut-out the various components from the design on the 6mm sheet of plywood indicated below;

Plate 3.26 Cutting-Out

3.14.2 Marking-Out Patterns

The researcher sets on 12mm sheet of plywood to mark-out the patterns indicated below;

Plate 3.27 Marking-Out Patterns

3.14.3 Cutting-Out Patterns

The various components making up the project was then cut-out with the use of portable Jig saw machine as indicated below;

Plate 3.28 Cutting of Patterns

3.15 Framing the Model

The model was then framed by joining both the solid wood planks and plywood by butt joints as indicated below;

Plate 3.29 Frame Construction

3.16 Webbing the Seat and Backrest

Jute webbing is a strong, closely woven strip of jute about 75mm-100mm wide. It is used to form the surface to support the cushion as indicated below;

Plate 3.30 Webbing of Seat and Back Rest

3.17 Covering the Webbing

Covering materials are those used for covering the webbing or stuffed materials to provide pleasant and attractive finish. Velvet fabric were used as covering material for the project as indicated in fig. 4.9.

3.17.1 Tacking the Covering Material

Tacking materials are mainly nails available in a range of types and designs. The researcher uses the blue cut tacks also called upholster tacks.

Plate 3.31 Covering with Fabric

3.18 Padding and Molding the Armrest and Backrest

Padding or stuffing material are those used for covering the webbing to form a soft, smooth contours with Latex foam of thickness 80mm were used.

Plate 3.32 Padding and Molding of Latex Foam

3.19 Cutting and Sewing the Arm rest leather upholstery

Rolled leather was spread evenly on the cutting board, measurement was taken out from the model shown in fig. 3.29 and the various patterns were marked out and cut-off. The arm rest patterns was then sewn as indicated in fig. 3.30.

Plate 3.33 Sewing Patterns

3.19.1 Fixing and Checking for Uniformity

The process of fixing and checking for uniformity was considered to make sure that the upholstery of the arm rest was correctly in form as designed. Figure 4.12 below indicates how the upholstery of the arm rest was fixed and checked for.

Plate 3.34 checking for uniformity

3.19.2 Fixing and Tacking the Seat and Arm Rest

Figure 3.32 indicates how the arm rest and seat was permanently fixed into the framed model.

Plate 3.35 Fixing of Arm Rest and Seat

3.20 Carving of Face Plates and Back Rest Head Crown

The face plates are ornamental wood fixed in front of the arm rest that features the Adinkra symbol called “Bi-Nka-Bi” carved and surround with carved robe.

The head crown placed at the top of the back rest features series of Adinkra symbols namely, “Akoko Nan”, “Hye Wonhye”, “Sankofa” and Gye Nyame which gives the contextual meaning of the project. Figure 3.36 and 3.37 indicates how the carving was being executed.

Plate 3.36 Carving Head Crown

Plate 37 Carved Face Plate

3.21 Surface Finishing

These are the application of selected materials such as stains, lacquer, paints etc. to a wooden surface to prevent the tendency of the wood to absorb moisture, fumes and oil that may cause shrinkage, swelling, checking, wrapping and discolouring. The ultimate reason for applying this finishes were to create desirable effects, enhancing the beauty of the model. The figures below shows the application of the finishes.

Plate 3.38 Finished Face Plates

Plate 3.39 Head Crown

]

Plate 3.40 Gye Nyame face plate

Plate 3.41 Middle Structure

Plate 3.42 Model Base

3.22 Final Assembling of the Model

The final assembling of the living room lounge chair were joined together by screwing the various components together in making the model as designed and constructed in accordance to the specifications.

Plate 3.43 Constructed Model of the Asante Traditional Stool Lounge Chair

Plate 3.44 Placement in Room

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents and appreciates the results of Traditional Asante stool: A Design Criteria for Developing Living Room Furniture as well as the philosophical concept or a designer statement behind the study. In addition, it outlines and discusses the studio research results that were obtained during the study.

4.2 Objective one

To identify the socio-cultural concept of Akan traditional stool and design criteria for product development.

The researcher observed that Akan traditional stools are exhibited ostentatiously; others, though superficially similar, were so sacred that they are concealed from all but selected few. It was observed that the context that gives the object its significance, but regardless of the dominant meaning manifest in the situations, there persist overtones or shadows "resonances" of the objects other sometimes antithetical qualities. Carved wooden stools, for example, which can be sacred shrines, symbols of prosperity, or simply seats-were laden with powerful evocative meaning that subtly allude to one another. As symbols embodying abstract ideas concerning the ancestors and the kingship, they condense.

It was also observed that ordinary stools (*nkondwa*) were used by common people and the king. Chief's stools tend to be large; women's stools are smaller than men's; and a spirit-medium stools were covered with white Kaolin. Another means of differentiation were the middle, or neck, which were carved in many patterns. An elder always sits on his own stool. In the evening, stools are tilted on their side to prevent wandering spirits and ancestors from using them.

Ceremonial stools was distinguished by their shape and symbolic design, such as the "knot of wisdom" motif (*nyansapo])* which signifies the chief's promise to his people, on his accession, but bind the kingdom together through prudent administration, Kyerematen, (1964).

The researcher observed that a chief's stool therefore functions as a shrine for the soul, a memorial to the ancestors and a vehicle of communication.

The Asante stools was the most important and symbolic complex of all Asante' art forms: the stools have multiple forms, functions and meanings. They range, in significance, from everyday furniture to a spiritual centre of this ethnic group. In Asante, as in most Akan communities, an intimacy was believed to exist between the chief and his stool. During the study, the researcher realized that Asantes stools perform religious, political, social, economic, medical, moral and communicative roles.

Design criteria for product development; an object were being designed from the moment it were thought of or conceived. The first thoughts were generally concerned with the intended use of the artefact. The particular need for it, creates some form of mental picture of the artefact; what it will look like; what it was made of; and perhaps a picture of it in its surroundings. Hence it was necessary to develop and record the mental pictures by means of sketches and drawings. These gave the researcher much better idea of its construction, general appearance, proportions and accommodation. This objective aimed at answering the first research question. "What are the socio-cultural concept of Akan traditional stool and design criteria for product development?" To answer this, the following sub questions were generated:

- Are there any features or parts which are superfluous for its use and appearance?
- Will the sizes of components and parts make it possible for them to be cut from standard commercial sizes of materials without undue waste?
- Can the shapes and decorative features be easily produced with the tools available?
- Will it fit and harmonize with its surroundings?
- Will its sizes enable it to pass through doors when moving it from the workshop to its final position?

In view of these questions the researcher conducted an observation of record keeping in reviewing the various types of Akan traditional stools designs.

This was done alongside the library research which also entailed some review of literature in relation to the project.

Finally, the researcher relied on both primary and secondary data related to the Traditional Asante Stool: A Design Criteria for Developing Living room Furniture as a creative model upon which ideas were developed for the designing.

4.3 Objective two

To ascertain the significance of the selected traditional symbols, local wood species and upholstery materials for the production of living room furniture.

Sarpong (1971) stated that, a handful of examples to illustrate the wealth of symbolic meaning that lies beneath the ocean of the art of Asante stool-carving. The designs are many and artistic, several have definite explanations. But the significance of others is a matter of conjecture and opinion, while that of quite a few is as obscure as to amount to ignorance of what the designs stand for.

The researcher identifies "BI NKA BI" (No one should bite the other)

This symbol signifies the peaceful co-existence among people devoid of provocation, retaliation and strife. This symbol cautions people against social vices like back-biting, cheating etc. It therefore encourages fair play and cordiality which brings about peaceful co-existence.

"AKOKO NAN" (leg of a hen); this symbol signifies the protective, corrective and loving nature of mothers for their children. Children are reprimanded and punished when they go wrong. The symbol teaches the importance of nurturing children and warns against pampering them. It also encourages showing mercy to offender. This is a symbol of mercy and nurturing.

"GYE NYAME" (Except God); this symbol reflects the supremacy, power and dominion of God over all situations and creations. God is therefore regarded as the omnipotent, omniscient and omnipresent. This is a symbol of the supremacy of God.

"SANKOFA" (Go back and take); this symbol signifies the importance of returning in time to bring to the present useful past cultural values, which are needed today. It is believed that progress is based on the right use of the positive contributions of the past, which helps in building the future. It also teaches people to cherish and value their culture and avoid its adulteration. This is a symbol of positive reversion and revival.

"HYE-WONHYE" (Burn, you do not burn); this symbol signifies the tendency to withstand pain and other hardships. This is a symbol of imperishability and endurance.

With regards to the accounts of Tsoumis (1991), among other wood researchers, the nature of wood as a result of the organic development from their optical and lateral meristems under the influence of environmental factors renders the basic chemical

composition that vary from one wood to the other as discussed in the literature review. The organic components and other cellular components notwithstanding the various conversion methods discussed in sections 2.3.4 and 2.3.11 respectively in the literature review renders the wood, certain mechanisms (e.g. movement by swelling ,shrinkage and warping); reaction to external factors (e.g. its reaction to the weather, water and chemicals) and mechanical status (e.g. Strength, toughness, porosity).

The local wood species used were Teak and Mahogany. The Teak was a plantation grown teak. The wood were both weather, termite and pesticide-resistant because of the natural oils that are contained within their fibers. This makes the wood extremely suitable for outdoor and indoor use, such as furniture or boat decks, even without treatment with oils or varnish. The attractive appearance makes teak desired for interior use as well. Bhat *et al*., 2005 reported that with Teak grown in plantations (and therefore in Ghana) the physical and aesthetic features ensure a high commercial value, making it one of the most profitable tree species for plantations worldwide. In West-Africa the production of teak has also been adopted successfully. In comparison to indigenous as well as other exotic tree species, teak performs best economically. The researcher observed that Teak has a close grain that makes it possible to cut joints very accurately and makes it suitable for carving as the close grain means it can be carved to include great detail.

Mahogany, it was observed that when freshly converted (processed) it looks pinkish but it becomes reddish when seasoned. The sapwood were yellowish-brown. The grains were sometimes straight but generally interlocked to produce a striped figure on quarter-sawn. It has a medium to course, but even texture. It seasons easily with less splitting or checking but were liable to warp. It was observed that it's easily attacked by powder post beetles and pin-hole bores. It was easy to work using hand or

machine tools and has good holding power for nails, screws and glue. It was used for the framing of the lounge chair and the occasional table.

Upholstery materials used for the production of the living room furniture were purchased from the local market, these materials were grouped as; webbing materials, padding materials, covering materials and tacking materials.

Webbing materials are those for forming the base of the upholstery, padding materials consist of foams, cotton, polyfoam and latex foam; Covering materials include fabrics, vinyls and leathers. The researcher employs two types of leather namely full – grain leather and top grain leather

4.4 Objective three

To utilize design criteria for the manufacture of upholstered living room furniture founded on Akan Traditional Stools.

The heart of the design concept applied in the research were based on the adoption of design guidelines that were structured to help the researcher reduce the cost and difficulty of manufacturing the living room furniture (Asesedwa concept). The following are a list of principles in which the researcher observed in manufacturing of the living room furniture founded on Akan Traditional Stools;

1. Reducing the total number of parts: The researcher realized that, the reduction of the number of parts in the product were the best opportunity for reducing the manufacturing costs. Less parts implies less purchases, inventory, handling, processing time, development time, equipment, engineering time, assembly difficulty, service inspection, testing, etc.

   In general, it reduces the level of intensity of all activities related to the product during its entire life.

2. Using of modular design: The researcher observed the use of modules in the living room furniture which simplifies manufacturing activities such as inspection, testing, assembly, purchasing, redesign, maintenance, service, and so on. The reason was that modules add versatility to the product update in the redesign process, which helps the researcher to run tests before the final assembly were put together, and allow the use of standard components in minimizing the living room furniture variations.
3. Using standard components: the researcher observed that using standard components were less expensive than custom-made items. The high availability of these components reduces the product lead times and also, their reliability factors were well ascertained.
4. Designing parts to be multi-functional: The researcher realized a multi-functional part on the occasional table where a magazine drawer were placed at the middle part where the "Gye-Nyame" Adinkra symbol were fixed, which reduce the total number of parts in the design, thus, obtaining the benefits given at principle1. For example this part acts as a storage unit and as a structural member.
5. Designing for ease of fabrication: the researcher realized optimum combination between the material and fabrication process which minimize the overall manufacturing cost.
6. Minimizing assembling directions: the researcher observed that all parts were assembled from one direction. The researcher was able to assemble the various parts taking into consideration the principle of minimizing the assembling of objects from different directions. In this case the joining of the parts were done from above, in a vertical direction, parallel to the gravitational direction

(downward). In this direction, the effect of gravity helps the researcher in the assembly process, contrary to having to compensate for its effect when other directions were adopted.

7. To maximize compliance. The researcher realized that errors can occur during insertion operations due to variations in part dimensions or on the accuracy of the positioning device used. These faulty behaviour cause damage to the part. For this reason, these made it necessary to include compliance in the part design and in the assembly process. For examples built-in compliance features such as tapers, step around and chamfers were moderate radius sizes to facilitate insertion, and non-functional external elements to help detect hidden features. For the assembly process, selection of a rigid-base part, tactile sensing capabilities, and vision systems were example of compliance.
8. Minimize handling. The researcher realized the importance of minimizing the handling of the living room furniture by observing the general principles for handling works of art in preventing accidental damages; in this case, to the upholstery and its finishing. The researcher first prepared a platform space to facilitate movements carrying risk and take time and other resources to complete. In this case, most serious and obvious kinds of damages were arose as a direct result of handling the project. handling were minimized by examining carefully to determine inherent problems and characteristics such as size, shape, weight, type of surface finishing and fragility that might affect it. It was realized that handling were found to be in four phases namely; touching, lifting, moving, placing and leaving.

4.5 Results from Observation

This section deals with what the researcher observed during the research period using participant and non-participant observation strategies to study in-depth the working processes involved in the nature of materials for production, how selection was done in assessing the quality of raw materials and its effectiveness by the design, how the nature of the raw materials were being transformed into finished products and how the various stack holders and furniture merchants defined quality of the finishing.

The results from the observations were conceived as the constituents considered as crucial to the effect of investigation. These comprise the studio observations and the studies made in the library. The results of observation from the various research fields visited were as follows:

4.5.1 Results from Indigenous Furniture Producers and Designers in Kumasi

During several visits to the furniture producers and designers at old Tafo and Oforikrom-Kumasi, the researcher observed that, even though the various producers worked individually, they adopted the same method of construction. They had been adopting this method of construction because that was the type they had grown up to understudy from their "Master's" years back.

The researcher introduce the designs of the living room furniture to the furniture producers for which they seek to found out the design criteria that the researcher developed in formulating the Akan traditional stool form into living room furniture realized.

It was observed that the fundamentals of design were not dependent on any style or fashion but are aspects which are flexible and can be applied to any creative activity at any time and they were influenced by what people thinks is beautiful and suitable,

and harmony with our constantly changing living conditions and environment. The practical aspects for the project were made efficient in used, based on the functionally sound and fit for purpose. The purpose suggested the shape and form.

4.5.2 Results from the Upholstery Merchants

The upholstery materials on the local market were all imported. These were evident from the interview responses by some upholstery merchants on the local market. Upholstery materials according to the merchandisers are mostly leather and fabrics. Due to, it was made known that, natural leather were rarely used for furniture but its scarcity in the local market (Focus Group Discussion of Upholstery Merchants in Manhyia, Central market, Oforikrom and Adum, 2015).

The researcher observed that, upholstery made of leather receives much patronage than that made of fabric. Factors like price, quality, durability, care and colour were among others are the major determinants of the demand for the upholstery materials. Even though leather and fabric have common grades in quality and durability, leather was identified as having easy care properties, being affordable and has variety in terms of colour ways according to the merchants. It was however observed that, leather was popular upholstery material. It gives a traditional look to the room, easy to clean and if much care is taken can last for ten years ; the one down side to leather is that it is very expensive and vulnerable (Choosing Upholstery leathers, 2014).

It was observed most merchants could identify the upholstery leather by their texture, weight and strength and not by their fibre structures. A few are able to identify the upholstery leather as natural or man-made.

It was observed that the names of the types of upholstery leathers were not known to them but they sometimes give names to these leathers by their scarcity, design

structures and the thickness of the leather. Names like cocaine, dollar-dollar, flower and heavy-duty were some of the common names given by the merchants. Some of the leathers are also named after their respective importer. The merchants explained that, the patronage and usage of leather are determined by furniture producers. According to the importers, leathers that sell on the market are mostly imported. Again, the leather designs that do well on the market are plain check leathers.

4.6 Realization of the Living Room Upholstered Furniture

The living room furniture was produced based on information obtained through observations and interviews. After production, the living room furniture were evaluated openly for criticism and appreciation by upholstery merchants, furniture producers and Designers at the studio of King of Kings Royal furniture works**.** The Design were recommended, the formulation of the traditional Asante stool model into living room lounge chair were also appreciated and found to be astonishing on the design formulation and the constructional outcome of the model.

Furniture producers express their concern on the possibility of the researcher to mass produce the model where they see it to be more complex, and the standard for which the researcher had used in designing the artefact were ergonomically good. The dimensions used for the seat height, width, seat slope and depth provides good sitting angle for comfortability.

The constructional material used were also recommended and appreciated for its durability and strength wise.

From the interviews, observation and design criteria, it was clear that the project was successful, that the design criteria could be used to raise the standard of the quality of the furniture production in Ghana and beyond.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter deals with the summary, conclusions and recommendations to end the study done.

5.2 Summary

This research sought to identify the socio-cultural concept of Akan traditional stools and design criteria for product development, and also to ascertain the significance of the selected local wood species and upholstery materials for the production of the living room furniture and finally, to utilized the design criteria for the production of the upholstered living room furniture founded on the Akan traditional stools.

After the study, the researcher found out that, most of the designs of Asante traditional stools, just like many other items were used for special purposes and were influenced by certain factors that are held in high esteem and these are passed on from one generation to another.

The researcher observed that stools basically were considered among everyday household items, however, to the Asante there were distinction between these and those meant for special persons and special occasions. The purpose to a large extent help the manufacture to determine the physical features required for each stool under construction.

Finally, the researcher reveals the design criteria of broadening the scope of developing the skills of designing and constructing new forms of living room

furniture from the Akan traditional stool and enlighten customers on the meaning and significance of Adinkra symbols incorporated in the Akan traditional stool.

Chapter One is about the background of the study, objectives and statement of the problem.

This research sought to find out if the popularity of the traditional Akan stool have specific set of design and to develop new design criteria which will serve as a guide for designing and manufacturing the living room furniture founded on the Akan traditional stool.

Chapter Two reviewed the related literature which includes History of the Traditional Asante stool, Modernity of the Traditional Asante stool, Ceremonial stools, Material Used for Making Asante Traditional Stools, Types of Asante Traditional Stools, Owners of Stools, Samples of Traditional Asante Stools, and Symbolisms of Designs on Asante Traditional Stools Construction, Design Principles, and Furniture Materials.

Chapter Three also dealt with the methodology. The research utilized the qualitative research design as the main method of gathering data where descriptive method of research and a Studio/Practice-based were employed in the study. Primary data was sourced through interview and observation and secondary data also obtained through collecting of information from various libraries in the Kumasi Metropolis on the traditional Asante stool: a design criteria for developing living room furniture.

Chapter Four dealt with the result and discussion, how the research methods were employed, interviews and observations done, data analysis, interpretation of results and the design criteria.

Finally, Chapter Five dealt with the Summary, Conclusions and Recommendations.

5.3 Conclusions

1. Results from the study confirmed that most of the indigenous furniture producers and designers in Kumasi had inadequate standardized design criteria that were constantly adopted due to the challenges in acquisition, ignorance of ergonomics factors and disunity in work, even though there were some characteristics considered on the raw materials to prevent the production of less quality furniture.
2. Design process were been used for exploration and understanding of the potentials of craftsmanship, traditions and native materials and how they may be combined together with technological innovation and shifting aesthetics of the modern world. In this sense the design and prototyping of the furniture pieces were the instrumental tools in conducting of research.
3. The evaluation of existing design criteria found on the Akan traditional stool for determining their relevance to the manufacturing of living room furniture was achieved through studio practice and observation.
4. The aim of the design criteria for assessing the constructional techniques employed for the production of the living room upholstered furniture was to educate designers and furniture practitioners on the need and the standards of quality design and the materials to be considered before transforming the Akan traditional stool into living room upholstered furniture.
5. In the nutshell, the researcher believes that without any developed standardized design criteria the quality of the final product of indigenous furniture industry will not yield any better fruits or meet the required standard of quality. Although the research was quite challenging, but at the end the results were good and successful.

The research is very important to our society especially the source that is where the researcher seeks to achieve.

The researcher decided to suggest these design criteria and also send a message to the concerned group to help the objectives of the researcher to be realized.

This research is gratifying that after two (2) years of studying at the Department of Integrated Art, one has been able to come up with a project that goes a long way to help the nation in general and provide standards of quality assessment on skin and hides for leather production.

The researcher finally hopes that such suggested criteria would be used extensively, even to the remotest corner of this country so that producers of wood and furniture designers can achieve quality production through thorough assessment.

5.4 Recommendations

The researcher believes that the project has been successful and recommends the following:

- For the indigenous designers and producers of wood products should improve upon the quality of surface finishing to make their works aesthetically pleasing to customers.
- The indigenous designers and producers of wood products should adopt to the Safe working conditions of putting proper guarding of moving parts of machines and safe storage of tools and materials.
- Safe working techniques which requires a sound knowledge of the right way to do a job, using the right tool for the job, the correct use of tools and

machines, care and maintenance of tools and machines should be well taken into consideration in their workshops.

- Proper electrical equipment safety at the electrical machine workshops should be adopted by checking the plugs frequently for fractures and to see that the leads are securely fixed to the terminals.

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APPENDIX I

INTERVIEW QUESTIONNAIRE FOR TRADITIONAL ASANTE STOOL: A DESIGN CRITERIA FOR DEVELOPING LIVINGROOM FURNITURE

PREAMBLE

I want to thank you for taking the time to meet with me today. My name is Paul Inkum, a student of the Kwame Nkrumah University of Science and Technology and conducting a research on the topic **"TRADITIONAL ASANTE STOOL: A DESIGN CRITERIA FOR DEVELOPING LIVINGROOM FURNITURE"**. The interview will take less than an hour.

All responses will be kept confidential. This means that your interview responses will only be used for only academic purposes and I will ensure that any information I include in the report does not identify you as the respondent.

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Interviewee Date

SECTION A

1. How can living room furniture have basis in a traditional Ashanti (Akan) stool?.....

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2. Will it serve the purpose for which it is required?

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3. Will its sizes suit human use?

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4. Will it be serviceable in everyday use?

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SECTION B

1. CUSTOMER, who is the product intended for?

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2. AESTHETICS, what appealing features would it have?

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3. FUNCTION, what are its functions?

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4. ERGONOMICS, how will the product relates to people's size, shape etc.?

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5. QUALITY, what design and manufacturing features will ensure a quality product?

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6. USABILITY, how easy is the product to use? Will a user guide be needed?

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7. ENVIRONMENT, how will the product relates to the environment- recycling parts, materials used in manufacturing process?

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8. SAFETY, how will you ensure that the product is safe?

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APPENDIX II

OBSERVATION GUIDE FOR THE COLLECTION OF DATA FOR DEVELOPING LIVING ROOM UPHOLSTERED FURNITURE USING THE TRADITIONAL ASHANTI (AKAN) STOOL AS A MODEL.

Agency…….

Products ……...
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Materials involved……

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Activities and production methods ……..

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Technology involved ……...

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APPENDIX III:

APPARATUS AND MATRIALS FOR THE STUDY

Hand Tools

Tool	Plate	Uses in the project
Tenon and panel saw		These were used for various wood sectional cuts in the project.
Spoke shave		This was use for planning curves surface.
Smoothing Plane		These were used for the smoothening of the wood surfaces to make piece neat and precise.
Chisels and gouges		These are flat cutting tools (chisels and curves edge cutting tool (gouges) employed for minor cutting and carving of the wood pieces.
Pincers		This was used for cutting studs and nails that were too long into specific size and also drawing them back in the case of a mistake.

Hammer		This was the main driver for nails, studs and punchers in the various operations.
Wooden mallet		This was the main driver of chisels and gouges

Portable Power Tools

Tool	Plate	Uses in the project
Router		This was use in the precision recession of wood surfaces and mould and rebating of edges
Drill		This was used in free style drilling operations.

Jig Saw		This was used for the cutting of curves, sawing of curvatures.
Orbital Sander		This was used in conjunction with an abrasive cloth for the execution of smooth flat surfaces.
Crosscut Mitre Saw		This was used to cut across and cut mitres.

Stationary Tools or Equipment

Tool / Equipment	Plate	Uses in the Project
Thicknesser Planer		This was used in reducing the thickness of wood surface to the required thickness.

Air compressor		This was used to convert power into potential energy stored in pressurized air.
Spraying Gun		This was used with the compressed air to applying cellulose finishes to the work surface.

Upholstery Tools / Equipment

Tools	**Plates**	**Uses in the Project**
Magnetic Tack Hammer		This was used in driving tacking nails into the work piece.
Staple Gun		This was used to fasten upholstery material into a work piece.

Scissors

This was used in cutting out pattern from hardboard paper and leather.

Tack Nail Removal

This was used to remove tacking nails or staplers from the work piece.

Webbing Stretchers

This was used to catch the webbing close to the frame with plenty of leverage.

Heavy Duty Industrial Leather Sewing Machine

This was used for stitching leather and other materials together with thread.