AN INVESTIGATION OF THE DESIGN PROCEDURES APPLIED BY JUA KALI FABRICATORS IN THE KIBUYE METALWORK CLUSTER, KISUMU CITY, KENYA

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DECLARATION

Declaration by the candidate

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This work is dedicated to my wife, Melenia for her understanding, encouragement and assistance.

ABSTRACT

Informal sector activities play a very significant role in the economies of developing countries. This is through the provision of a portfolio of tradable goods and services. In addition, a large proportion of the available labour force is employed in this sector. In Kenya, the informal sector is popularly referred to as *"Jua kali"*, largely due to the open-air working conditions which characterize operations within the sector. "The Jua kali" manufacturing enterprises attract people with varying degrees of education, skills and experience. This situation raises concerns with regard to quality assurance of the products and services offered. Currently, there is no uniform strategy for training "Jua kali"manufacturers. The "Jua kali" sector of Kenya remains one of the most extensively studied entities. However, studies focusing on knowledge and technology are few. The purpose of the study was, therefore, to investigate the design approaches utilized by "Jua kali" fabricators during manufacture of their products as a measure aimed at addressing the identified knowledge gap. This investigation was critical since a number of "Jua kali" enterprises are sole proprietorships and therefore the players need all the information they can use in facilitating their production efforts. Appropriate research questions covering various fields in design work guided the investigation. The study was conducted using the descriptive survey approach. This research design was considered appropriate because the major aim of the investigation was to study design work in "Jua kali" manufacturing and report on the same without influencing the respondents in any way. Multi-stage sampling procedures with both probability and non-probability characteristics were used when choosing the study location and sample size. Information was collected using a questionnaire for the "Jua kali" artisans and a formal observation checklist for the researcher. The validity of the data collection methods was assured through co-operation with university academic advisors. The reliability of the data collection methods was checked using a Pearson Product Moment Correlation coefficient. The significance of the reliability coefficient was tested using the student t-test. Data was organized using descriptive statistics. The descriptive techniques employed included the determination of sample means, sample standard deviation, percentages and frequencies. Relationships were determined using Pearson Product Moment correlations between design, technical training and years of work experience. Major findings indicated that design in "Jua kali" manufacturing was existent but to a limited scale. Other findings revealed poor material selection techniques, poor site and workshop layout, uncoordinated product research and prevalence of informal apprenticeships in the cluster. From the findings of the study, it was concluded that Kibuye "Jua kali" artisans are not sufficiently literate on formal design methods. The study therefore recommended re-orientation of the education system of Kenya, co-operation between the informal sector and formal learning institutions, better design of the "Jua kali" sites and improvement of infrastructure in "Jua kali clusters as a way of promoting the informal sector.

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CHAPTER ONE

INTRODUCTION

1.0Introduction

This section deals with the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, and assumptions of the study. Others are significance of the study, scope of the study, limitations of the study, conceptual framework and definition of terms.

1.1Background to the study

Millions of people, especially in developing countries depend at least partly on gaining an income from manufacturing and processing activities. In addition to those whose incomes are from making goods, there are others whose livelihoods depend on using the manufactured tools and equipment in their enterprises. A large proportion of these manufacturers and users operate within the informal sector system (Cook, 2006). The general view of the informal sector is that it comprises of activities of petty traders involved in such activities as selling of second hand clothes, shoe shining, food selling, repair of automobiles and construction; operating mainly from the streets of the main urban centers. The operations in the informal sector are dynamic and not tied to formal regulations.

The informal sector is of immense significance to the economies of developing nations. A number of reasons may be used to explain this situation. For instance, the liberalization and privatization policies that are being undertaken by these states have resulted in diminishing employment opportunities in governments. The private sector has therefore been left with the task of providing employment to the ever increasing labour force.

However, the organized private sector has been unable to absorb the growing number of job seekers and hence the origin of the exponential growth of the informal sector. At another level, a high growth in population versus a slower economic growth has resulted in high unemployment (Amenya, 2007). Therefore the unemployed turn to the informal sector for sustenance. Other factors which have contributed to the growth of the informal sector are competition among manufacturing firms and nations, effects of globalization and automation. All these have contributed to mass layoffs in the formal sectors.

Although the informal sector is often associated with the developing countries, all economic systems have an informal economy in some proportion. According to Cook (2006), the informal sector employs up to 60% of the labour force in developing countries and estimates for developed countries at around 15%.

The formal sector and the informal sector can be categorically differentiated according to Meier and Rauch (2000) as follows:

I) Informal sector characteristics

i) Ease of entry

ii) Reliance on indigenous resources

iii) Family ownership of enterprises

iv) Small scale of operation

v) Labour intensive and adapted technology

vi) Skills acquisition outside the formal school system

vii) Unregulated and competitive markets.

II) Formal sector characteristics

i) Difficult entry

ii) Frequent reliance on overseas resources

iii) Corporate ownership of enterprises.

iv) Operation on large-scale

v) Capital intensive and mostly uses imported technology

vi) Skills acquired formally

vii) Protected markets through tariffs, quotas and trade licenses.

Despite the categorization above, the formal and the informal sectors relate and their activities overlap. For instance some of the workers from the formal sector move to the informal sector after acquiring skills and experience to start their own enterprises.

The formal sector is closely linked to government which facilitates and regulates its activities. On the other hand, the informal sector is mostly perceived as illegal. This is because most of the enterprises operate from diverse sites like pavements, road reserves or plots set aside for other projects. In addition the businesses are not regulated and hence the perceived illegality. It is therefore associated with risk and uncertainty. The people involved in it carry out business in low prices and sometimes involve risky undertakings (Amenya, 2007).There are other issues within the informal economy. For instance workers in this sector generally earn less and unstable income. They also do not usually have access to basic protections such as those provided by tariffs and quotas. In addition, basic services like water, electricity, roads and waste disposal have not been adequately

addressed. Therefore informal businesses lack potential for growth, trapping employees in menial jobs indefinitely (Amenya, 2007).

From the viewpoint of governments, the informal sector can generate a vicious cycle, because being unable to collect taxes from the sector; the government may be hindered in financing public services that might have benefited it. This in turn makes the sector less attractive. Conversely, some governments' view the informal sector as a means through which the ever increasing labour force can be absorbed thereby relieving unemployment problems (Kahando, 2007).

Over the years, the informal sector has been expanding. This expansion can be attributed to the economic liberalization strategies adopted by majority of these countries. This pattern of expansion began in the 1960s when a lot of developing countries failed to create enough formal jobs in their economic development plans. In the 1980s, the sector grew alongside the formal industrial sectors. In the 1990s an increase in global communication and competition led to a restructuring of production and distribution, often relying more heavily on the informal sector (World Bank, 2006).Today the informal sector accounts for more than half of the newly created jobs in many of the developing countries. Many explanations exist as to why the informal sector has been expanding in the developing world. Meier and Rauch (2000 pg. 317) gave some of the reasons as follows:

i) The kind of development that has been occurring has failed to support the increased labour force in a formal manner.

ii) Increased subcontracting due to globalization and economic liberalization has resulted in an increase of business opportunities to the informal sector enterprises.

iii) Employers could be turning to the informal sector to lower costs and cope with increased competition.

Closer home, the three East African countries of Kenya, Uganda and Tanzania have followed different approaches with regard to the informal sector. In Kenya, the informal sector rose to prominence in 1972 after the publication of the International Labour Organization (ILO) employment mission report. Among other things the ILO report advised the government to stop demolition of "Jua kali" sheds and other harassment policies. The government was also encouraged to institute site-and-service schemes and greater security of tenure for the informal sector workers. In addition the report recommended simplification of the trade licensing system and closer ties between the formal and informal sectors through subcontracting (King, 1995).Throughout the 1970s the informal sector development was viewed to correspond with the capitalist economy adopted by the Kenyan government and as a way of indigenizing the economy (Amenya, 2007).

In Tanzania, there was rapid development of the micro-enterprises after independence. However, after the Arusha declaration of 1967, private entrepreneurship was viewed to be contradictory to the socialist policies that were adopted by the independence government. Consequently, there was little development of the small scale enterprises in Tanzania in the1970s under the Ujamaa system (Lugalla and Joe, 1997). However, there were efforts under the Small Industries Development Organization (SIDO) to establish

modern small-scale enterprises. This however, focused more on technology transfer and indigenization than on entrepreneurship and therefore failed (Alila and Pedersen, 2001).

In Uganda, the official approach on small-scale enterprises was harsh. This was followed by the general collapse of the economy due to a series of civil wars in the 1970s till the first half of the 1980s (Amenya, 2007). After this debacle, the government changed its approach towards the micro-enterprises and started supporting them. From the 1990s, the East African countries have been forced to focus more on the micro and small enterprises (MSEs). The renewed interest has been prompted by the effects caused by the Structural Adjustment Programmes (SAPs) imposed on developing countries by the International Finance Institutions and donor countries. Though government support for the MSEs in terms of policy is being witnessed, these enterprises are still faced with numerous bottlenecks. Some of these are due to market liberalization and globalization hence the products from the MSEs are facing stiff competition from cheap imported items from Asia.

The significance of improving the performance of products from the informal sector in Kenya through research and development gained prominence in the 1990s. For instance the Mungai report (ROK, 1995) advocated for closer collaboration between Youth Polytechnics and the informal sector in terms of giving quality training to the latter so as to improve the quality of their goods. The Koech commission (ROK, 2001) recommended the involvement of universities and middle level institutions in improving the quality of “Jua Kali” industry through research. This collaboration as envisaged by the two reports is yet to take off on a serious note.

Kenya Vision 2030 rolled out by the Kenya government in 2008 is a strategy aimed at projecting Kenya into becoming a middle income nation by the year 2030. One of the pillars that support vision 2030 is that of Science, Technology and Innovation (STI).It is envisaged that the role of design in understanding STI will be crucial for the informal sector workers as they propel Kenya's economy towards the realization of vision 2030. It is therefore with the appreciation that design is paramount in manufacturing that the present study was undertaken.

1.2 Statement of the problem

The overall problem that was investigated in the study was the application of the design component in "Jua kali" production activities. This sector attracts a large number of workers with diverse backgrounds in education, technical training and work experience. For one to enter the sector there is usually no threshold of qualifications.

Maundu (1997) noted the absence of a centrally developed and agreed upon curriculum for training "Jua kali" artisans in Kenya. This means that each artisan produces goods and services according to his level of experience and means at his disposal. Further studies; World Bank (2008) and Wamalwa (2003) have echoed the inadequacy of technical knowledge in general and design in particular in the informal sector.

The design phase is paramount for any manufacturing activity. This is because design determines plant selection and layout. Colin (1996) pointed out that work areas should be designed for certain tasks and be clearly marked as such. Design of a work station influences the production rates, efficiency and accuracy with which an operation can be performed (Khanna, 2004).Design also plays a critical role in the selection of materials to use for a given job. Selection of materials is so important that modern design techniques

like Computer Aided Design (CAD) also suggest appropriate materials to be used in fabricating an item that has been designed (Khanna, 2004).

If the question of design in "Jua Kali" production is not urgently addressed, we risk marginalizing this sector of our economy. Kenya vision 2030 and the constitution of Kenya 2010 explicitly place a premium on the generation and management of knowledge and the need to raise productivity and efficiency (ROK, 2012). We expect the Kenyan economy to be knowledge based by the year 2030 and hence there is need for more work to be done with respect to knowledge relevant to manufacturing in the informal sector. In addition, if standard engineering design practices are not adopted in "Jua Kali" manufacturing set-ups, the sector will continue to suffer the consequences of products that do not satisfactorily address the qualities of a good design. These qualities as given by Margaret (1982) are use, durability and appearance.

With the realization that knowledge about appropriate production procedures can act as a prime mover for development, it is crucial that this be embraced in "Jua Kali" manufacturing. This can be done through nurturing the use of formal design principles within the sector coupled with product research and development in conjunction with Science, Innovation and Technology (STI). Otherwise the informal sector will continue to operate at low levels of knowledge and technology thereby foreclosing any chances for sustainable growth and development in this area of our national economy.

1.3 Purpose of the Study

The purpose of this study was to investigate the design steps employed by "Jua kali" metal fabricators within Kibuye market in Kisumu city when planning the production of their items. This investigation was important because design is paramount in many

activities in general and production in particular. With respect to fabricated items, design influences their performance and appearance. Knowledge about design also helps in determining the materials to use and the layout of the workplace. Design plays a supportive role during product research and development. It is, therefore, important that production work in informal sector manufacturing be guided by adequate preparation in terms of elaborate plans of the items to be made.

1.4 Objectives of the Study

The aim of the study was to investigate the application of the formal design procedures in informal sector manufacturing. The following objectives guided the investigation:

i) To establish the procedures which "Jua Kali"metal fabricators use to ensure that their products have the right size, shape and performance.

ii) To examine the suitability of the "Jua Kali" premises for the kind of production being undertaken.

iii) To investigate the methods used by "Jua kali" artisans to conduct product research and development.

iv) To examine how the artisans select materials for particular jobs.

v) To establish the effect which technical training and work experience have on the application of the formal design process in the informal sector.

1.5 Research questions

i) What procedures do the "Jua Kali" artisans use to give their products the right size, shape and performance?

ii) How suitable are the "Jua Kali" workshops for the work being undertaken?

iii) How do the "Jua Kali" workers conduct research and product development in their field?

iv) What criteria are used by the metal fabricators when selecting materials for given jobs?

v) What effect does technical training and work experience have on the design abilities of the "Jua kali" metal fabricators in Kibuye market?

1.6 Significance of the Study

This study aimed at getting findings that would be utilized by the following stakeholders in informal sector manufacturing:

i) The "Jua kali" metal fabricators who will benefit from the measures that will be put in place to promote design practices in their activities. Also considering the size of "Jua kali" establishments, the entrepreneurs often do not have the advantage of division of labour and hence the need for them to equip themselves with all the knowledge they can get access to.

ii) Non-Governmental Organizations (NGOs) that work with the informal sector in directing more aid towards improving design work in "Jua Kali".

iii) Curriculum developers who will appreciate the importance of design and hence infuse it in learning programs in Kenya.

iv) The government of Kenya which will realize the need to take closer interest in informal sector manufacturing activities for continued growth and sustainability.

1.7 Scope of the Study

The scope of this study covered the design practices applied by "Jua Kali" metal fabricators within Kibuye market in Kisumu City, Kenya. The respondents were drawn from members of the Kibuye"Jua kali" Association (KJKA).

1.8Limitations of the Study

The findings of this study could be generalized to the entire "Jua kali" manufacturing sector in Kenya while considering the following limitations:

i) The study was conducted within Kibuye market only.

ii) The study was confined to the "Jua Kali" metal fabricators registered with the Kibuye"Jua Kali" association.

1.9Assumptions of the Study

i) The "Jua kali" metal fabricators in the Kibuye metalwork cluster follow some procedures outlined in the formal engineering design process.

ii) The education and professional training background of the artisans have a direct influence on design ability.

1.10 Conceptual framework

A conceptual framework is a representation of independent and dependent variables showing how they are related in a study. The conceptual framework for this research was built around independent variables in design that may contribute to the fabrication of a

good quality product. These variables comprise of knowledge about formal design procedures like:

i) Problem identification
ii) Generation of preliminary ideas
iii) Problem refinement
iv) Analysis
v) Decision
vi) Implementation

The other independent variables were plant location/ layout, product research and development, selection of materials and professional training. The dependent variables in the conceptual framework represented the objectives of the study.

Possession of adequate knowledge about design contributes to a manufactured item having optimum size, weight, performance and aesthetic appeal (Margaret, 1982). Layout of the workplace in terms of the disposition of machinery and any other services connected with production is also largely governed by design principles. Knowledge concerning material properties has a defining effect on the overall performance of a product, its beauty and durability. In this regard, advanced engineering design methods incorporate suggestions of materials to be used in the fabrication of a designed item (Cole, 2005).

Product research and development is an activity which leads to sustainable and dynamic improvement in the quality of products in industry. Research and development improves the current performance of a product, reveals material substitutes and discovers unexplored uses of an item (Ahuja, 1993). The factors outlined above lead to fabrication

of good quality products which may enjoy enhanced chances of competing more effectively in the market. Such products satisfy customers more, have improved sales and this leads to enterprise growth (Kahando, 2005). Figure 1 below is a model representing the interaction between the variables discussed above.

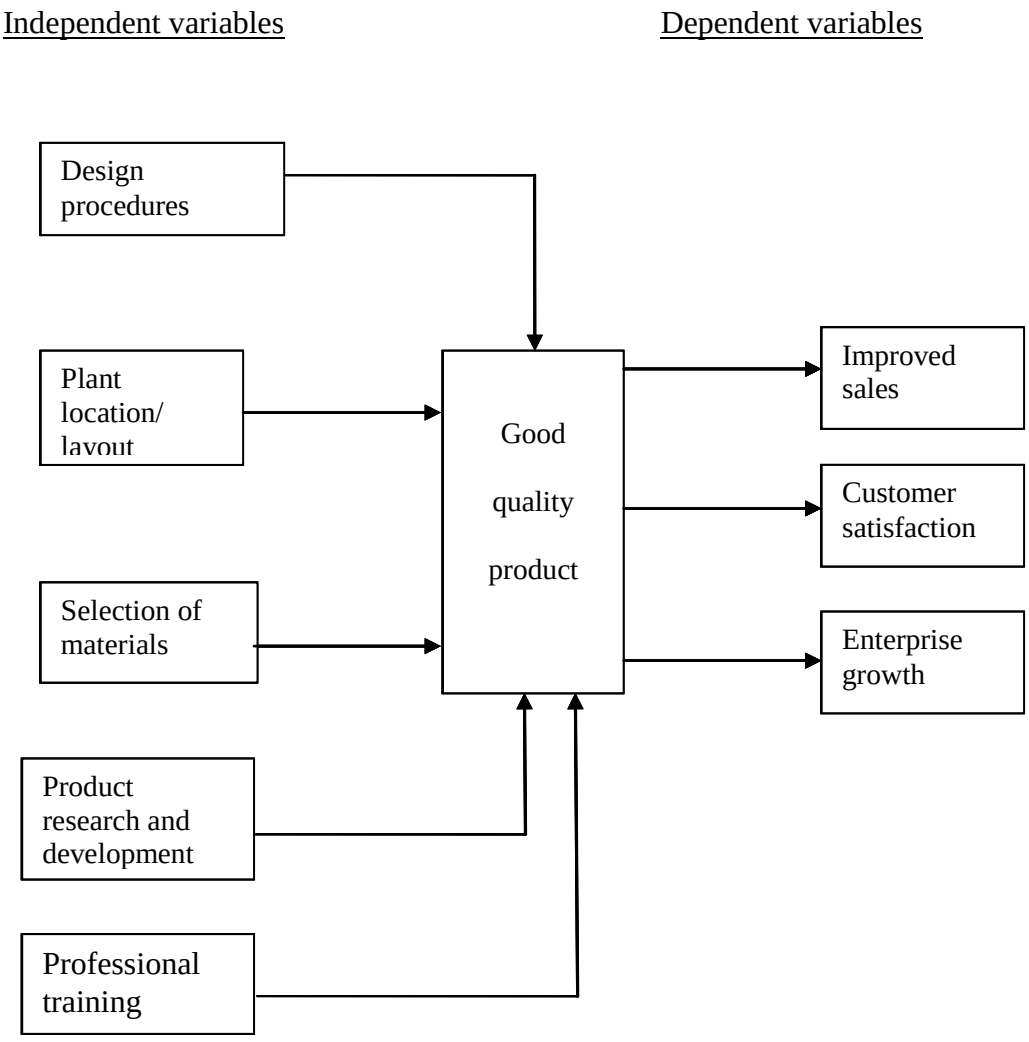

Fig. 1: Conceptual framework of dependent and independent variables.

1.11Operational definition of terms

Anthropometry- The scientific study of the measurements and proportions of the human body.

Artisan- A person who makes things skillfully especially with his or her hands.

Design- The process and skill of making drawings that show how something should be made and how it will work.

Ergonomics-The science of matching the job to the worker and the product to the user

Informal Sector- Any activity that generates income on a small scale uses simple skills, is dynamic and not tied to any regulation of the activities.

Innovation- Creation of new things, ideas or ways of doing something or the application of ingenuity to produce a product, system or process which is different from what exists.

Jua kali- Kenyan name for the informal sector where people work metal, wood and render other services either in open air or in small workshops.

1.12 Chapter Summary

From the foregoing discussion, it has emerged that informal sector manufacturing activities play a crucial role in the economies of developing nations. “Jua kali” production work in particular is so important to the Kenyan economy that the researcher decided to explore the application of the formal engineering design in this sector. Kibuye Metalwork Cluster in Kisumu City, Kenya was selected as the study site because it is rich in terms of respondents. It is hoped that the findings of this study will spur stakeholders to direct more efforts towards encouraging the application of the formal design process in the “Jua kali” sector.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section covers historical development of informal sector enterprises in Kenya, Training in the "Jua Kali" sector, Design in the "Jua Kali" sector, Challenges in the "Jua Kali" sector, Interventions in the "Jua Kali" sector, the engineering design process, Relationships between design, Materials and construction, Design of the work environment, Product quality, Computer Aided design and Vision 2030.

2.1 Historical Development of Informal Sector Enterprises in Kenya

The informal sector in Kenya is also referred to as the "Jua Kali" sector. The term "Jua Kali" is Swahili for 'hot sun'. It refers to hard work done predominantly by male blacksmiths and metal workers out of doors; in open air (King, 1995).The term seems to have been extended to motor vehicle mechanics that operate in similar conditions. Today it encompasses everything informal including selling of second-hand clothes, shoe shining, food selling, repair and construction (Amenya, 2007).

The "Jua Kali" sector is one of the most important components of the services sector in Kenya. It covers all semi- organized and unregulated small-scale activities largely undertaken by the self-employed or those employing only a few workers. It has grown considerably over the years providing employment to many people. The activities in the sector are carried out by artisans, traders and other operators under a variety of work sites such as temporary structures, markets, developed and undeveloped plots, residential premises or street pavements (ROK, 1998).

The sector relies on simple technologies and the businesses are not usually registered with the registrar of companies. However, the operators may be required to obtain licenses from relevant local authorities for carrying out business (ROK, 1999). A majority of the informal sector activities are based in urban areas.

The existence of the informal sector activities in Kenya was recognized way back in the 1950s. Between 1953 and 1955, the East African Royal Commission published a report that addressed issues that were considered as an obstacle to informal sector development. These were:

i) Licensing
ii) Credit
iii) Land use

The second milestone came in 1966 in the major Kericho conference. This meeting was the result of the growing awareness of the scale of Kenya's primary school leaver crisis, and what was considered as the stark arithmetic of unemployment that faced the dramatically rising numbers of young people (King, 1995). This conference explored means through which the unemployed would earn a living by being utilized in small-scale service industries such as vehicle and machinery repair, maintenance, construction and other activities for which demand was constantly rising in urban areas. After this conference, the informal sector was recognized as a productive sector of the economy.

The third milestone occurred in 1971 after the International Labour Organization (ILO) employment mission, whose report was published in 1972.The report called upon the

Kenya government to stop shanty demolition and harassment policies against informal sector workers. It also recommended simplification of trade licensing systems and closer ties between formal and informal sectors. An important outcome of the ILO study was the realization that the vast majority of people seeking livelihood in the informal sector were not documented and the sector provided a big safety valve for these individuals would have otherwise been a big problem for the government.

The first two decades after independence saw little or no support for "Jua Kali" enterprises. The Africanization strategies documented in sessional paper No. 10 of 1965 and subsequent five year development plans were concerned with the Africanization of European and Asian businesses and did not address issues related to "Jua Kali" businesses. Academics, planners and politicians during this period thought that modernization, industrialization and import substitution would replace indigenous modes of production. Therefore, policy provided support to medium and large scale firms rather than "Jua Kali" businesses (Kahando, 2005).

Indeed, an attempt made by the government of Kenya at industrialization through large scale production has met limited success. In one of its renewed attempts the government facilitated the setting up of Export Processing Zones (EPZs) in various parts of the country. Their establishment commenced in 1990 following the enactment of the EPZ act by parliament. Though the EPZs have attracted investors to Kenya, they have been blamed for encouraging production of specific export products as well as importation of raw materials, technology and expertise. There are therefore no backward or forward linkages between the EPZ industries and local industries. The poor transfer of technology as demonstrated by the EPZs has been largely blamed for the failure to industrialize in

Africa (Amollo, 2008). It therefore appears that other strategies will have to be explored alongside the establishment of EPZs to bring about rapid industrialization.

In his study, Amollo (2008 pg. 3) recommended the following measures as the way forward towards improving the "Jua kali" sector in Kenya:

i) Provision for accessible and affordable licensing and registration for Jua Kali entrepreneurs by the Government.

ii) Research and development programmes to be undertaken by local universities and other research institutions to improve "Jua Kali" production and entrepreneurship.

iii) Use of indigenous knowledge systems to design products for local use and export.

iv) The use of recycled materials and renewable sources of energy as sustainable means for "Jua Kali" production.

Attention on the "Jua kali" sector was facilitated and accelerated by the visit of the President of the republic of Kenya to the Kamukunji metalwork cluster, Nairobi in November 1985. After the November visit the President made several other tours of the cluster in a symbolic show of support for the metal workers. The President urged the workers to organize themselves into groups in order for them to be easily helped in terms of land acquisition. He also promised the construction of sheds for the artisans. This promise saw the erection of a number of sheds in various parts of the country for the "Jua Kali" workers. The first sheds were built in 1986.

The government's change in attitude towards "Jua Kali" workers during this time was spurred by social and political crises in the country (World Bank, 2008). These crises were partly brought about by structural adjustment policies and waning support for the government among the formal sector elite (Amenya, 2007). As a result, the economy of Kenya slowed down significantly. This led to high unemployment in the formal sector that and hence the renewed interest in the informal sector. From 1986 the informal sector started appearing in official government plans (Kahando, 2005). Sessional paper no.1 of 1986 on economic management for renewed growth recognized that the bulk of workers were employed in the informal sector. Also the government undertook to issue new regulations on tendering to require that central ministries and district authorities favor small scale producers (King, 1995).

The government in its 6th development plan of 1989 saw the inclusion of "Jua Kali" sector into major planning documents. In this plan the government projected the creation of 2 million new employment opportunities in the small scale and "Jua Kali" sector by the year 2000. Sessional paper no. 1 of 1992 put more emphasis on development of "Jua Kali" enterprises based on an enabling environment, gender, credit and finance (Kahando, 2005).Currently, the informal sector of Kenya is still the major employer according to the economic survey conducted in 2012 by the Kenya National Bureau of Statistics (KNBS). According to the report presented by the KNBS (ROK, 2012) the informal sector accounted for 80.8 percent of all the new jobs created during the year under review. Therefore out of the 520100 additional jobs created, 445900 were in the informal sector.

Sessional paper no. 2 of 2005 on the Development of Micro and Small Enterprises for wealth and employment creation recognized the limited access to skills and technology experienced by these enterprises(World Bank, 2008).In this paper, the Government proposed the creation of micro and small enterprise development technology fund to finance research and development. Though well-intended, the paper had the following limitations as identified by a World Bank (2008, p.32) study:

i) It did not offer any specific incentives for promoting micro and small enterprises.

ii) The policy was too general and did not show how collective efficiency, knowledge and technology flows would be diversified and advanced to enhance growth.

iii) The policy appeared to be a top-down approach to technology transfer whereby the entrepreneurs would be the recipients of what was produced by research bodies.

Because of the reasons given above, the small enterprises development technology fund did not succeed in disseminating knowledge into the "Jua Kali" sector.

Through encouragement by the government the "Jua Kali" workers have formed welfare associations. These associations have played a number of important roles in conjunction with relevant ministries. These include trade exhibitions and skill development programmes. Also intervention projects sponsored by the United Nations (UN) Organizations have been channeled through "Jua Kali" associations. Examples are the voucher training programme for skill development, establishment of the Ziwani learning and demonstration centre and the Kariobangi training centre (World Bank, 2008).

2.2Training in the Jua Kali sector

In order to succeed, manufacturing firms require immense knowledge. This knowledge is then used to facilitate their decision making in production, sourcing of raw materials and customer relationships. A World Bank study (2008) found that the search for knowledge in "Jua Kali" businesses is a continuous process that is not deterred by the entrepreneurs' low levels of education, limited investment capacity and limited research and development.

Training and knowledge acquisition in the "Jua Kali" sector happens through a variety of methods.Kinyanjui (1998) found competition between the artisans to be a major factor contributing to skill development and subsequent technological advancement. Entrepreneurs 'self-initiatives also help individuals to acquire the necessary skills for survival in the sector. These initiatives are enhanced by peer learning networks in the "Jua Kali" cluster. Together, peers design and make products similar to those manufactured in formal enterprises (World Bank 2008). The networks define the rules and regulations of learning and are both real and virtual.

Customers-including individuals, households and traders are another vital source of knowledge and technology (Kinyanjui, 1998). Customers bring product designs to "Jua Kali" entrepreneurs, who use their own intuition and know-how to create custom-made products. In addition, recognized and well-established trainers within the "Jua Kali" sector teach new entrants how to go about the production activities. The entrants often have an informal internship agreement with the trainers. They therefore receive an on- the job training that takes place through observation and practical activities.

The foregoing discussion shows that training is often facilitated through informal apprenticeship. This is where motor vehicle mechanics, welders, builders, carpenters, cooks, farmers, tailors, house helps and a host of others learn on the job under an "experienced" practitioner (Kerre, 2010). However training through the apprenticeship system in the informal sector is not well organized. A study done by Robert and K'Aol (1997) revealed that apprenticeship in the informal sector does not follow any set curriculum. There is no demarcation between training and normal production activities. It therefore becomes difficult for the trainers to evaluate what has been taught and schedule what is to be taught next. The observation above is in agreement with Kerre (2010) who noted that knowledge and skills possessed by the instructors in the informal sector is of an unknown quality and is unregulated. Other challenges that weigh down the apprenticeship system as given by Robert and K'Aol (1997 p.81) are (a) lack of tools and equipment (b) training activities are product or service oriented (c) inadequate workspace (d)lack of theoretical knowledge (e) loose contracts with the apprentices

Despite the challenges outlined above, informal apprenticeship still provides essential skills to the trainees that eventually help them to operate and survive in the informal sector. The unstructured nature of informal apprenticeship programs is a call for closer collaboration between formal technical institutions and the informal sector. This collaboration is at present not strong in most developing countries. A number of reasons may explain this state of affairs. In many developing countries, the resources of formal vocational training systems can serve only a small segment of the population and are generally aimed at meeting the needs of formal sector businesses (Fluitman, 1989; Yambo, 1992). According to Fluitman (1989), many craftsmen and apprentices in the

informal sector have mixed feelings about learning in formal settings. They consider formal institutions as "outsiders" who are out of touch with the background and aspirations of the trainees and therefore may not offer the right kind of training. Linkage between training institutions and the informal sector is again affected by the nature of the structure of the programs in institutions. Such training activities are typically based on the assumption that the participating craftsmen will conform to the prescribed programs, time, schedules and locations. In addition, many informal sector craftsmen may be illiterate, thus making it impossible to use conventional training methods (Robert and K'Aol, 1997).

2.3Design in practices the Jua Kali sector

A study by Wamalwa (2003) found that formal design in the "Jua Kali" sector was lacking and that formal education, professional training and working period had a direct influence on the use of the design process. Due to the low levels of design in the informal sector, the quality of products and services in the sector is affected negatively.

Design work in the "Jua Kali" sector as documented by the World Bank (2008, p.30) takes any of the following forms:

i) Copying of new products in the market.
ii) Designing according to customers' wishes.
iii) Copying by former workers from industrial firms who get laid off. These workers imitate product designs they used to make.

The practice where "Jua Kali" artisans copy the designs of imported products or those made locally is an infringement of intellectual property rights. This infringement is also

rampant among the artisans themselves. This is because they work in overcrowded conditions with most of the production work being done in the open.

Though design in “Jua Kali” production is exists up to some degree, its scope and relevance cannot be ascertained. This is despite many studies that have been carried out in the “Jua Kali”sector. In agreement with this observation World Bank (2008) acknowledged the scarcity of studies concerned with knowledge and production methods in the informal sector.

2.4 Challenges in the Jua Kali sector

Though the informal sector is characterized by ease of entry and exit for individuals, there is in fact nothing easy about working in this sector. Bottlenecks and other obstacles abound. Kerre (2010, p.35) identified some of these as follows:

i) Cumbersome laws and regulations that are often more inhibitive than supportive to the small scale entrepreneurs.
ii) Stiff regulations and requirements for securing loans or credit facilities.
iii) Poor infrastructure as most entrepreneurs work under difficult conditions.
iv) High taxation from local authorities and municipalities that often reduces their profits.
v) Limited education and training backgrounds to be able to adapt to changing technologies and the work environment.

World Bank (2008, p.32) outlined other stumbling blocks as follows:

i) A mismatch between policy and the political will to implement it. Lack of a mechanism to facilitate the movement of information and knowledge from the government bureaucracy to the "Jua Kali" clusters.
ii) There is a substantial movement of employees and trainees who move out of established "Jua Kali" clusters to start their own businesses.
iii) Absence of links between the "Jua Kali" clusters and learning institutions.

2.5 Intervention measures in the Jua Kali sector

Since the 1980s the informal sector has received a lot of attention from the government. This has resulted in the enactment of a number of measures to boost the performance of the sector. The increased interest from the government of Kenya is evident in the various sessional papers from 1986 onwards. Following a promise from the President of Kenya in 1985, some "Jua Kali" workers received sheds constructed by the government.

In 1988 the Ministry of Technical Training and Applied Technology (MTTAT) was created. Its portfolio included technical training policy, technical education and vocational training in youth Polytechnics, Institutes of Technology, the Directorate of Industrial Training (DIT) and National Polytechnics (Kerre, 2010).This ministry was also charged with the development of the "Jua Kali"sector. Through the "Jua Kali" development program in MTTAT, the government according to King (1995) tried to have an impact by encouraging greater "Jua Kali" participation in regular agricultural trade shows but more particularly by sponsored exhibitions dedicated to "Jua Kali" products. Companies like the British American Tobacco (BAT) have greatly assisted this effort by sponsoring the "Jua Kali" Nguvu Kazi exhibitions throughout the East African region.

The Ministry of Labour in the year 2000 conducted a study which specifically analyzed the level of skills possessed by the "Jua Kali" artisans and their relevance to production in the sector (ROK, 2001 p.4) and its recommendations were:

i) Training in the informal sector as a whole be co-coordinated and harmonized to avoid cases of many years of an on- the -job training not being recognized.

ii) Training institutions that produce majority of the "Jua Kali" artisans be strengthened and their curriculum reviewed in consultation with stakeholders in the sector.

iii) Greater linkage between "Jua Kali" associations, relevant government agencies and other stakeholders.

In 1994 the World Bank introduced a voucher training program for skill development in the "Jua Kali" sector. This scheme intended to provide training vouchers to 60,000 entrepreneurs and workers already established in manufacturing. The program was to run for six years from 1994-2001. The intention was to promote private sector training provision while building on traditional forms of apprenticeship. However, little information is available on the outputs of the project to date. Soon after the project became operational, it became clear that as a result of conflicts within and between the "Jua Kali" associations along with other institutional weaknesses other mechanisms would have to be found to manage the distribution of the vouchers(World Bank 1995).The voucher training program did not therefore achieve the envisaged results. Local "Jua kali" associations have also had an impact through advocacy, identification of problems and seeking solutions to those problems. For instance, the Kamukunji "Jua kali" Association helps improve the technical and managerial skills of members through

training (Ferej et *al*, 2012). In 2005, the local "Jua kali" associations created and registered the National Informal Sector Coalition (NISCO) to address the problems inhibiting the development and growth of the "Jua kali" sector (Orwa, 2007).

Non-Governmental Organizations (NGOs) also play a role in terms of training in the informal sector. In the 1990s, an NGO known as SITE (Strengthening Informal Training and Enterprise) implemented in collaboration with Appropriate Technology (APT UK) a skills upgrading project to: (i) Upgrade the technical and managerial skills of master crafts (ii) Strengthen their capacity to provide quality training to their apprentices, and (iii) Strengthen the capacity of selected vocational training institutes to support master crafts on an ongoing basis (Haan, 2006).

2.6 Formal Engineering Design Process

An Engineering design process is a procedure used by Engineers to help develop products. It is defined as an iterative decision making activity whereby scientific and technological information is used to produce a system, device or process which is different in some degree from what the designer knows to have been done before and which is meant to meet human needs(Edward, 1994).

A design may be represented by means of drawings, models, patterns, specifications or other similar methods of communications (Thomas, *et al*, 1984). In addition, every detail important to production must be given. Such details include information about materials and their work, relationship of parts within the whole and the effect of finished product upon those who may see it, use it or become involved with it (Thomas *et al*, 1984).Among the fundamental elements of design process are the establishment of objectives, criteria, synthesis, analysis, construction, testing and evaluation. The

engineering design process can be divided into a number of steps depending on the situation under consideration. Edward (1994) identified the following steps:

i) Problem identification

Most engineering problems are not clearly defined at the outset. Consequently they must be identified before an attempt is made to solve them.

ii) Preliminary ideas

This step involves the accumulation of as many ideas as possible for the solution. The objective here is to promote the free flow of ideas, any or all of which may be candidates for adoption as the final solution. All the ideas generated should be recorded in written form. Many rough sketches of the preliminary ideas should be made. All possibilities should be listed and sketched to give the designer a broad selection of ideas.

iii) Problem refinement

Several of the better preliminary ideas are selected for further refinement to determine their true merit. Rough sketches are converted to scale drawings that permit space analysis, critical measurements and the calculation of areas and volumes affecting the design. Special attention is given to spatial relationships, angles between planes, lengths of structural members, intersection of surfaces and planes.

iv) Analysis

It involves the evaluation of the basic design to determine the comparative merits of each with respect to cost, strength, function and market appeal. Graphical principles can also be applied to the analysis to a considerable extent. The making of models is valuable for

the analysis of a design to establish relationships of moving parts and the outward appearance. Full – scale prototypes are often constructed after the scale models have been studied for function.

v) Decision

Here, a single a design that is accepted as the solution to the design problem is chosen for implementation. In many cases, the final design is a compromise that offers as many of the best features as possible.

vi) Implementation

It is the final step of the design process where drawings and specifications are prepared from which the final product can be constructed.

The process outlined above is not universal for all engineers or all processes. In most cases, individuals utilize their personal knowledge and experiences to follow the path to design success. Therefore the "Jua Kali" artisans only need to apply those steps within their capabilities when designing their products. Hence the "Jua Kali" artisans need to be educated about formal design procedures and be empowered to apply those steps comparable with their abilities for design success.

An alternative engineering design procedure as proposed by Yarwood (1994) comprises the following steps:

i) **Problem identification-** It involves stating the problem which the design is supposed to solve.
ii) **Design brief-** It gives the terms of reference for the design.

iii) **Ideas for solution-** Any ideas about how the design brief can be tackled are written down and also sketched.

iv) **Appropriate solution-** Here, the best of the solutions is chosen and accurate technical of this chosen solution are made.

v) **Models-** A model from the drawings of the chosen solution is made. The model may be full size or scale.

vi) **Evaluation-** Here, drawings are checked, the model checked; for suitability in solving the design brief.

vii) **Realization-** The chosen design is made

viii) **Evaluations of realized design-**Checks are made to see whether the completed design answers the design brief. The parts of the design may be given a range of tests to ascertain their suitability. If the design brief has been satisfied, the design process will stop. If the design brief has not been satisfied, the design process is repeated.

2.7 Design for human comfort/Ergonomics

Ergonomics is the scientific study of the relationship between people and their working environment. Therefore, today's engineers need human dimensions and physical capabilities in physical units in order to design hand tools, equipment and work stations to fit human dimensions and capabilities (Edward, 1994).

The study of Ergonomics or human engineering has 4 main disciplines:

i) Anatomy and physiology (human structure and functioning).

ii) Anthropometry (body size).

iii) Physiological psychology (human structure and functioning).

iv) Experimental psychology (human behavior)

It is not important that engineers should be experts in these disciplines but they should be aware of the need to address the problems of human/machine interface which include human comfort if the maximum output is to be obtained with minimum input. Issues that need to be addressed when designing for human comfort are many and varied. They include the position of a person in relation to controls and instruments, working geometry of seats and work stations, climate, noise, light and vision,body balances and the senses(Edward, 1994). A lot of research has been done in connection with these aspects and a number of conclusions have been formed upon which modern controls and instrumentation layout is based. Some suggestions with respect to work place layout to accommodate workers according to Khanna (2004) are:

i) Bench tops should have a height of between 712mm to 762mm
ii) The seat should be such that the worker is able to adopt different postures, if necessary, for carrying out different operations. In addition, the height and back of the chair should be adjustable.
iii) A proper footrest, arm rest and leg room should be provided.
iv) Design and layout of display panels and instrument dials should result in accurate observations.
v) Design and location of various manual controls, knobs, wheels and levers should not cause excessive physical and mental strain to the worker.

vi) All controls should preferably move in one direction for one kind of action. For example, upward movement of the levers should energize the system and downward motion should power off the system.

vii) Where possible, clear access should be given around workplaces to allow for adequate supervision and inspection.

2.8 Qualities of a good Design

There are certain attributes that must be satisfied in order for a design to be certified as good. Margaret (1982) highlighted that the design of an item can be analyzed by considering three factors:

i) Use function-When examining this factor, one must ask himself whether the item is likely to do what it is intended to do. Next to be considered is whether it will do the job well. Other issues to be addressed include ease of use and comfort, explicit operating instructions, position of control knobs and switches, ease of maintenance and the suitability of the product for the age and ability of the customer.

ii) Quality/durability-Here, one considers whether the product looks well made, the suitability of the materials, its life and the price. If examination of the item shows that it will last long, then it can be described as durable. If the price seems reasonable then the item should be good value for money.

iii) Appearance- evaluation of this aspect addresses such concerns as whether the shape, line, colour, pattern and texture of the product appeals to sight and touch. One should also check to see if the item has any features that he/she thinks are unnecessary or could be improved upon.

2.9 Relationships between Design, Materials and Construction

A prime consideration in design is the materials to be used in fabricating a product. This is because the assembly of parts, their shapes and their aesthetic appearance are affected by the material used. More important reasons however are the conditions under which the finished product is expected to operate (Thomas, *et al*, 1984). Construction against mishandling is also important especially for home appliances or other devices operated by non-professionals. The rule of thumb to satisfy the above condition is to design and dictate construction details to provide as many guards against damage to the device as is consistent with the price range of the product. Materials should be of the right quality and composition to meet the product's specifications. The shape and size of the materials should restrict scrap (Cole, 2005). Black (2010) asserts that in engineering, it is important to be aware of the ways in which materials are applied and of the properties which make them suitable for these applications. This calls for an understanding of both the physical and mechanical properties of various types of materials. Practical knowledge about heat treatment procedures is also of critical importance to any manufacturer to enable him produce items with the required strength.

2.10 Design of the Work Environment

The conditions under which a product is fabricated have a strong influence on its quality. The arrangement of the work area needs to be organized to minimize risks. Areas should be designed for certain tasks and be clearly marked as such. Colin (1996) asserts that specific storage sites, gangways and traffic routes that are clearly marked and kept clean must be included. In addition work areas should have sufficient floor area, height and unoccupied space for people to get to and from workstations. The occupational Safety and Health Act (ROK, 2007) has addressed the concerns above as follows:

i) Cleanliness-the act states that every factory should be kept in a clean state by removing dirt and refuse, washing the floor as well as washing the inside walls and ceilings. The inside walls where applicable should be painted at least once every five years.

ii) Overcrowding - a factory is considered to be overcrowded if the amount of cubic space allowed for every person employed is less than 350 cubic feet. In addition every workroom should not be less than 9 feet in height, measured from the floor to the lowest point of the roofing material.

iii) Ventilation – effective and suitable provision shall be made for securing and maintaining, by the circulation of fresh air in each workroom the adequate ventilation of the room.

iv) Lighting – effective provision should be made for securing and maintaining sufficient and suitable lighting, whether natural or artificial, in every part of a factory in which persons are working or passing.

v) Drainage of floors – where any process is carried on which renders the floor liable to be wet then effective means shall be provided and maintained for drawing off the wet.

vi) Sanitary conveniences – sufficient and suitable sanitary conveniences for persons employed in the factory shall be provided, maintained and kept clean, and effective provision shall be made for lighting the conveniences; and where persons of both sexes are or are intended to be employed, such conveniences shall afford proper and separate accommodation for persons of each sex.

Therefore, the design of a work station is an important function in production. This is because it affects the production rates, efficiency and accuracy with which an operation can be performed (Khanna, 2004).

2.11 Product Quality

A product that achieves the stated requirements, specification and set tolerances in areas such as reliability, durability, safety, strength, size and shape, appearance, function, cost and inter-changeability could be said to be a quality product (Colin 1996).Maintenance of quality during production must be an emotional issue. Failure to understand how to improve quality and value of goods and services on an ongoing basis means dissatisfied customers, declining markets, vanishing profits and ultimately loss of jobs (Edward, 1994).

The purpose of quality management is to enhance the ability to improve products and services. Today, major purchasers demand proof of a company's ability to produce quality products. It is therefore essential that the producer of a product be committed to quality assurance. To do this, it is necessary to have effective and continuing market research. Unless these needs are fully understood, the designer will be unable to cater for them. Methods which are used to evaluate quality might include quality control, attribute analysis and quality assurance (Colin, 1996).

2.12 Computer Aided Design (CAD)

Computer Aided Design is the use of computer technology for the process of design and design documentation. The output of CAD usually conveys information on materials, processes, dimensions and tolerances applicable on the product being designed. The use of computers to aid in the design of products is now a relatively common practice. CAD

and Computer- Aided Engineering (CAE) programs are readily available; enabling designs to be constructed and viewed on the computer's screen (Edward, 1994).CAD has become an especially important technology with benefits such as lower product development costs and a greatly shortened design cycle. It enables designers to set out and develop work on screen, print it out or save it for future editing. This saves time on their drawings. Also, graphics programs facilitate the making of major and minor changes to a drawing before it is put on paper.

2.13 Kenya Vision 2030

Kenya hopes to become a newly industrialized middle income country providing a high quality life to all its citizens by the year 2030(Kenya, 2007). This ambition is popularly referred to as vision 2030. Vision 2030 is anchored on three pillars which are:

i) Economic pillar.

ii) Social pillar.

iii) Political pillar.

These pillars are supported on a base of Science, Technology and Innovation (STI).STI is of immense importance to the "Jua Kali" sector in the sense that most of the jobs available are in the informal sector hence its applicability in this sector needs to be addressed. Therefore, the overall objective of STI is to manage the science technology and innovation value chain so that it delivers new products, services and leads to productivity improvement within the economy (Kenya, 2007). The informal sector should therefore not be left out in these initiatives.

Among the units that are going to be strengthened in the STI cluster is that of design and engineering skills and capabilities. It would be unfortunate for STI to be strengthened in the formal production sector while the informal sector is ignored. One of the ways through which STI can be assured in "Jua Kali" is by teaching the artisans how to design products in a better way.

With the realization that the 'Jua Kali" sector attracts people with all manner of qualifications, it becomes imperative that design be taught at all levels of education ladder. This will go a long way in ensuring that a larger portion of the entrants have at least basic literacy in design. Kenya needs to borrow a leaf from the developed world to ensure that design becomes a major component of the school curriculum. Kerre (2010, p.74-75) therefore recommends the need to develop a balanced school curriculum for Africa that encompasses the following:

i) The development of an understanding of the nature of technology and how it is related to modern society.

ii) The development of an understanding of and ability to create a design.

iii) The development of an understanding of and abilities for a technological world.

Kenya vision 2030 explicitly places a premium on the generation and management of knowledge and the need to raise productivity and efficiency (ROK, 2012). This calls for a rigorous application of science, technology and innovation in all the sectors of national economy. Kerre (2010) therefore proposes the introduction of linkages between the informal sector and formal institutions as one way of cultivating the application of STI in "Jua kali" manufacturing. These linkages have so far been weak because of limited

infrastructure in formal institutions, inflexible programs, unsuitable instruction methods, negative perceptions and inadequate tools and equipment.

2.14 Product Research and Development

A good product design should ensure customer satisfaction and bring in adequate profit. Therefore, there is need for products to continually evolve in order to meet the changing needs of customers. Product research and development involves design or redesign and fabrication of new or modified products. It addresses all aspects of a product and includes its functional efficiency, quality, unexplored uses, possible material substitutes, utilization of waste products and standardization (Khanna, 2004). Products may be developed through imitation, adaptation or invention. It may involve a small refinement or a major redesign of an item.

2.15 Plant Location and Layout

A plant is a place where various factors crucial for production are combined in order to make products. Plant location means deciding a suitable area where the production site will be situated (Ahuja, 1993). Plant location plays a major role in the design of a production system as it determines the cost of:

i) Getting suitable raw materials

ii) Processing raw material to finished goods

iii) Distribution of finished products to customers

According to Khanna (2004) hardly any location can be ideal. One has to strike a balance between various factors affecting plant location which include:

i) Nearness to raw materials

ii) Reliable transport facilities

iii) Nearness to markets

iv) Availability of reliable fuel and power

v) Availability of labour

vi) Availability of land

Plant layout means the arrangement of the various facilities of the plant within the site selected previously. For the guidance of plant layout engineers, many principles of plant layout have been developed. A lot of research work has been advanced in this area in order to develop a scientific approach for solving plant layout problems. Some of the outcomes of these investigations according to Ahuja (1993) are as follows:

i) Integration

It means the combination of production facilities in a logical and balanced manner.

ii) Minimum movements and material handling

The number of movements of workers and materials should be minimized by transporting materials in optimum bulk.

iii) Smooth and continuous flow

Bottlenecks, congestion points and back tracking should be removed.

iv) Cubic space utilization

As much as possible floor space as well as overhead space should be utilized so that more material can be accommodated in one room.

v) Safe and improved environments

Working places should be safe, well ventilated and free from dust, noise, fumes, odors and other hazardous conditions.

vi) Flexibility

Machinery and workstations should be arranged in such a way that changes of the production process can be achieved at the least cost and disturbance.

It therefore emerges that the plant location and layout is an activity that should be undertaken in a very careful manner. A scientific step- by- step approach must be followed in order to come up with a satisfactory arrangement.

2.16 Chapter Summary

The literature reviewed has helped to show how various factors interact during the stages of product design as well as the actual fabrication of an item. It has also helped bring to the fore the glaring scarcity of studies focusing on the technical aspects of informal sector manufacturing like the application of the formal design process. The discussion above has in addition showed that design is not only about having elaborate plans of the item to be fabricated. It goes much deeper to include the location of the fabrication site, the arrangement of facilities in the production site and even the choice of materials to be used in making the product.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0Introduction

This chapter deals with the description of the Research Design, Study location, Target population, Sample size and sampling procedure, Methods of data collection, Validity and reliability of data collection methods and Data analysis.

3.1 Research Design

The study was conducted using a descriptive survey design. Gay (1981) defined descriptive research as a process of collecting data in order to test hypotheses or to answer questions concerning the current status of the subjects in the study. Mugenda and Mugenda (2003) noted that descriptive research attempts to describe such things as possible behavior, attitudes, values and characteristics in a population. Descriptive studies are logistically easier and simpler to conduct because of their limited geographic scope (Mugenda, 2011). They however provide a foundation upon which correlational and experimental studies emerge.This study was aimed at exploring the current design procedures applied by the "Jua Kali" metal fabricators within Kibuye market. The chosen research design was deemed appropriate for the study because of the following reasons:

i) It described the current level of design in the "Jua Kali" sector without influencing the artisans in any way.

ii) The reasons behind the current design practices as displayed by the artisans were addressed.

iii) The design is particularly suited for describing large populations like the "Jua kali" workers in Kenya.

3.2 Study location

This study was conducted within Kibuye market in Kisumu county. This site was chosen because it is the largest market in Kisumu town. Due to this the "Jua Kali" metal artisans enjoy a relatively high customer base. In addition, Kisumu town is strategically situated for export business as it is connected to Uganda and Tanzania via Lake Victoria. The "Jua Kali" businesses are, therefore, well positioned to get customers from even outside the country. The foregoing reasons have contributed to the sustenance of a thriving "Jua Kali" metal cluster in Kibuye market.

3.3Target Population

The target population for this study was all the "Jua kali" metal fabricators in Kibuye market of Kisumu City. The craftsmen in the study worked in small metal fabrication concerns. For the most part, these businesses employed less than five workers.

3.4 Sample Size and Sampling Procedure

In order to get the study sample, the researcher employed a multistage sampling procedure with both probability and non- probability characteristics. Purposive sampling was used to select Kibuye market as the study site since it is the largest market in western Kenya. This site has a vibrant metal fabrication cluster and hence is richness in terms of respondents. Purposive sampling was again utilized in selecting the 410 artisans involved in metal fabrication from the 923 registered members of the Kibuye"Jua Kali" Association.

The actual sample was obtained through simple random sampling. The 62 respondents were selected using Gay's (1981) suggestion that, for descriptive studies, 10% of the

accessible population is adequate. Other factors that were utilized when deciding the size of the sample were according to Kothari (2004) who pointed out that:

i) If the universe is homogeneous, a small sample can serve the purpose. Available literature on the characteristics of "Jua Kali" Enterprises suggests that the sector is homogenous.

ii) Technical surveys require only 10% of the accessible population. The present study was primarily technical in nature because it aimed at exploring the engineering design procedures used by "Jua Kali" metal fabricators.

Therefore, the researcher decided to use a sample comprising 15% members actively involved in metal fabrication out of the available 410 metal fabricators. This gave a sample of 62 respondents to assure a wider representation. The actual respondents were selected by assigning a number to each of the 410 metal artisans. These numbers were placed in an empty bucket which was then thoroughly shaken. After this, any number was picked at random and the artisan corresponding to the number was included in the sample. This procedure was repeated 62 times to get the required sample size of 62 respondents.

3.5 Methods of Data Collection

3.5.1 Pilot Study

Before actual data collection for the study was done in Kisumu, a pilot study was conducted in Kitale Municipality. During this exercise, 15 randomly selected metal artisans were used. Majority (80%) of these workers did not fill out the questionnaire fully in the initial trial. The main reason given for this failure was their inability to understand some of the items in the questionnaire. This made the researcher to redesign

the instrument to eliminate ambiguity in the questions. A second trial was performed at a later date using the same subjects. This time round, the researcher administered the instrument to ensure a 100% response rate. This practice provided an opportunity for the researcher to clarify issues or even translate some items to Swahili for the benefit of some artisans who were not articulate in the English language.

This approach was in agreement with Mugenda and Mugenda (2003) who suggested that in situations where the respondents may lack the ability to interpret questions because of their educational level, then a researcher administers the questionnaire. The filled questionnaires were marked by the researcher and each subject awarded marks. These marks were used to calculate a reliability coefficient (0.82) for the questionnaire which showed that the instrument had a high internal consistency.

3.5.2 Questionnaire

The modified questionnaire was now used to collect information from the 62 randomly selected respondents from Kibuye market. This instrument was organized into five main parts. Part I addressed general characteristics of the artisans such as (a) name of enterprise (b) gender (c) number of workers per enterprise (d) educational background (e) working period

Part II of the questionnaire addressed the application of the design process in “Jua kali” metal fabrication. The following areas were tackled, (a) meaning of design (b) design steps (c) documentation of designs (d) relationship between design and level of formal education (e) sources of design ideas. Fourteen items were developed to examine the above mentioned ideas. A five – point rating scale was used on some of the questions to

gauge the perceptions of the subjects about engineering design. On this scale, 1 represented “very dissatisfied” and 5 “very satisfied”.

Part III of the guide dealt with product research and development activities undertaken by the “Jua kali” artisans. These activities are (a) seeking feedback from customers (b) corrective actions (c) experimentation (d) utilization of modern design methods (e) linkages with technical training institutions

Part IV of the questionnaire touched on the work environment in “Juakali” premises. The areas it covered were (a) availability /absence of a shed (b) working space (c) ventilation within the shed (d) lighting (e) storage space (f) sanitary facilities (g) waste disposal

A five – point rating scale where 1 represented “very inadequate” and 5 represented “very adequate” was used to assess the above mentioned attributes.

3.5.3 Observation guide

Through the observation technique, the researcher collected information without involving the participants directly. The observation method was used as a supportive tool to set in perspective data collected by the questionnaire. A formal observation checklist was prepared to guide the observation. The aim of augmenting data collection with observation was to ensure better reliability and validity as proposed by Colin (2002). This instrument was divided into three parts. Part I addressed the design process as follows: (a) number of design steps followed (b) design tools (c) design documentation (d) functional and aesthetic aspects (e) production equipment

Part II examined the work environment in terms of: (a) working space (b) lighting (c) ventilation

(d) Storage space (e) work benches (f) sanitation facilities (g) waste disposal. Part III addressed product research and development measures like: (a) search for new ideas (b) experimentation

3.5.4 Scoring of questionnaire

The questionnaire items were assigned scores to provide empirical values for data analysis. In section one; the responses were awarded values ranging from one to four. In section two, the responses were awarded between one to three marks depending on the strength of the response in relation to standard design practices. For questions involving Likert type scales, the marks were 4 for "satisfied" and 5 for "very satisfied", 2 marks were awarded for "Adequate" and 3 marks for "Very Adequate". Other responses on the Likert scale were scored at zero. In section three, the marks were between a half and one for the correct response and 0 for the wrong answer. In section four, one mark was given for the right answer and 0 for the wrong response. A suitable marking scheme (Appendix IV) was prepared for marking the questionnaire for each subject. The total marks for each questionnaire were 100.

3.6 Validity and Reliability of Data Collection Instrument

3.6.1 Validity of Data collection Instrument

The following measures were instituted to address the validity of the questionnaire:

i) The initial draft of the questionnaire was given to my supervisors from the Department of Technology Education for scrutiny. Their suggestions about the

content and relevance of the questions in addressing the issues in the study were incorporated in the revised edition of the questionnaire.

ii) The questions were framed in such a way that they addressed specific objectives of the study.

iii) The questionnaire was piloted using similar subjects from Kitale town and the issues arising from this exercise were dealt with before going for the actual data collection.

3.6.2 Reliability of Data Collection Instrument

To test the reliability of the questionnaire, the split-half technique was employed. The questionnaire was administered to 15 respondents from Kitale town. These subjects were similar to the study sample but did not participate in the actual study. The items in the questionnaire were separated into two equal parts using the odd and even number technique. The scores obtained were used to compute a Pearson's Product Moment Correlation Coefficient. The formula for determining the coefficient is shown below:

$$r = \frac{N\sum XY - \Sigma X\Sigma Y}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right]\left[N\Sigma Y^2 - (\Sigma Y)^2\right]}}$$

Where:

R= sample correlation coefficient

N= sample size

X= scores of respondents on even numbered items in the questionnaire

Y= scores of respondents on odd numbered items in the questionnaire

The value of the coefficient was used to establish the extent to which the items in the questionnaire were consistent in eliciting the same responses every time they are administered. A reliability coefficient of 0.82 was obtained.

A test of significance of the reliability coefficient was performed on the coefficient obtained. According to Lind (1991), a test of significance for the coefficient of correlation is used to determine if the computed value from the sample data could have been obtained from a population in which the variables are not related. The formula for the t- test used in ascertaining the significance of the reliability coefficient is shown below:

$$t= r \sqrt{(n-2/ (1-r^2)}$$

Where r=sample correlation coefficient

n=sample size

n-2= degrees of freedom

In this particular case, the values of r and n were 0.82 and 15 respectively. The critical value and the observed t value were 1.771 and 5.17 respectively. Since t observed was greater than t critical, it emerged that there was a strong positive correlation between the variables and hence the questionnaire had a high internal consistency.

3.7 Data Analysis

Several procedures were adopted during data analysis. This process was guided by suggestions advanced by Colin (2002) who noted that if a study is purely descriptive, frequency distributions may be used. The findings were categorized and entered into frequency distribution tables. Percentages were also computed for the findings. The mean

as a measure of central tendency was calculated for the scores attained by the various categories of “Jua kali” artisans on the questionnaire used to collect information. It therefore provided a summary of the variables under investigation.

Variability of the scores was also determined. This was done by computing a sample standard deviation. It was intended to show how spread out the scores on the questionnaire was. A value of 6.15 was obtained from the sample used. This figure indicated that there was a small variability among the scores in the distribution. This is in agreement with Mugenda and Mugenda (2003) who pointed out that a small variance of the scores indicates that the values are close together. The implication was that the artisans were similar with respect to the design practices they followed while working.

Inferential statistics were used during data analysis to determine whether relationships between variables in the study existed. For this purpose, Pearson-Product moment correlations were calculated to determine the relationship between design and level of technical training of the artisans. Positive correlations were established for all the levels. Other correlations were calculated to gauge the relationship between design proficiency and work experience. At all the stages of data analysis, the information was organized in tables. These provided a quick summary of the major findings of the study.

3.8 Chapter Summary

This study was undertaken using a descriptive survey design that enabled the researcher to report on the application of formal engineering design procedures in the Kibuye metalwork cluster. Out of the registered 410 metalwork artisans, a sample of 62 respondents was selected using the simple random sampling technique. A researcher administered questionnaire and an observation guide were used to collect data during the

study. Validity of the data collection methods was assured through constant guidance from academic supervisors in the school of Education of the University of Eldoret. Reliability of the questionnaire was checked using the split – half technique that gave a Pearson Product Moment Correlation of 0.82. The significance of this correlation coefficient was tested using the student t – test. Statistical computations that were done during data analysis included frequencies, percentages, means, standard deviation and correlations.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Introduction

The objectives of the study were to:

i) Examine the design procedures used by the "Jua kali metal" workers and how they conform to universal design procedures.

ii) Investigate the methods used by the "Jua kali" artisans when performing product research and development.

iii) Examine the layout of the "Jua kali" premises with respect to workshop requirements.

iv) Determine the steps utilized by the "Jua kali" artisans in choosing the materials for given jobs.

v) Determine the relationship between the level of technical training and years of work experience on design practices in the "Jua kali" sector.

Descriptive statistics were adopted for analyzing the data collected during the study. The information was presented using means, frequencies and percentages. A sample standard deviation was computed to find out the variability of the scores on the questionnaire for various groups of "Jua kali" metal workers. Pearson product-moment correlations were calculated in order to determine the relationship between the level of technical training and years of work experience and design practices. Data was organized in tables for easier interpretation.

4.1 Education and Training Background of the Jua kali Workers

As table 4.1 shows, the education background of the respondents was varied. A higher percentage of the artisans had attended primary school (45%). A significant proportion (40%) of the artisans had secondary education while 14% had attended a middle level college. No respondent had university education. This distribution of respondents generally indicates that a high proportion (86%) of the respondents had not received formal professional training in their trade.

Table 4.1: Education Background of Jua Kali Workers in Kibuye Market

Level	**Respondents**	**Percentage**
Primary School	28	45.16
Secondary School	25	40.32
College	09	14.52
Total	62	100

Some of the "Jua kali" workers had attended technical training relevant to their trade. However these constituted a minority. According to Table 4.2, 14% of the respondents had received technical training from Youth Polytechnics. A smaller proportion (10%) had some training from a Technical Training Institute while 2% had training from a National

Polytechnic. Majority of the respondents (74%) reported having received their training through apprenticeship. This shows that most of the "Jua kali" workers had acquired their skills through informal means and hence its quality may not be easy to ascertain. This observation is in agreement with Kerre (2010) who observed that it was difficult to ascertain the quality and standards of apprenticeship training in the informal sector.

Table 4.2: Highest Professional Training of the Jua Kali Workers

Type of Institution	**Mean Score on Questionnaire**	**Respondents**	**Percentage**	**Mean Duration of Training**
Youth Polytechnic	28	09	14.52	1 Year
Technical Training Institute	30	06	9.68	1.5 Years
National Polytechnic	41	01	1.61	2 Years
Apprenticeship only	28	46	74.19	4 Years
Total	_	62	100	_

4.2 Mean Scores on the Questionnaire for Various Groups of Jua Kali Workers

In order to collect information regarding design in "Jua kali" enterprises, a questionnaire was employed. The questionnaire had suitable items regarding formal engineering design procedures, layout of work stations, selection of materials and product research. A marking scheme was developed and used to mark the responses from the participants. This enabled the researcher to get empirical values for use during data analysis.

There was no significant difference in the mean scores of the different groups of "Jua kali" workers as indicated by Table 4.3 The mean score for all the artisans was 28%. For the workers with training from Youth Polytechnics, the score was 28%. The workers with training from middle level colleges scored 30%.The respondent with training from a National Polytechnic had a higher score of 41%. The score on the questionnaire was low indicating that the majority of the respondents did not understand fully the concept of engineering design. One factor that may have contributed to the low score was that design is not a strong component of the school curriculum in Kenya and that the content of the apprenticeship training in the informal sector is deficient on formal design practices.

Table 4.3: Mean Percentage Scores of the Jua Kali Workers on the Research Questionnaire

Group	**Respondents**	**Mean Score (%)**
All Metal Workers	62	28.4
Artisan Level	09	28
Certificate Level	06	30
Diploma Level	01	41
Apprenticeship	46	28

The picture painted by table 4.3 above indicates that product and work place design within the Kibuye metalwork cluster was minimal. This aspect may not be in agreement with Khanna (2004) who observed that it was important to design a product before starting its manufacture. This is critical because design determines a product's appearance, performance, durability and price.

The calculated sample standard deviation was 6.15. A small standard deviation denotes less variability of the scores in the distribution (Mugenda and Mugenda, 2003). The implication was that majority of the "Jua kali" workers were similar with respect to their understanding of formal design processes regardless of their training background.

4.3 Design Practices in Jua Kali Metal Fabrication

Majority of the "Jua kali" artisans sampled lacked basic drawing equipment. A small proportion (16%) of the workers did not have any instrument to show that they engage in design work. A significant proportion (26%) had simple templates which they used to copy common shapes. This observation implied that not much formal engineering design was engaged in at the Kibuye metalwork cluster. As a consequence, documentation of any designs made within the cluster was difficult.

Table 4.4: Design Materials and Equipment in Jua Kali Production

Accessory	**Respondents**	**Percentage**
Pencil	31	50
Drawing Paper	05	8.1
Templates	16	25.81
None	10	16.09
Total	62	100

This situation indicated a general lack of awareness among the "Jua Kali" workers on the importance of design in production work. The artisans reported that they usually conceived their designs off- head.

As table 4.5 below shows, design documentation among "Jua Kali" metal workers was not widespread. Designs can be documented through various methods which include

making detailed descriptions about the design, Preparation of models to represent the design, making prototypes and scale drawings among others. Only a small proportion of "Jua Kali" workers (3%) reported ever making descriptions of their designs. A small number (5%) of the artisans reported making scale drawings of their designs. A significantly large proportion of the workers (92%) reported conceiving and committing their designs to memory.

This showed lack of appreciation of the core functions and importance of design in production. The workers reported that the rigors of design were beyond their abilities and would consume a lot of time that would otherwise be used in actual fabrication of goods. The process of design may not serve its ultimate purpose if a designer is unable to present his/her ideas to others through effective documentation. A design may be documented by means of drawings, models, patterns, specifications or other similar methods of communication (Thomas *et al*, 1984).

Table 4.5: Documentation of designs in Jua Kali premises

Method	**Respondents**	**Percentage**
Detailed description	2	3
Drawings	3	5
Memory	57	92
Total	62	100

All the “Jua Kali” artisans reported using simple hand tools like hacksaws, files, pliers and mallets during fabrication of products. A significantly large proportion (69%) of the artisans reported using simple hand- operated machines during production work. A smaller proportion (31%) of the artisans reported using electric driven machines in their work. None of the artisans made use of advanced production equipment like lathe machines, shapers and milling machines.

All the respondents indicated that they took work requiring specialized operations to workshops with the requisite machines whenever need arose. The technology utilized by the “Jua Kali” workers in making products was therefore found to be low. This hindered optimum realization of the designs in “Jua Kali” because of inadequate technological capacity. This might contribute to low quality products and increased bottlenecks during the process of production. In a related study, Kahando (2005) observed that production in “Jua kali” enterprises was not fully exhausted due to lack of appropriate tools and machines. Therefore, good design practices should be coupled with adequate technical capacity to make the items so designed.

Table 4.6: Realization of Designs in Jua Kali

Method	**Respondents**	**Percentage**
Simple hand tools	62	100
Hand operated machines	43	69
Electric machines	19	31

All the “Jua kali” artisans reported painting as the only finishing procedure they applied to their products. They were not aware of other available methods that could be utilized to finish products. This clearly put a limitation on the aesthetic design capabilities of the “Jua Kali” workers. The limitation also affected the durability of the fabricated items. This over-reliance on one method of finishing is not in agreement with Margaret (1982) who pointed out that a good design must serve the use function, durability function and appearance function.

The respondents in the study showed similarity with regard to the sources of their design ideas. All the artisans (100%) reported that their ideas mostly came from customers who ordered for products with certain features. Other sources of ideas were also utilized though on a minimal scale. A small proportion of artisans (11%) reported that they sometimes used their own ingenuity to develop new designs. A few artisans (3%) indicated that they had received inspiration for new ideas after attending trade fares. Some workers (29%) reported having copied designs of products from the formal manufacturing sector. A small number (2%) of the respondents had received new ideas from mass media and 5% said they were inspired after observing technical problems in real life.

Table 4.7: Sources of Design Ideas for Jua Kali Artisans

Source	**Respondents**	**Percentage**
Customers	62	100
Self	7	11
Trade Fares	2	3
Formal Sector	18	29
Mass Media	1	2
Real Life Problems	3	5
Other	31	50

The distribution above showed that customers were the main source of design ideas in the cluster. However their contribution alone cannot be expected to yield diverse design ideas unless it is coupled with systematic product research and development. There is need for other sources of design ideas to be explored on a larger scale in order to inject vibrancy in "Jua Kali" designs. Therefore, there is need for the metal artisans to consider getting design ideas through self – intuition, trade fares, the formal sector, mass media and even through observation of real – life problems. This would be in line with Yarwood (1994) who emphasized that the engineering design process is cyclical and can begin at any step

or move back and forth between the steps many times. This can be effectively facilitated if new ideas keep coming in from diverse sources.

4.4 Design of Jua Kali workshops

Very few of the "Jua kali" premises visited had some provision with respect to meeting basic requirements in setting up a workshop as follows: lighting (5%), ventilation (13%), workbenches (8%), storage space (8%), show room (3%), and electricity connectivity (20%). Other requirements like adequate working space, waste disposal arrangements, running water connectivity, sanitation facilities and noise pollution control had not been catered for satisfactorily by any of the premises. Observation indicated that most of the production work was being done in the open with the sheds being used for storage purposes only.

The posture of the workers while working had obviously not been addressed by majority of the premises. Most artisans were found to be working while sitting on makeshift accessories thereby flouting provisions regarding the design of the workplace. Suggested critical dimensions for a group of males using a seated work place as given by Khanna (2004, pg 14-15) are as follows:

i) Normal working area when elbows fall naturally by the side of the body should be about 380 mm.
ii) Maximum working area over which a seated or standing worker has to make full length arm movements is about 660 mm.
iii) Distance from the Centre line of the body to the edge of the work bench should range from 150 mm to 200 mm.
iv) Seats should be adjustable for height and rake.

v) Height from the top of the seat to the floor should be from 406mm to 508mm.

vi) The approximate height for a work bench should range from 712mm to 762mm.

In addition to the dimensions above, a proper footrest, arm rest and leg room should be provided. It is important that a worker should feel natural and comfortable while on the job. Observation showed that tools and scrap pieces were scattered all over the place with negative implications on safety, speed of working and quality of goods. This practice is against the rules governing the layout of workshops. According to Khanna (2004) areas that need to be addressed in a good workshop layout are nature of manufacturing process, flexibility, future expansion employee facilities, lighting and heating, noise control and waste management. Results obtained from the study point towards inadequacy in observing these guidelines.

Table 4.8: Design of Jua Kali premises

Factor	Premises with some provision	Percentage
Lighting	2	5
Ventilation	5	13
Work benches	3	8
Storage space	3	8
Posture	3	8
Total	16	42

All the "Jua Kali" workers reported that occupation of their present sites was guided by the availability of space only. It emerged that planning and design of premises had not been carried out. This was a contributing factor for the inadequate workshop space, extremely poor access, and the makeshift nature of the sheds. Electricity was connected in a small proportion (13%) of the sheds and none had running water. Therefore, the basic guidelines on plant and site layout had not been fulfilled when selecting the location of the "Jua Kali" sheds in Kibuye market. Most of the production was happening in the open, which means that work had to stop in bad weather. The selection of a workshop site is one of the most important decisions in production work. According to Ahuja(1993), factors influencing plant location include availability of raw materials, transport facilities, markets, labour, fuel and power, availability of water and adequate space. The location of

“Jua kali” sheds within Kibuye market seemed to have been guided chiefly by the availability of space. Other crucial factors may not have been adequately considered hence contributing to the present congestion. Additional areas in which no provision whatsoever had been instituted was with regard to waste disposal, provision of sanitation facilities, and noise reduction. No premises sampled had their own washrooms or toilets. This was a serious omission because sanitation facilities contribute immensely to a worker’s comfort at the work place. Provision of personal facilities promote workers’ morale and promotes good labour relations (Khurmi, 2009). Lack of personal facilities within “Jua kali” sheds meant that work had to stop for the artisans to access them from private entrepreneurs or municipal authorities. However, these services are not for free and their enjoyment eats into the artisans’ meager profits.

4.5 Product Research and Development in Jua Kali

As table 4.9 below indicates, product research and development activities were limited. For instance only a small proportion (8%) reported ever having added a new feature to a product to improve performance. Only 11% of the respondents had removed an unnecessary feature. Other areas in which research and development activities were seen included re- arrangements of parts (11%), altering the shape (5%), changing the materials (5%), seeking feedback from customers (7%), participation in trade fares to gain new ideas (16%) and seeking new ideas from mass media (3%). A significant group of the respondents (32%) reported discussing new ideas with colleagues. Other research and development activities like linkages with technical institutes, use of Computer Aided Design (CAD) technology and search for ideas from real life problems had so far not received attention from respondents.

Table 4.9: Product Research and Development activities in Jua Kali

Activity	**Respondents**	**Percentage**
Added new feature	5	8
Removed unnecessary feature	7	11
Re- arranged parts	7	11
Altered the shape	3	5
Altered the materials	3	5
Feedback from customers	4	6.5
Participation in trade fares	10	16
Search for ideas from mass media	2	3
Other	21	34.5
Total	62	100

4.6 Selection of materials by Jua Kali artisans

Only a small proportion (11%) of the "Jua Kali" artisans, indicated that they chose the materials for given jobs in terms of their suitability. A large proportion (73%) of the respondents reported that the choice of materials was largely determined by customer

opinions and requirements. A small group (6%) of the subjects chose their materials according to what they had in stock and through trial and error. In addition, level of funds available was another factor determining the choice of material to be used and 3% of the artisans utilized this mode.

Table 4.10: Methods used by the Jua Kali artisans in selecting materials for given jobs

Mode of selection	**Respondents**	**Percentage**
Suitability	7	11.30
Customer requirements	45	72.58
Availability in stock	4	6.45
Level of funds	2	3.22
Trial and error	4	6.45
Total	62	100

4.7 Pearson-Product Moment Correlations between design, technical training and years of work experience

Pearson Product - moment Correlations were used to establish the relationship between design in “Jua Kali” and level of professional training and years of work experience. Results presented in table 4.11 indicate that there was a weak positive relation between training at youth polytechnics and design practices. For the respondents with technical

training from TTIs, there was also a positive relationship between design and level of training. A similar picture was presented for the artisans who had trained through apprenticeship.

Table 4.11: Pearson Product - Moment Correlation between design and level of technical training

Institution	**Correlation coefficient**
Youth polytechnic	0.213
Technical Training Institute	0.305
On - job	0.217

Levels of design exhibited were higher for those who had received some technical training from Technical Training Institutes than any other cadre of training. However the generally low values of correlation between training and design indicate a deficiency of the component of design in the technical training received by respondents. The analysis above indicates that technical training has an influence on design practices. However the technical education curriculum offered in Kenyan technical institutions does not have sufficient grounding in design. This should not be the case because as Kerre (2010) observes, one of the key components of a well-structured technical education curriculum is the application of the design process.

As table 4.12 shows, years of work experience were positively correlated with design practices for the "Jua Kali" workers with 1 – 5 years on the job. However this relationship was weak. Similarly, there was a positive relationship between years of work experience and design for groups with 6 – 10 years, 11 – 15 years, 16 – 20 years and 21 – 25 years. There was a stronger positive correlation for the group with 21 – 25 years' experience than for any other group. This indicates that the longer one stays on the job, the better the design skills. The low correlation however indicates that a long period of work in "Jua Kali' production did not necessarily make one proficient in design. This finding indicates that the informal apprenticeship training that is prevalent in the "Jua kali" sector only equips the participants with skills that are already within the cluster. This leaves little room for any meaningful product improvement.

Table 4.12: Pearson Product - Moment Correlation between design practices and years of work experience

Years of work experience	**Correlation coefficient**
1 – 5	0.161
6 – 10	0.178
11 – 15	0.265
16 – 20	0.280
21 – 25	0.286

4.8 Chapter Summary

Results obtained from the study indicated that majority (75%) of the respondents had received training through informal apprenticeships. However, the respondents showed insufficient understanding of the formal engineering design practices. Selection of materials by the artisans was found to rely heavily on trial and error due to limited knowledge about material properties within the cluster. Also, the relationship between the work environment and the quality of products made was found to be limited as evidenced by the poor state of the “Jua kali” sheds.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Summary

This study focused on investigating engineering design practices used by "Jua Kali" metal workers in Kibuye market when planning the production of their goods. Data for the study was collected using questionnaires and observation check lists. The data collected from the field were analyzed using descriptive statistical methods like means, standard deviation, frequency tables and percentages. These provided quick and easy way of presenting the information. Relationships were also investigated using Pearson Product-moment correlations. These correlations gauged the relationships between levels of professional training and years of work experience with design. In both instances, positive correlations were established from the study sample. The findings from the Study indicated that the level of design in "Jua Kali" was low. The number of design steps followed, procedures for material selection, finishing methods, the layout of the sheds, limited product research and development all pointed to a deficiency in the knowledge possessed by the "Jua Kali" artisans.

5.1 Conclusions

Based on the findings of this study, it is concluded that majority of "Jua Kali" artisans in Kibuye market and Kisumu city in general are not sufficiently literate in design. This was shown by the low mean score (28%) obtained by artisans on the questionnaire used to collect information. These workers therefore do not enjoy fully the numerous opportunities presented by formal engineering design methods like better material selection, improved products, improved productivity and creation of safe working environments. It was revealed that a large proportion of the "Jua Kali" artisans relied on

informal methods like personal intuition, blind copying and job experience when deciding the size, shape, function and appearance of the products they make. However as pointed out by Kerre (2010), the informal training received by the artisans is often unregulated and uninspected. Therefore it is difficult to ascertain the quality and standards of such training. The manufacture of the products in the Kibuye cluster is usually performed using a combination of manual technologies with little machine applications in congested environments. The technology employed is in some instances unsuitable hence compromising the quality of the products and to some extent exposing the workers to danger. Therefore the process of production is not usually exhausted due to lack of proper tools ((Kahando, 2005).

This is unfortunate for a sector that is employing over 80% of labour force in Kenya accounting for about 18% of Kenya's gross domestic product (World Bank, 2008). To realign the informal manufacturing sector and put it on track for Vision 2030, streamlining and upgrading are required and this calls for a coordinated multi-sectoral approach. Learning and training institutions will be expected to play a critical role in upgrading informal sector production. This shall be largely through the application of research, development, science, technology and innovation. Towards this effort there are three critical building blocks, namely the university education, technical vocational education and training as well as basic education (ROK, 2012). The poor state of design in informal sector is in one way or the other compounded by the fact that most of the workers have low levels of formal education. Many of the workers have only a primary or secondary school education. It therefore appears that some of the workers only venture into "Jua Kali" manufacturing after failing to get openings elsewhere.

All the “Jua Kali” sheds in Kibuye market were found to be non-compliant in observing specifications for setting up workshops. Due to limitations imposed by inadequate space allocation, the artisans may not be expected to run workshops of standard size unless individual enterprises are merged. However work sites should at least be designed and constructed to specifications outlined in ergonomics. A work site should be so proportioned that it suits a group of people.

The findings of this study suggest that the “Jua kali” artisans within the Kibuye metalwork cluster may not have been well-informed with regard to specifications governing work station set-up. In addition other inadequacies were noted in such areas as space requirements, lighting, display, posture of workers, access, soundness of sheds, electricity and water connectivity, waste disposal, noise control and sanitary considerations. These limitations translate to poor working conditions from which it might be difficult to fabricate good quality products. The location of “Jua Kali” sheds was primarily determined by the availability of space which in any case is inadequate for all the artisans leading to congestion. This has forced a large proportion of the artisans to work out doors, further exacerbating an already bad situation. The state of “Jua Kali” sheds is an area that should be looked into seriously by Non-Governmental Organizations that work to uplift the status of the informal sector. The artisans should be informed that work station design has a profound effect on the production rates, efficiency and accuracy with which an operation can be accomplished.

Product research and development activities in the “Jua Kali” sector were found to exist on a marginal scale. The artisans are generally unaware of the centrality of research and development for the growth of enterprises. Their activities towards this end are therefore

uncoordinated and are not guided by specific goals. This means that most enterprises may remain trapped at their present levels of operation thereby condemning their owners to low earnings. Education materials meant for "Jua kali" fabricators should include information about the role of research and development. In addition they should be sensitized about new technologies in design and manufacturing like Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM).

Knowledge about the physical and mechanical properties of various types of metals is inadequate for the "Jua Kali" players. Though they displayed some correct choices in some instances like the fabrication of metal boxes and chicken feeders, this was largely through copying what others did and not necessarily by possession of adequate knowledge about the capabilities of the materials. The artisans should be empowered through the provision of knowledge about the physical and mechanical properties of materials to enable them make informed choices during fabrication of products. This is important because materials to a large extent determine the lifespan, performance and aesthetic properties of goods. Local Vocational Training Colleges should therefore be encouraged to design short courses for the "Jua kali" fabricators where among other things, material properties will be taught.

The low status of design in informal sector production could be attributed to the limited education and training among the "Jua Kali" artisans. Though various agencies have intervened and offered training to the "Jua Kali" operators, these measures have largely been lacking on technical components of manufacturing like design (World Bank, 2008). Future efforts should therefore include instruction materials with a heavier inclination towards design and manufacturing technology as this will have a direct uplifting effect on

the technical capabilities of workers. This is in agreement with Kerre (2010) who outlined the foundational domains of technology education as including an understanding of, and ability to create a design. This domain is of critical importance to the "Jua kali' manufacturing.

5.2 Recommendations

5.2.1 Re – orienting Education, Training and Skills

This study has revealed that there is a relationship between education, training and engineering design. This link should be capitalized upon by incorporating the design option in school curriculum at levels of the education ladder in Kenya. This will ensure that all the learners acquire some basic competencies in design work which they can apply in case they venture into "Jua Kali" manufacturing. Technology studies should be part of the envisaged restructuring to provide information about appropriate methods of production and new technologies which are in use. It is highly recommended that Kenya adapts the model of having technology education as a subject examinable at Kenya Certificate of Secondary Education (KCSE) to ensure technological literacy for all. Input from the Ministry of Education, Science and Technology, The Kenya Institute of Curriculum Development (KICD) and other stakeholders should be integrated in enacting a curriculum to specifically train "Jua Kali" personnel.

5.2.2Linkage with local Training Institutes, Universities and Research bodies

Through cooperation with learning institutions and research institutes like Kenya Industrial Research Development Institute (KIRDI) and the National Council for Science, Technology and Innovation (NACOSTI), product research and development can be strengthened in the "Jua Kali" sector. These agencies can provide facilities for

experimentation and the results so obtained be disseminated to the “Jua Kali” people. The artisans can also act as sources of ideas that may be worked on by the learning institutions and research centers. This measure can ensure continued innovativeness and vibrancy in the informal sector.

Provision of theoretical backgrounds to practical skills possessed by “Jua Kali” artisans is another sphere in which the informal sector may partner with formal institutions. Towards this end, the learning institutes will be expected to mount short courses specifically for the “Jua Kali” artisans. This will go a long way in nurturing the concept of Life Long Learning (LLL) for “Jua Kali” workers and help propel the informal sector to greater heights.

Another area where the “Jua kali” sector could collaborate with learning institutions is with regard to industrial attachment of trainees. This co-operation should be co-ordinated by the National Industrial Training Authority (NITA). This body should organize industrial placements in such a way that some trainees get attached in relevant informal sector enterprises. Through this practice, the trainees will gain valuable experience with regard to operational dynamics within the informal sector. This is in line with the objectives of the ministry of labour which among other things calls for the strengthening of linkages between industry, training and research institutions.

5.2.3Better Design of Jua kali Workshops

It is recommended that local “Jua kali” associations should partner with the government, NGOs and vocational training colleges in designing a standard “Jua kali” workshop. Such a workshop should have appropriate work stations, tool racks and reasonable storage

space. The artisans should then be facilitated to copy the standardized workshop for better productivity.

5.2.4 Improvement of Infrastructure in Jua kali Designated Areas

The central government as well as County governments should ensure that “Jua kali” clusters are adequately served with access roads, water, electricity and waste disposal systems. Such interventions would help create more conducive work environments. In addition, availability of electricity would open avenues for improved design practices like the use of Computer Aided Design software.

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APPENDICES

Appendix I

The following is a list of the expenses that were incurred in carrying out this research.

Table 5: The Budget

ITEM	COST (Kshs)
Stationery	1,500.00
Typing and printing	20,000.00
Binding	1,200.00
Pre-testing of measuring instruments	4,000.00
Transport	10,000.00
Miscellaneous expenses	8,000.00
Total	44,700.00

Appendix II

Below is the proposed work plan for this study:

Table 6: Work plan

Activity	**Quarterly**			
	1st	**2nd**	**3rd**	**4th**
	Jan. – March	**April – June**	**July – Sept.**	**Oct. – Dec.**
Development of proposal			2010	
Submission of a typed proposal			2010	
Proposal presentation				2010
Correction and typing of approved proposal				2010
Piloting of data collection instruments		2011		
Data collection		2011		
Data organization, analysis and interpretation			2011	
Typing and submission of final report				2011

Appendix III

Letter of transmittal

SAMBAYA JOSHUA ELEDI
UNIVERSITY OF ELDORET
P.O BOX 1125-30100
ELDORET.
1/12/2011

TO WHOM IT MAY CONCERN

REF: RESEARCH PROJECT

Iam a student of the University of Eldoret studying for a Masters degree in Technology Education. As part of the requirements for the award of the degree, Iam undertaking a research study entitled **"An Investigation of the Design Procedures Applied by Jua kali Metal Fabricators in the Kibuye Metalwork cluster, Kisumu City, Kenya".** This inquiry aims at examining the design steps followed by "Jua kali" artisans against documented engineering design procedures. This study is important in the sense that its conclusions and recommendations will be utilized by various stakeholders in improving the "Jua kali" sector. Iam therefore kindly requesting you to contribute to this effort by completing the attached questionnaire as honestly as possible. I wish to assure you that the findings of this research will be used for academic purposes only.

Thank you

SAMBAYA ELEDI JOSHUA

Appendix IV

Questionnaire for the artisans

Instructions

1. Please respond to all the questions as honestly as possible.
2. Do not write your name anywhere on this questionnaire.
3. Complete this questionnaire by a tick in the bracket provided.

NOTE: All the information given shall be treated with strict confidentiality and shall be used for the purposes of this study only.

Section 1:a) General information

Enterprise name	
Gender	
Number of workers	

b)Educational background and working period

Note: Please tick inside the appropriate box.

Formal education	**Professional training**	**Working period**	**Position in enterprise**
Primary level	Apprenticeship	Below 5years	Owner
Secondary level	Artisan certificate	5-10years	Manager
Middle college level	Craft certificate	10-15years	Worker
University level	Diploma /Degree certificate	Above 15years	Other

Section2: Design process

1. Which of the statements given below best describes your understanding of the concept of design? **(Tick only one response)**
    a) Design is the addition of decorations on a finished item []
    b) Design is the process of deciding how something will look and work by drawing plans [ ]
    c) Design involves copying items made by other people [ ]
    d) Design is fabricating what the customer wants [ ]
2. Have you ever been taught about the procedures in formal design work?
    a) Yes [ ]
    b) No [ ]
3. From the list given below indicate the most common sources of your design ideas **(Tick as many responses as is applicable)**
    a) Customers [ ]
    b) Self [ ]
    c) Trade fares [ ]
    d) Similar items from formal sector[ ]
    e) Print media [ ]
    f) Technical problems in real life[ ]
4. How do you ensure that your products:
    a) Work properly…….....
    ……
    ……
    ……
    …….
    b) Are attractive……
    ……
    ……
    ……
    ……
    …….

c) Are safe to use……..

……

……..……

……..……

……...

5. After designing an item, how do you document the design? (Tick at most 3 responses)
    a) By writing a detailed description of the design [ ]
    b) By drawing sketches representing the design [ ]
    c) By preparing models to represent the design [ ]
    d) By committing the design to memory [ ]
    e) None of the above [ ]
6. How do you decide on the materials to use on a particular product? (Tick any suitable response)
    a) Availability [ ]
    b) Level of finances available [ ]
    c) According to the customers' wishes [ ]
    d) Suitability of the material for the job [ ]
    e) Trial and error [ ]
7. Does your level of education influence how you design items?

    YES [ ] NO [ ]

    If YES, specify in which way

    ……

    ……

    ……

    ……..

8. How do you design your present range of products?
    a) Copying from colleagues [ ]
    b) Through trial and error [ ]

9. How satisfied are you with the products you make in relation to:
    a) Function 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
    b) Attractiveness 1[ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
    c) Safety 1[ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
    d) Size 1[ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
    e) Weight 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
    f) Shape 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]

    KEY

    1 - Very dissatisfied
    2 - Dissatisfied
    3 - Unsure
    4 - Satisfied
    5 - Very satisfied

10. Do you follow a well-documented procedure when undertaking the design exercise?

    YES [ ] NO [ ]

11. If the answer to question (10) above is YES, approximately how many steps do you utilize before getting the final design (Tick an appropriate bracket)

    1 [ ]
    2 [ ]
    3 [ ]
    4 [ ]
    5 [ ]
    6 [ ]
    7 [ ]

12. Do you understand the concept of Computer Aided Design (CAD)?

    If YES, what does it mean?

    ……

    ……

    ……

    ……

13. Have you ever used CAD in your design work?

    YES [ ] NO [ ]

14. Give your views about the importance of CAD in Jua kali production efforts?

    ……

    ……

    ……

    ……..

Section 3: Product Research and Development

15. Have you ever designed something new from what is commonly in the market?

    YES [ ] NO [ ]

16. Have you ever sought to know whether your customers are satisfied wholly with your products?

    YES [ ] NO [ ]

    If YES, what did they say?

    ……

    ……

    ……

    ……

    ……..

17. What measures did you take to rectify the concerns in (16) above?

    ……

    ……

……

……

18. Which of the following have you done on a product? (Tick an appropriate bracket)
    a) Added a feature [ ]
    b) Removed a feature [ ]
    c) Re-arranged the parts [ ]
    d) Altered the shape [ ]
    e) Changed the materials[ ]
19. Do you have a working relationship with any technical training centre?

    YES [ ] NO [ ]

    If the answer to question (19) above is YES, briefly explain how this relationship is beneficial to your work

    ……

    ……

    ……

    ……..

Section 4: Work Environment

20. Do you work from inside a workshop?

    YES [ ] NO [ ]

    How do you rate your working environment with regard to the following aspects?

ASPECT	1	2	3	4	5
Working space					
Ventilation					
Lighting					
Storage space					
Sanitation facilities					
Waste disposal					

KEY

1-Very inadequate

2-Inadequate

3-Unsure

4-Adequate

5-Very adequate

Appendix V

Marking Scheme for the Questionnaire

Section 2: Design Process

1. Design is the process of deciding how something will look and work by drawing plans [2marks]
2. YES [1 MARK]
3. One mark for each response [max. 3 marks]
4. a) Work properly

   -Designing the product using formal engineering design procedures before fabricating

   [1 mark]

   -Making prototypes and testing them to ascertain their functional efficiency [1 mark]

   -Using suitable materials for all the parts [1 mark]

b) Attractive

-Including decorative features on the product [1 mark]

-Painting the product in attractive colors [1 mark]

c) Safe

-Suitably enclosing all dangerous/movable parts [1 mark]

-Preparing user manuals where appropriate [1 mark]

-Using suitable materials [1 mark]

5. One mark each for a,b and c [max. 3 marks]
6. One mark each for either c or d [max. 2 marks]
7. YES [1 mark]

   -Technical education provides insights on how to design better products which satisfy the customers more [2 marks]

8. -According to customers' wishes (c) [1 mark]

-Using engineering design procedures (d) [1 mark]

9. 2 marks for "satisfied"

   3 marks for "very satisfied" [max 18 marks]

10. YES [1 MARK]
11. One mark for each choice [max 7 marks]

12. YES [1 MARK]

    -Use of computer technology for the process of design and design documentation [3 marks]

13. YES [1 MARK]
14. –Output of CAD would provide information on materials, processes, dimensions and tolerances applicable on the product being designed.

    -Could lower product development costs

    -Shortened design cycle

    -Saves time

    -Permit alterations on the design to be made more easily

    [max 8 marks]

Section 3: Product Research and Development

15. YES [1 mark]
16. YES [1 mark]

    1 mark each for at least 3 customers' concerns [3 marks]

17. 3 marks each for any stated corrective measure [max 9 marks]
18. 1 mark each for a, b, c, d and e [max 5 marks]
19. YES [1 mark]

    Explanation

    -Teaching technical drawing which is crucial for design

    -Providing facilities for experimentation

    -Carrying out further research on products with the aim of improving their performance

[1 mark each for 2 correct points]

20. YES [1 mark]

21. 2 marks for “adequate”

3 marks for “very adequate”

[max 15 marks]

Appendix VI

Observation checklist

Part 1: Design Process

a) Number of design steps utilized

i. 1-2 [ ]
ii. 2-4 [ ]
iii. 4-6 [ ]
iv. 6-8 [ ]

b) Design tools

i. Drawing board [ ]
ii. Drawing instruments [**]**

c) Design documentation

i. Drawings [ ]
ii. Models [ ]
iii. Prototypes [ ]
iv. Descriptions [ ]
v. Photographs [ ]

d) Functional and aesthetic design procedures

i. Testing parts before assembly [ ]
ii. Testing the assembled product [ ]
iii. Painting [ ]
iv. Electroplating [ ]
v. Polishing [ ]
vi. Bluing [ ]
vii. Decorative features [ ]
viii. Selection of materials based on material properties [ ]

e) Production equipment

i. Hand tools [ ]
ii. Simple machines [ ]
iii. Power driven machines [ ]
iv. Advanced machines [ ]

Part 2: Work environment

i.	Working space	Adequate [ ]	Not adequate [ ]
ii.	Lighting	Enough [ ]	Not enough [ ]
iii.	Ventilation	Enough [ ]	Not enough [ ]
iv.	Storage space	Adequate [ ]	Not adequate [ ]
v.	Work benches	Available [ ]	Not available [ ]
vi.	Sanitation facilities	Available [ ]	Not available [ ]
vii.	Waste disposal	Adequate [ ]	Not adequate [ ]

Part 3: product research and development

i.	Active search for new ideas [ ]	Observed [ ]	Not observed [ ]
ii.	Alteration of size, shape, parts [ ]	Observed [ ]	Not observed [ ]
iii.	New ongoing projects [ ]	Observed [ ]	Not observed [ ]

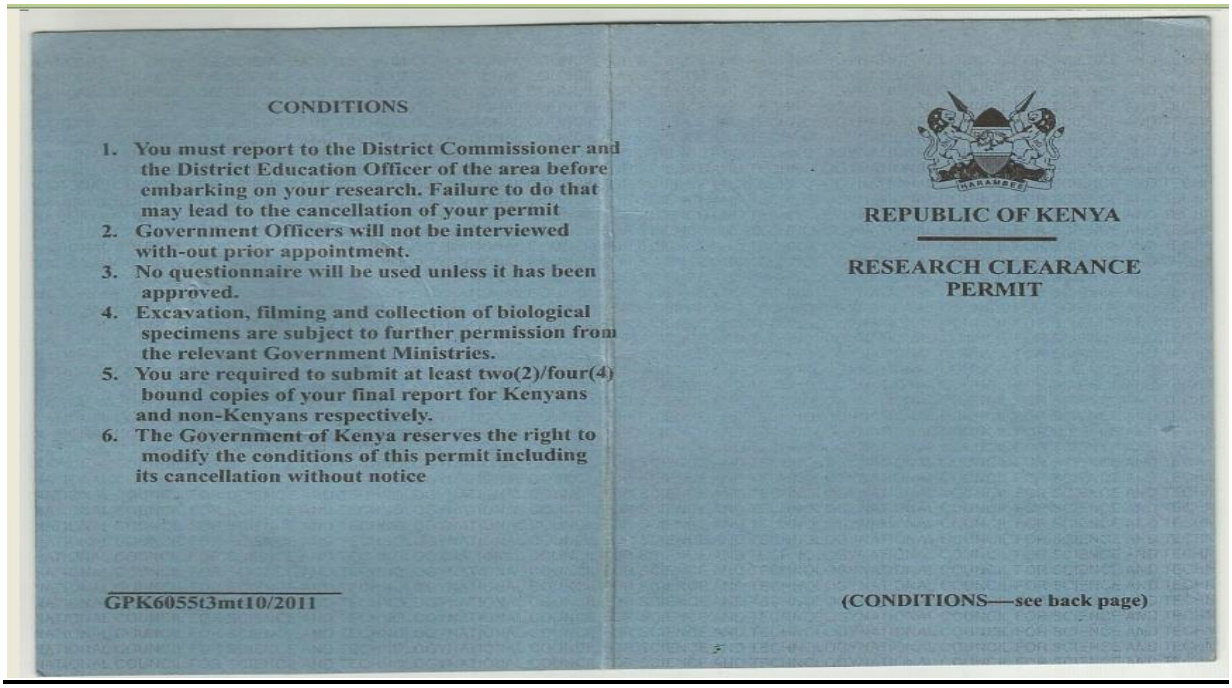
Appendix VII

Scores on Pilot Study Questionnaire

SCORE	24	30	34	35	36	37	38	40	41	43	45	47	51	59
FREQUENCY	1	1	2	1	1	1	1	1	1	1	1	1	1	1

Appendix VIII

Research permit



CONDITIONS

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed with-out prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2)/four(4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

GPK6055t3mt10/2011

HARAMBEE

REPUBLIC OF KENYA

RESEARCH CLEARANCE PERMIT

(CONDITIONS—see back page)

PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Joshua Eledi Sambaya
of (Address) *Moi University*
P.O. Box 3900 Eldoret
has been permitted to conduct research in

	Location
Kisumu	District
Nyanza	Province

on the topic: A survey of the design procedures applied by jua kali metal fabricators in Kisumu. The case of Kibuye market

for a period ending 30th June 2012

PAGE 3

Research Permit No. *NCST/RR1/12/1/SS 011/124*
Date of issue . *9th September 2011*
Fee received . *Ksh1000*

.....
Applicant's Signature

.....
Secretary
National Council for Science and Technology

Appendix IX

Research authorization from the DEO, Kisumu East district

MINISTRY OF EDUCATION

Telegrams:

Telephone: Kisumu (057) 2022626
When replying please quote

DISTRICT EDUCATION OFFICE
KISUMU EAST
P.O. BOX 1914
KISUMU

REF:KSM/MIS/29/III/(158)

13TH DECEMBER, 2011.

TO WHOM IT MAY CONCERN

RE: RESEACH AUTHORIZATION
MR. JOSHUA ELEDI SAMBAYA

This is to certify that, Mr. Joshua Eledi Sambaya who is a student at Moi University has been granted authority to carry out research on **"A Survery of the design procedures applied by Jua Kali Metal Frabricators in Kisumu. The Case of Kibuye Market"** within Kisumu East District for a period ending **30th June, 2012.**

Kindly accord him the necessary assistance to enable him complete the exercise.

FOR: DISTRICT EDUCATION OFFICER
KISUMU EAST DISTRICT

JOSEPH OCHIENG' ONDHORO
FOR: DISTRICT EDUCATION OFFICER
KISUMU EAST

Appendix X

Research authorization letter from NCST, Nairobi

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telegrams: "SCIENCETECH", Nairobi
Telephone: 254-020-241349, 2213102
254-020-310571, 2213123.
Fax: 254-020-2213215, 318245, 318249
When replying please quote

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RRI/12/1/SS-011/1244**

Date: **9th September, 2011**

Joshua Eledi Sambaya
Moi University
P.O Box 3900
ELDORET

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on **"A survey of the design procedures applied by jua kali metal fabricators in Kisumu. The case of Kibuye market "** I am pleased to inform you that you have been authorized to undertake research in **Kisumu District** for a period ending ***30th June, 2012.***

You are advised to report to **the District Commissioner and the District Education Officer of Kisumu District** before embarking on the research project.

On completion of the research, you are expected to submit **one hard copy and one soft copy** of the research report/thesis to our office.

P. N. NYAKUNDI
FOR: SECRETARY/CEO

Copy to:

The District Commissioner
Kisumu District

The District Education Officer
Kisumu District