TECHNOLOGY DIFFUSION AND ITS IMPACT ON PRODUCT DEVELOPMENT IN THE INFORMAL METALWORKING SECTOR IN KENYA

BY

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A Thesis submitted in fulfillment of the requirements for the award of the degree of Doctor of Philosophy in Mechanical and Manufacturing Engineering of the University of Nairobi

DECLARATION

This thesis is my original work and has not been presented for the award of a degree in any other University or institution.

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ABSTRACT

This study dealt with technology diffusion and its impact on product development in the informal metalworking sector in Kenya. Therefore, the research aimed to identify product development methods in use by firms in the informal metalworking sector. This was in order to show how these methods relate to conventional product development methods and routes of training undergone by artisans before self-employment. Further to this the study sought to establish how the metal working processes used in the sector relate to material selection, choice of equipment and levels of training. This research also attempted to show the relationship that exists between the routes of training for the artisans in the sector and the achievement of quality products in desired quantities and on schedule. Moreover, the research also aimed to demonstrate how technology diffusion occurs in the sector.

The method of data collection for this study was through cross-sectional survey. Questionnaires for the data were administered to 112 owners of Small and Medium-Scale Enterprises (SMEs). The statistical method of analysis of variance (ANOVA) was used to study the relationship between product development methods used and the quantities produced, quality and the ability to deliver products on schedule. ANOVA was also used to determine the influence of route of training on production quantity, choice of quality control method and number of orders delivered without delay. The Chi-square analysis was further used to show the relationships between routes of training and choice of product development method and number of rejected products.

The findings of the study show that the methods of production in the informal sector are determined by the acquired equipment and type of training received by the operators. The results of the study have further shown that the mean of the quantities of products produced varied significantly across the product development methods. Furthermore, product quality is influenced by equipment, materials, production skills and quality control methods. The study also shows that delivery of products on schedule to the customer is affected by the product development method in use. It is evident that ideas for product development are mainly obtained from customers, friends or colleagues, consultations with experts and cooperation with other firms. Moreover, the existence of training programmes for employees is also a source of technology in the sector.

It is concluded from this study that the conventional process of product development which involves idea generation, idea screening, concept development and concept testing is not practised by any of the firms in the informal sector. The results of this research have also shown that there exists no technology diffusion model supported by government policy that would help the informal sector achieve the goal of producing products of desired quantity, quality and on schedule. This research project has therefore proposed a technology diffusion model for the sector. This is after having identified product design, material and equipment selection, and production scheduling and quality assurance as the weak areas of product development in the informal metalworking sector. Hence, it is recommended that these areas of production should form the basis of technology diffusion to the sector.

DEDICATION

I dedicate this academic report to my late father Ibrahim Ogola Omwonyo, my beloved late mother Pascalia Atsieno and to the entire Ogola family, whose material and moral support has contributed significantly to my present achievements.

ACKNOWLEDGEMENTS

I would like to acknowledge my supervisors Prof. S.M. Mutuli, Dr. J.A. Nyang'aya and Dr. Martin Ogutu for their invaluable comments and suggestions throughout the duration of the writing of this thesis. To carry out a project like this, one invariably comes across a lot of hurdles which are not usually easy to jump. There are many people who in one way or the other have contributed in lifting me cross these hurdles.

I owe them my invaluable gratitude. In this regard, I would like to thank Prof. G.K. Misoi, Chairman. Department of Mechanical Engineering, University of Nairobi, who has offered me moral support that has been helpful in the completion of this thesis. I am especially grateful to the University of Nairobi for granting me a fee waiver without which, the completion of this thesis would not have been possible.

Finally, I would like to thank members of my family and friends for their love, inspiration and untiring support throughout the years of my study.

ABBREVIATIONS

CBS	_	Central Bureau of Statistics
FDI	_	Foreign Direct Investment
GOK	_	Government of Kenya
ILO	_	International Labour Organization
IMF	_	International Monetary Fund
K-REP	_	Kenya Rural Enterprise Programme
MNC	_	Multinational Corporations
MSE	_	Micro and Small Enterprise
MSETTP	_	Micro and Small Enterprise Training and Technology Project
NGO	_	Non-Governmental Organizations
OECD	_	Organization for Economic Co-operation and Development
R & D	_	Research and Development
SBS	_	Small Business Centres
SE	_	Small Enterprise
SME	_	Small and Medium-Scale Enterprise
TEP	_	Training and Enterprise Programme
TNC	_	Trans-National Corporation
UN	_	United Nations
UNCTAD	_	United Nations Conference on Trade and Development
UNCTC	_	United Nations Centre on Transnational Corporations
UNDP	_	United Nations Development Programme
VTI	_	Vocational Training Institutes

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CHAPTER ONE

INTRODUCTION

The informal sector is increasingly playing an important role in the building of the Kenyan economy. It consists of a wide range of small enterprises and in most cases employing between one and ten workers. However, a few employ up to fifty workers on the upper side as described by Romijn (1998). Official policy initiatives show that the Government of Kenya has taken increasingly specific steps in recent years to formulate policies which address market failures and environmental constraints facing informal sector entrepreneurs on different fronts. Both the informal and small-scale enterprises sectors have been targeted as primarily vehicles for social and economic development.

The Sessional Paper No. 1 of 1986 on "Economic Management for Renewed Growth" recognized that a majority of future non-firm job opportunities would be in the informal sector which in spite of its past negative public image possessed many positive characteristics [Kenya (1986)]. Kenya's sixth National Development Plan of 1989 – 1993 [Kenya (1988)] and subsequent development plans as well as sessional papers of 1986 and 1992 proposed more detailed measures to promote informal sector enterprises.

1.1 Background To the Problem

The master plan for Education and Training 1997 – 2010 [Kenya (1998)] outlines serious failures of the public provider institutions to maintain equipment and update technologies. For instance, in what should be the leading institution in Kenya, Nairobi's National Industrial and

Vocational Training Centre (NIVTC) in the heart of the Industrial Area is completely outdated. You will find that the equipment in many of the workshops in the institution dates from the early to mid - 1970s and even senior policy figures have been heard to refer to it as a "museum".

The training and technology strategies given to most artisans and operators in Kenya project towards finding markets for finished products and how to source for finances from bankers and other lending bodies [Maundu (1992)]. The other form of technology transfer, which is common in the Kenyan situation, is whereby the skilled and experienced personnel from the formal sector of production and manufacturing firms leave to put up their own informal metal working workshops. After the purchase of a few essential tools and machinery, these persons put up their own production or manufacturing firms and thus transfer technology to their own staff. This kind of technology transfer is so common in Kenya that almost the whole lot of retired and retrenched persons end up starting income generating activities similar to what they were doing in formal sectors [Maundu (1992)] .

The transfer of skills from larger to smaller firms in Kenya as charted by King (1977, 1996 and 1999), appears to be the only tangible way of technology transfer in the informal sector. However, other researchers have argued that structural adjustment in the formal sectors has not led to such an influx of larger firm skills and that many such skills are irrelevant in the contexts faced by the informal sector. Jeans (1999: 178) has however argued that "downsizing" and "retrenchment" from large industries and government, has led to a new cadre of entrants to the small enterprise sector in Kenya. These artisans have developed their skills elsewhere such as from training schools like polytechnics.

Despite the fact that numerous studies and several governmental development strategies have been directed into the informal sector. It is evident that very little has been realized on its expansion and growth in terms of product quality, quantity and time space worthy of meeting customer demands. Several previous researchers attribute this anomaly to problems facing the sector inclusive of limited funds, poor market opportunities, lack of work site, insecurity, low skill levels and poor management practices. Moreover, the sector also suffers from inadequate training and exposure, limited access to infrastructure, inability to source information on relevant technology and marketing techniques. The sector is also characterised by inadequate access to professional assistance such as banking, insurance and legal services [Ondiege and Dondo (1995)] .

Technology transfer can be defined in general terms as the process of conveying a technology from one party and applying it to the other party. In the process, the technology which is not necessarily derived from a competitor organization is converted into a form that can be applied [Edwards (1997)]. This definition of technology transfer applies to the informal sector of our Kenyan situation. However, it is evident from previous surveys that there is a crude copying of product designs in the Kenyan informal sector which results in the duplication of very many similar products in the market. These products do not meet customer demands in terms of quality, quantity and time. In order to solve this problem, there is the need to employ professional and academic knowledge in the transfer of technology in the informal sector.

1.2 Statement of the Research Problem

Ngahu (1999) states that there is inadequate relevant technology to suit our local industries. Thererefore, artisans in the sector cannot produce quality products in desired quantities and on schedule. Moreover, the conventional process of product development which involves idea generation, idea screening, concept development and concept testing [Meredith (1994: 97- 98)] is not practised by any of the artisans or owners of firms in the informal sector. This is brought about by lack of research and development which should be aimed at upgrading the technology in the informal metalworking sector with a view of addressing the limitations relating to product development processes, skills and quality of outputs. It is also evident from past studies in the informal sector that issues of technology diffusion and product development limitations have not been adequately addressed. Hence, the continued lack of improvement in this sector. Therefore, this study attempts to fill this gap.

1.3 Research Questions

1) What factors affect product development in the informal metalworking sector ?

2) What is the impact and extent of technology diffusion in the informal sector ?

1.4 Objectives of the Study

1) To identify product development methods in use by small and medium enterprises in the informal metalworking sector in Kenya and to identify how these relate to conventional product development methods and routes of training undergone before self-employment.

2) To establish how the metalworking processes used in the sector relate to material selection, choice of equipment and levels of training.

3) To determine the relationship that exists between the routes of training for the artisans in the sector and achievement of quality products in desired quantities and on schedule.

4) To determine the effectiveness of product development methods used by the sector in achieving quality products in desired quantities and on schedule.

5) To demonstrate how technology diffusion occurs in the sector and assess its impact on product development in achieving quality products in desired quantities and on schedule.

6) To identify the limitations of technology diffusion in the sector and propose a model of technology diffusion most appropriate for the informal sector in Kenya.

1.5 Hypotheses

1) Existence of inadequate production skills is a product of a deficient education and skill acquisition processes.

2) The absence of an appropriate model of technology diffusion applicable to the metalworking sector is the main drawback to effective production of marketable quality products.

CHAPTER TWO

LITERATURE REVIEW

The literature review of this study attempts to discuss various issues related to product development and technology diffusion in the informal metalworking sector in Kenya. It focuses on conventional product development models to help in the determination of any relationship that exists between these models and those methods that are currently used by the informal (small enterprise) sectors in the making of products. Technology diffusion and the models through which it occurs have been described in detail. This chapter has also highlighted those problems and limitations that are likely to be encountered in the process of technology diffusion within the informal sector's Small and Medium Scale Enterprises (SMEs) in Kenya.

2.1 Product Development Methods

Meredith (1994: 97 - 98) describes the steps followed in a conventional process of product development. These steps can be summarized as follows: Idea generation ➔ technical drawing and specifications of product ➔model building and testing ➔final product. Meredith (ibid) also argued that the idea generated will go through several stages as follows:

Firstly, there is the idea generation stage whereby ideas for promising potential products can come from a large number of sources, such as customers, vendors, market research, sales persons, internal research and development (R&D) laboratories and competitors. Secondly, in the screening and selection of ideas stage, ideas have to pass through a large variety of tests and screens before receiving a final go-ahead for full-scale production. Screening includes market analysis and forecasts of customers' needs, assessments of the reaction of competitors, analyses of economic viability, studies of technical feasibility and checklists for organizational fit. Thus, on the basis of these analyses and studies, one or a few ideas are selected for further study.

Thirdly, the preliminary design stage focuses on decisions about the product. In this regard, specific attributes of the product such as cost are first set as goals. Hence, various designs are then considered that may have the potential to achieve the set goals. Furthermore, basic but critical trade-offs such as quality and reliability versus price are considered at the preliminary design stage.

Fourthly, the prototype testing stage is where a model is built and tested against product attributes like technical performance, appearance, customers' reaction and tastes. Fifthly, based on the reaction to the prototype and any desirable changes or alterations in the preliminary design, a final design is developed with full drawings, specifications, procedures and other information needed for the production system. If the changes from the preliminary design are extensive, a new prototype may be constructed and tested again.

Lastly, once the final design has been agreed upon, the process of making the product must also be specified. Thus, a full process plan is prepared which includes not only product specifications, but also quality requirements, capacity rates, technological needs, skill levels, materials required and production methods.

Past studies have shown that overall development of new or modified products, using new production processes is considered costly, risky and time consuming by the entrepreneurs in the informal sector [Ngahu (1999)]. SEs do not always work with fixed designs as the general tendency is to produce things to match people's needs (Juma, 1993). This means that customers are a major source of innovative ideas, as their needs and problems call for innovation. The products in this sector reflect a keen effort to adapt to local conditions and customer-needs. The adaptability leads to the development of new skills and product improvements. For instance, the repair of worn out cooking pans may not feature as a need in many advanced societies. Lack of resources has made repair and improvisation in the use of waste materials and available tools an important characteristic of innovation in the SE sector [Ngahu(1999)].

2.2 Assessment of Product Development Methods and their Effectiveness

Woodcock and Mosey (2002) have identified cost, benefit, strategic fit and difficulty of implementation as the main criteria for assessing product development methods and their effectiveness. The two criteria of cost and benefit are the most obvious. This is because cost deals with such factors as people, time, materials, research, marketing, legal issues, promotion, distribution and contingency. On the other hand, benefit is analysed in terms of number of potential customers, margins in the market, market growth rate, long term market potential, unique benefits to customers. Furthermore, benefit also deals with value for money to customers, differentiation from competitors, quality relative to competitors, positive impact on other products and motivation.

Major studies in the United Kingdom, United States of America and Canada [Freeman (1988); Booz – Allen and Hamilton (1982); Cooper (1993)] have been undertaken with the aim of backtracking through completed product development projects to find out how they were done and how this related to their commercial performance. In total, over 14,000 new products in 1,000 firms were studied, some of which went on to be commercially successful and others which failed.

By studying what was done differently during the development of successful products, on the one hand, and failed products, on the other, key factors for new product development have been identified. A number of factors in three broad areas made the most important differences between success and failure as described by Cooper (1993). The biggest and probably most obvious single factor determining commercial success was market differentiation and customer value (ibid). Products which were seen by customers as being substantially better than competing products and being better in ways which were highly valued, had 5.3 times the success rate of those that were only marginally different.

Secondly, products which underwent a thorough and stringent assessment prior to development were 2.4 times as likely to succeed as those that had not. Products which are sharply and well defined in a design specification prior to development were 3.3 times as likely to be successful as those that were not. Thirdly, where technical activities are consistently carried out to a high quality, products have in general, a 2.5 times greater success rate, specifically, where the company's technical skills were well marched to the activities needed to develop the new product.

Fourthly, the chances of success were 2.8 times greater, where there was a high degree of working harmony between the technical and marketing staff within a company. Furthermore, chances of product success were 2.7 times greater than where there was severe 'disharmony'. A great many conclusions have been drawn from the above studies. One of the most generic conclusions is Robert Copper's "gambling rule" as stated by Cooper (1993). This states that: when the uncertainties are high, keep the stakes low; as the uncertainties reduce, increase the stakes.

In new product development terms, the uncertainties are highest at the start [Baxter (1995)]. The reasons for this are that, you do not know what the product is going to look like, how it will be made, what it will cost, and what customers will think of it. Doing the early design work, producing sketches or models, estimating costs, and talking to customers requires only time and a minimum of materials. If this proves successful, the uncertainties are reduced and the stakes can increase. On the overall commercial success for a new product means that the product must sell in sufficient numbers and at sufficient price. This will enable the product to be able to cover its full cost of sales, its full development costs and still be able to return a sufficient profit to the company [Baxter (1995)].

2.3 Definition of technology

SMEs in the informal sector in Kenya see technology as machinery and knowledge to use in production. Goulet (1989) looks at technology as asserting control over nature and human processes of all kinds. Another group of authors define technology as a process [Methe (1991), Georghiou et al (1986) and McIntyer (1986)]. Methe (1991) points out that this process is characterized by using knowledge; reducing the uncertainty and achieving desired end. So it is a process for creating solution to problems. McIntyer (1986) emphasises the driving forces of the process and regards technology as an integral part of Research and Development. Meissner (1988) defines technology as the configuration of processes, plans, techniques, knowledge and skills. The function of this structure, according to his idea, is to effectively produce, process and market a product or service.

However, in recent years, more and more definitions connect technology with knowledge [Knaap (1987) and Jegathesan (1990)]. The differences between those authors are in two aspects. One is in the description of quality of knowledge. For example, Meissner (1988) thinks that technology is a quantum of knowledge. Adeoba (1990) used the word 'technical' to describe it. Most authors limit the scope of the knowledge only in production or only in industry. For example, Knaap (1987) says that the body of knowledge is used in the production of goods. However, some authors do not satisfy the narrow scope and try to enlarge the traditional scope of technology. Adeoba (1990) puts human skills as an important component of technology and Jagathesan (1990) covers services in his definition.

2.3.1 Structure of technology

It is a tradition to divide technology into two parts: a tangible part of hardware and intangible part of software technology (United Nations, 1989). However, there are also some authors who do not satisfy the division. United Nations Centre on Transnational Corporations (1984) states that technology can be embodied in various forms. In addition to machinery and human capital, written documents are also very important form. Kranzberg (1986) suggests that there are three elements in technology: material element, design element and capacity element.

Organization for Economic Co-operation and Development (1988) sets a four-level structure of knowledge according to its sophistication. This applies to producing a new product or mastering a new process, when there is technology transfer. These are operation knowledge, maintenance knowledge, modification knowledge and design knowledge. Hobday (1991) points out that there are two types of relations among these levels of knowledge. For technology developers, the knowledge flows from the high level to the low level, whereas for the later comers, the knowledge is accumulated from the low to the high level.

Although technology has boundless application many authors such as Adeoba (1990), and Jegathesan (1990)) state that technology is used to sort out only two types of problems. One is in the management field, which deals with the relation among people. The other is in the production aspect that copes with the challenges raised by natural environment. In addition to the above divisions, some authors such as Georghiou (1986) and Gomulk (1990) suggest another technology structure, which is based on the activity of knowledge. They all believe that technology is made from two parts. One is active and the other is dormant. It means that because of the limitations of certain factors such as price, function, financial constraints, only a small fraction of knowledge or techniques is used at each moment in time. On the other hand, the other possible methods or techniques remain dormant. When these factors change, the dormant part may be activated and be used. Thus, the scope of technology cannot be limited only to currently used or active part.

2.3.2 Technological change, Innovation and SMEs

According to Lundvall (1988) successful innovation largely depends on the close interaction between producers and users of a particular technology. Hence, the importance of interactive "trial and error" and cumulative learning by doing, by using and by interacting. Mowery and Rosenbury (1989) give the following instances of interaction within the firm which results in innovation. First, between marketing and production (feedback from consumer complaints and suggestions leading to product improvement). Second, between production and design (continuous interaction between engineers and designers leading to a bottom-up approach where focus is on manufacturability). Lastly, between Research and Development (R & D), marketing and production (joint product development teams, consisting of R & D, marketing and production people).

The various interactions that constitute the process of innovation however extend well beyond the boundaries of the firm. Therefore, strong and continuous interactions between materials producers, component suppliers and final assemblers respectively have substantially increased in importance [O'Connor (1992)]. Nelson (1990) points out that in Organization for Economic Co-operation and Development (OECD) countries, academic research has provided many of the original "invention" or pilot versions of designs that industry subsequently develops and commercialises. The main contribution of academic research however, related to the generation of generic knowledge. Nelson (ibid) defines generic knowledge as a body of understanding of how things work, key variables affecting performance, the nature of various opportunities and currently binding constraints and promising approaches.

According to Ernst (1980) firms can build technological capabilities in a variety of ways. The most important distinction is whether they do so internally, based on their own Research and Development (R&D) design and engineering activities or whether they rely on external linkages. This links can be with technology producers within the domestic economy such as Universities or public R & D labs or other private firms. However they can also be with foreign technology suppliers. In a growing number of industries the focus of technology development is shifting from the level of the final product to technologies related to materials and core components. As a result, both suppliers of materials and core components have had to upgrade substantially their technological capabilities. This is in order to act as external technology sources for the final assemblers [Smitka (1991)]. Vickery (1991) emphasises that the effective acquisition of foreign technology by developing countries is an essential prerequisite for developing technological capabilities in the respective countries. This is so because most global R & D technological resources, are located in the United States, Western Europe and Japan, with a large share concentrated in large Trans National Corporations (TNC) in leading industries.

Smith and Jordan (1990) distinguish between four types of international technology transactions. Firstly, the acquisition of the right to employ a technology which is protected by a patent. Secondly, the acquisition of a capital goods which embody a technology or a set of technologies. Thirdly, the provision of technical support services which enable the receiving firm to use the technology. Finally, the transfer of knowledge about basic design features and specifications of the technology. This in principle should enable the receiving firm to reproduce, adapt and further develop the imported technology.

Dunning (1988) reports that direct technology diffusion occurs when the foreign company makes conscious efforts and resource commitments to transfer certain product or process technologies or technical support services. Dunning (ibid) points out that research on the role of Foreign Direct Investment (FDI) for international technology diffusion has concentrated more on direct forms of technology transfer. This has led to a neglect of a great variety of more indirect and informal technology diffusion mechanisms. Wong Poh Kam (1991) points out that indirect technology diffusion in general does not result from any conscious effort by the foreign company but occurs as a side effect of interactions with a foreign firm. Smith (1988) and Esubuyi (1992) point out that conventional analyses of SMEs hardly associate the African variety with significant technical change and inventive activities. This is because a large part of the technology in the use in African SMEs is imported. Moreover, very limited post-investment analysis of firm level activities have been undertaken even for large scale firms.

According to Lall (1995) the determinants of the industrial technology development (ITD) fall into three groups: The incentive framework, the "supply" factors and institutions. An institution broadly defined is about the 'rules of the game" but is also on organization set up to supply the functioning of the skills, capital and information markets. In this context, these are the agencies for science and technology, training and vocational centres. Supply factors comprise skills, finance and information.

For Ernst, Mytelka and Ganiatsos (1995) it is more appropriate to identify the incentive system (IS), which comprises sets of factors that determine technological development. The incentive system comprises three elements, which are policy dynamics, market forces and historical practices. The main feature of the idea of 'policy dynamics" is that time and contexts affect the reactions of economic agents when faced with seemingly identical policies. Again, market forces are shaped by government policies, as well as by the strategies and organizations of private firms. In effect, enterprise and government determine the texture of a nation's incentive system. Market forces flow from different sources, three of which are: factor markets (labour and capital); the size and structure of demand; and industry structure (including patterns of competition).

In the Small Enterprise (SE) sector technological innovation is built around methods of production, where over time the firms builds its technological knowledge to the point where it becomes a source of new technologies. Freeman (1982) distinguishes between five types of strategies toward innovation: offensive, defensive, imitative, dependent and traditional strategies. Offensive and defensive strategies are concerned with the early introduction of technologies while imitative tend to follow innovative firms. Small subcontracting firms whose technology is determined by the customer mainly use dependant strategies. Traditional strategy is basically non-innovative, as firms do not change in technically significant ways. This is closely linked to market structure and is related to competitive strategies of market leaders, challengers, followers and nichers. Many SEs are generally associated with imitative and followership strategies, mainly because of their lack of resources.

The process of technological change involves three stages generally classified as Schumpeter's trilogy. These are: First, invention which refers to the generation of new ideas. Second innovation which covers the development of new ideas into marketable products. Third, diffusion which is the adoption of these products by the relevant actors in the economy [Stoneman (1987)]. Drucker (1985) points out that there is no such thing as a "resource" until man finds a use for something in nature, and thus endows it with economic value. Innovation empowers individuals and enables them to generate wealth and improve their circumstances. It is creativity and innovativeness which enable resource-poor entrepreneurs to use ingenious techniques to transform resources, otherwise thought of as unproductive into usable assets.

According to Stewart (1987:3), the characteristics defining Appropriate Technology (AT) normally include more labour usage, less-capital usage, and less skill-using innovation. Furthermore, AT is characterised by making more use of local materials and resources in small scale, and producing a more appropriate product. That is, a simpler product designed for low-income consumers or a product suitable as input into other appropriate technologies. SEs do not always work with fixed designs, as the general tendency is to produce things to match people's needs. Most innovations from the SE sector reflect an effort to adapt to local conditions and needs. They appear to aim at modifying existing product designs, to ensure easy maintenance and repair [Juma et al (1993)].

The problem of management has been identified as a major obstacle to the advancement of SEs. The typical SE owners or managers develop their management style through a process of trial and error. A consequence of poor managerial ability is that entrepreneurs are less prepared to respond to changes in the business environment, and to plan appropriate changes in technology. The entrepreneur's levels of education affects their access to technological information and their ability to understand, respond to, use and control technologies [Anderson(1985)].

2.4 Policy and Technology change

A broad range of government policies affects industrial development. This is evident in general macroeconomic management, through trade and competition policies and human resource development, to specific industrial and technology policies. This study deals with what is commonly known as 'industrial policy". These are policies directed specifically at promoting industrial development by diverting resource allocation from what free market forces would have done. This leaves out of consideration macroeconomic policies and general issues of policy making such as credibility and sustainability. It does, however, include some trade, education and training, and technology policies, and all the policies that are directed at industrial promotion and support [Lall (1996)].

'Industrial policy' in this sense can take two main forms: functional and selective. While both affect overall resource allocation, functional policy aims at improving markets in a generic sense for example improving education, infrastructure or capital markets. Selective policies on the other hand promote specific industries or economic agents. In an extreme form, selective policies consist of "picking winners" at the level of specific technologies or firms. However, there can be many levels of selectivity, and selectivity can be exercised at a much broader level e.g. in education and training, the promotion of all export-oriented activities, and offering incentives to all technological activities [Lall (1996)].

In the current jargon, functional policies are termed "market friendly" according to the World Bank (1993), while selective policies are widely regarded as "market unfriendly".The economic rationale for any policy intervention by a government lies in remedying market failures, deviations from a competitive equilibrium where all markets are "efficient". Efficiency requires the fulfilment of certain stringent assumptions: perfect competition, absence of externalities and existence of a complete set of markets, including all future markets and those covering all risks. Standard theory admits to market failures caused by public goods, externalities and monopolistic elements, and allows for some (rather limited) interventions. However, new information and evolutionary theories suggest a wider and more fundamental set of market failures. These revolve around the nature of technological activity, and so have direct relevance to industrial policy. To quote Stiglitz (1996: 156):

....Whenever information was imperfect or markets were incomplete, government could devise interventions that filled in for these shortcomings and that could make everyone better off. Because information was never perfect and markets never complete, these completely undermined the standard theoretical basis for relying on the market mechanism. Similarly the standard models ignored changes in technology; for a variety of reasons markets under-invested in research and development. Because of this shortcoming, developing economies have underdeveloped markets and imperfect information systems....

Stiglitz (1996) lists market failures in developing countries: weak and non-existent market, diffuse and extensive technological externalities, marketing spillovers, returns to scale, coordination failures, and strategic negotiations. He also notes the remedies: guiding capital markets, encouraging difficult technology acquisition, promoting export marketing, protecting infant industries, co-ordinating linked industries with technological potential or scale economies, overcoming risk and improving bargaining positions. These arguments for government intervention in development still mainly ignore or oversimplify the micro-level process of leaning to technological effort required for manufacturing enterprise to become efficient (and becoming efficient is surely the essence of industrial success). This has little to do with 'technological innovation' in the normal use of the term. It is more concerned with mastering existing technologies, a process that is generally assumed away. Hence, developing countries are advised to simply 'open up' to technology inflows in line with existing comparative advantages. Taking the learning process fully into account provides additional, more compelling arguments for selective interventions.

Drawing on the evolutionary tradition of economic growth (Nelson and Winter, 1982) and on empirical work at the firm level, a substantial literature has arisen around the development of technological capabilities in developing countries [Wangwe (1995); Lall, (1996)]. The most important relevant features of the micro-level learning process are: its hazy and poorly understood nature; the risky, uncertain and unpredictable duration of learning, pervasive and diffuse spillovers, externalities and increasing returns. In addition, weak financial markets; missing or weak human capital markets; and similarly weak institutional structures to support technological activity. Since technologies differ significantly between activities, all these processes are necessarily highly activity specific. Given such market failures, free markets could lead to under-investment in technologies with high and prolonged learning cost, exceptional risks and widespread externalities and linkages. Not intervening in deficient markets would thus have costs, depending on the existent and severity of the failures involved. Intervention to restore efficient resource allocation must therefore vary by activity. Furhermore, uniform support across activities in the presence of activity-specific market failures, makes as little sense as non-intervention if these features of technology and learning are taken into account. This is all at the abstract level.

At the empirical level, the experience of the Asian 'Tigers' has demonstrated that both selective and functional interventions are essential to successful industrial growth and deepening.Thus a wide range of alternative strategies are possible [Lall (1996)]. In other words, there is no single optimal industrialization path but a range of possible paths. The initial conditions of the economy, the capabilities and objectives of the government, and the political economy within which it functions. What is clear, however, is that industrial policy can work very well.

In the past two decades, and for good reasons, more discussion has revolved around the issue of government than around market failures. It is clear that industrial policy practically in all countries outside East Asia has failed to produce industrial efficiency and dynamism. Mainstream economic thinking has therefore not been in favour of industrial policy, particularly in Africa, where the history of import-substituting industrialization is marked by distorting and pervasive government interventions, widespread inefficiency, and failure to become competitive. The disillusionment with past industrial policy has been reinforced by a neoliberal resurgence, which introduces strong political elements into the argument. This suggests that all governments are inherently and forever inefficient and corruptible. This interpretation of industrial policy has been supported by (now largely discredited) arguments that the success of the Asian Tigers was due to market forces and the lack of selective government interventions. The adoption of these arguments by the two leading development institutions (the World Bank and the IMF) in what is called the "Washington consensus" has led to many African countries starting to adopt, willingly or otherwise, strong liberalization policies [World Bank(1994)].

2.5 Government Policy on SMEs in Kenya

The Kenya government position on the salient role of the Micro and Small Enterprise (MSE) sector is articulated in various policy documents. Kenya's blueprint to the year 2000 recognised the sector by declaring that, "Indeed a large measure of Kenya's industrialisation will be carried out by small industries" [Kenya (1986)]. Furthermore, the 1989-93 development plan spelt out specific strategies and programs for the small firms in Kenya. These include (i) developing an award scheme to promote innovation and invention through small and medium enterprises. (ii) Availing information and knowledge. (iii) Examining the legal machinery governing small firms by reviewing by-laws and regulations inhibiting development of such enterprises and the improved accessibility of suitable financial and marketing infrastructure. (iv) Restructuring of supportive public and private sector efforts in training, advising and counselling [Kenya (1988)].

The session paper No. 2 of 1992 on Small Enterprise and informal sector development in Kenya is also an important and relevant document. This policy document is the blue print for MSEs development in Kenya. It was based on the work of a special task force established by the government in 1987 to review all policies with a view of promoting the sector and creating an enabling legal and regulatory climate. This would be achieved by eliminating existing constraints. The paper deals with the provision of finance through the Ministry of Technical Training and Applied Technology. This money was to be used for the construction of sheds to accommodate informal sector artisan workshops located in rural areas. Furthermore, the cash would avail industrial and commercial land to small enterprises to construct and install their own facilities [Kenya(1992)]. Moreover, the same session paper on Small Enterprises and informal sector industrial development in Kenya of 1992 confirmed the lack of any significant graduation of micro firms from micro to small-scale enterprises.

The session paper No. 1 of 1994 on Recovery and Sustainable Development to the year 2010 is another important document with respect to MSEs. It notes that most are service-oriented enterprises, the success of which depends upon their having a convenient location relative to their potential consumers. The policy paper states that land near commercial centres of Kenya's secondary towns and cities will continue to be made available to MSEs [Kenya (1994). In 1987 the Kenya Government in collaboration with International Labour Organization (ILO) and United Nations Development Programme (UNDP) started a project on entrepreneurship. This soon broadened in 1989 into a small enterprise development policy project and was organised in a highly participatory manner. This involved all the relevant ministries, the aid agencies, representatives of industry and commerce. Also with targeted seminars and workshops focused on small-scale exporters, the banking sector, Non-Governmental Organizations (NGOs) and many other interested parties. This was probably one of the most thoroughgoing attempts in Africa to put into place a set of strategies that would privilege the small enterprise and informal sector [Assuncao (1993)].

Assuncao (ibid) points out that the small enterprise development programme of 1987 had three main concerns. The first of these was the promotion of an enabling environment for SMEs. This examined many of the macro-economic, legal, technological and fiscal obstacles to small enterprise. Central to this part of the strategy was the argument that the role of government should be changed from being interventionist to being facilitative of efforts by the private sector itself. Evidence for this position on small-scale enterprises was not derived from the informal sector where the great majority of the firms had never received any government assistance at all. It seems rather to have been confirmed by the poor showing of Kenya Industrial Estate (KIE), which was alleged to have undermined entrepreneurial capacity by featherbedding and over-subsidising.

The second concern of the small enterprise development programme of 1987 was the development of an enterprise culture. This elicited a whole series of recommendations, which sought to ensure that students at all educational or training levels in Kenya should receive instruction in courses relating to self-employment and entrepreneurship [Assuncao (1993)]. The third element in the 1987 SMEs development programme was concern for the many obstacles to credit experienced by the small and micro-enterprise sectors. This caused a whole range of compelling changes to be proposed, involving shifts in collateral policies, changes in bank incentives for lending money to small enterprises and much more [Assuncao(ibid)].

The primary role of the informal sector in strengthening the economy has been presented in the Session Paper No. 1 (Kenya, 1986), Session paper No. 2 [Kenya(1992)] and the eighth National Development Plan [Kenya(1997)]. These policy documents highlighted the role that the SE sector was expected to play in the economy and established direction for the promotion of small and micro enterprises in the country. The sector has recorded high rates of growth and is expected to play a key role in the creation of employment in Kenya. During the 8th National Development Plan (1997 – 2001), the sector was expected to contribute 25.6% of the 1.6 million jobs targeted. However, it is generally recognised that SEs face unique problems which affect their survival, growth and profitability; and hence decrease their ability to contribute to sustainable development. The problem of management has been identified as the main obstacle to the advancement of SEs. The typical SE owners or managers develop their management style through a process of trial and error. The consequence of poor managerial ability is that entrepreneurs are less prepared to respond to changes in the business environment, and to plan appropriate changes in technology. The entrepreneur's levels of education affects their access to technological information and their ability to understand, respond to, use and control technologies (Anderson, 1985). Low market demand and lack of access to inputs and working capital also dog the sector.

2.6 Models of Technology Transfer

Seaton and Cordy – Hayes (1993) define technology transfer as the process of promoting technical innovation through the transfer of ideas, knowledge, devices and artefacts. That is from leading edge companies, R & D organisations and academic research to more general and effective application in industry and commerce. Therefore, the following is a description of the pathways through which technology is transferred in the SMEs as shown in Figures 1 up to 9 as well as in Table 1. The models to be covered will form the basis for the development of a suitable model of technology diffusion in the informal metalworking sector in Kenya.

2.6.1 World Bank Model

At school level, the World Bank has tended to argue that what is needed most is a concentration of effort on getting the basics right [World Bank(1988)]. Here what are meant are language, mathematics and science, rather than practical subjects of various kinds. It is further argued, in this model as shown in Figure 1, that post-school training should ideally be done on-the job. This will help to maximise the fit between the supply and demand of trained labour. However, it is accepted that there will be some cases, particularly in the least developed countries, where some state-sponsored training will be necessary due to the weakness of the industrial sector [World Bank (1991), Middleton et al. (1993)]. There is also a stronger place urged for private (proprietary) training. Nonetheless, the World Bank's recent interest in the traditional apprenticeship system of West Africa and the informal sector system of Kenya suggests an awareness of the possibilities of on-the job training taking place in the informal sector itself, as well in the formal sector enterprises.

General Education

↓

Enterprise –Based Training

↓

Self-employment

Figure1: World Bank model

Source: Mc Grath Simon et al (1994), **Education and Training for the Informal Sector-Education, Research Paper No. 11,** p.141

2.6.2 Grierson Model

Grierson (1989 and 1993) argues that enterprise based training is the key to successful preparation for self-employment as illustrated in Figure 2. He was solely concerned with informal sector based training and his arguments are more relevant in this context rather than in that of formal sector-based training. Enterprise based training, Grierson (ibid) argues, provides the package of technical skills that the worker will require in the world of work. Therefore, implicitly, formal sector training will tend to provide a somewhat different and possibly less appropriate package for self-employment. Clearly, it is also implicitly assumed that Vocatinal Training Institutres (VTIs) are unlikely to be the best provider of a skills package that is relevant to the world of work.

In addition to possessing the skills necessary to produce in the informal sector, Grierson (1989 and 1993) points out that the prospective self-employed artisans also need tools which will allow them to break down the barriers to entry that do exist in the informal sector. Such barriers, Grierson (ibid) argues are both social and economic which can be broken down by the acquisition of social networks by the trainee. Such a process is most likely to occur in the traditional apprenticeship location. The potential self-employed worker can rise without state intervention. Such capital accumulation is likely to take place during a period of wage employment [Grierson (1993)]. This employment may be in the formal sector or could be as a journeyman in an informal sector workshop. After a period of five or so years the individual will have accumulated sufficient capital, contacts and experience to enter into self-employment. This view is reflected in evidence [Mead and Kunjeku (1993)] that the most successful self-employed artisans are typically those with significant wage employment experience.

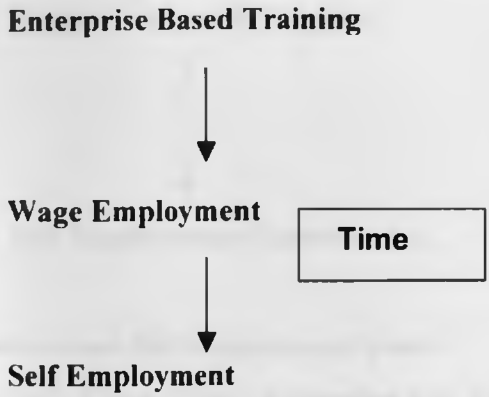


Figure 2:Grierson model

Source: Mc Grath S.et al (1994),**Education and Training for the Informal Sector-Education Research Paper No. 11,** p.142

2.6.3 Subsistence Self-Employment Model

This model points to the stark reality of most people inhabiting the informal sector worldwide. For this population, a complete basic education for all remains rhetoric rather than reality, since they frequently have to leave school before the end of the full cycle as Figure 3 shows. Equally, they lack access to post school training. Traditionally there has been a great shortage of training, which focuses on the skills needs of the subsistence self-employment sub-sector. This is true even within the informal sector itself. In West Africa, for example such activities do not form part of the principal focus of the traditional apprenticeship [World Bank(1991)].

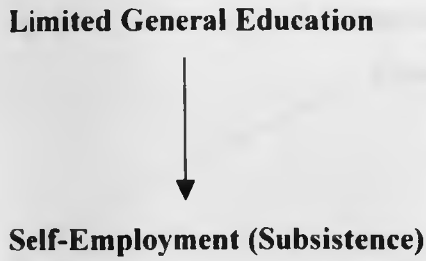


Figure 3: Subsistence Self-Employment model

Source: Mc Grath S.et al (1994), **Education and Training for the Informal Sector-Education Research Paper No. 11,** p.144

2.6.4 Enterprise Self-Employment model

Figure 4 illustrates three possible branches on the pathway to enterprise self-employment. It should be viewed more as a description of what experience the entrepreneurial self-employed are likely to have had rather than a prescription of probable career paths from school to self-employment. It assumes that a good basic education is the foundation of most individuals' success in achieving access to enterprise self-employment, although it does not make assumptions about the form and content of the basic cycle. Increasingly, even in the first branch (e.g. traditional apprenticeship), the average education level of entrants appears to be rising [Boeh-Ocansey (1993), Fluitman (1994)]. Thus the general basic education is needed for the training to be effective in preparation for wage employment.

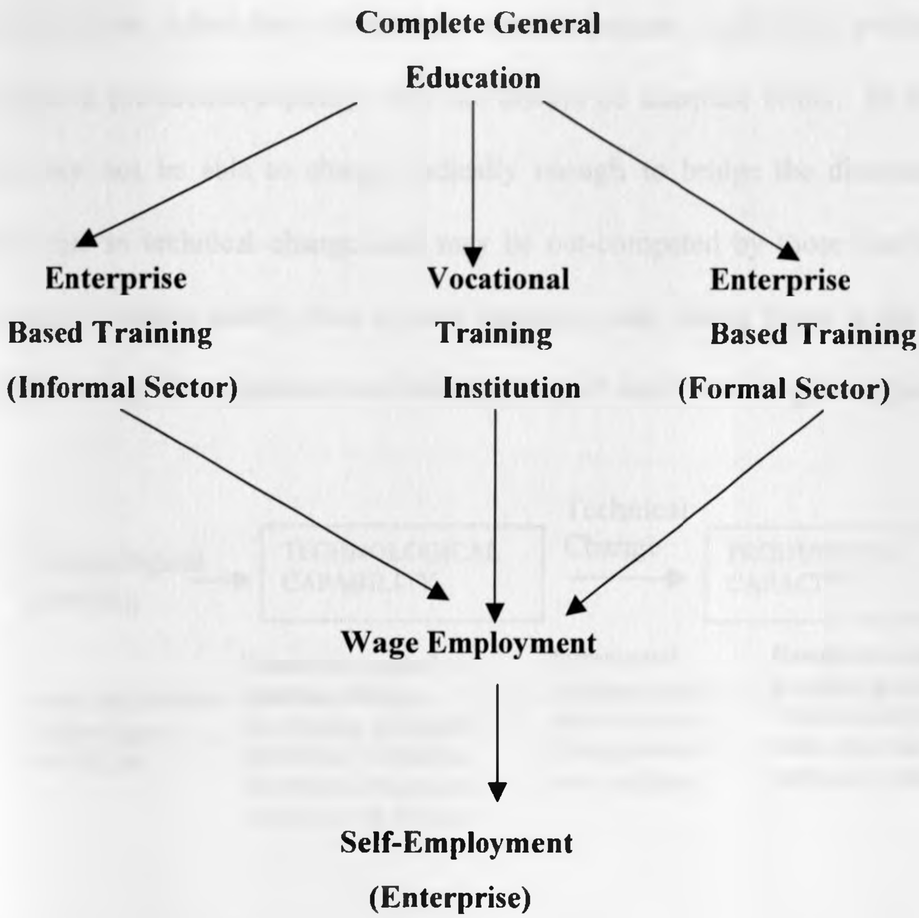


Figure 4: Enterprise Self-Employment model

Source: Mc Grath S.et al (1994), **Education and Training for the Informal Sector- Education Research Paper No.11,** p.145

2.6.5 Bell and Pavitt Conceptual Model

Using Bell and Pavitt's (1993) conceptual model as shown in Figure 5, it is easy to see how a firm with a fixed set of technological capabilities might generate a stream of improvements in production capacity over time. Such improvements may be important in enabling the firm to modify or scale-up production. A firm with no technological capabilities at all, would be rigidly unable to adapt to any changes in its environment, and would not survive long.

However, the fact that a firm has a limited set of technological capabilities, and uses these to gradually improve production capacity, may not always be adequate either. In the long run, such a firm may not be able to change radically enough to bridge the discontinuities that occasionally arise in technical change, and may be out-competed by those that can. If this conceptual model reflects reality, then a most important task facing firms in the long run is technological learning: the acquisition and strengthening of their technological capabilities.

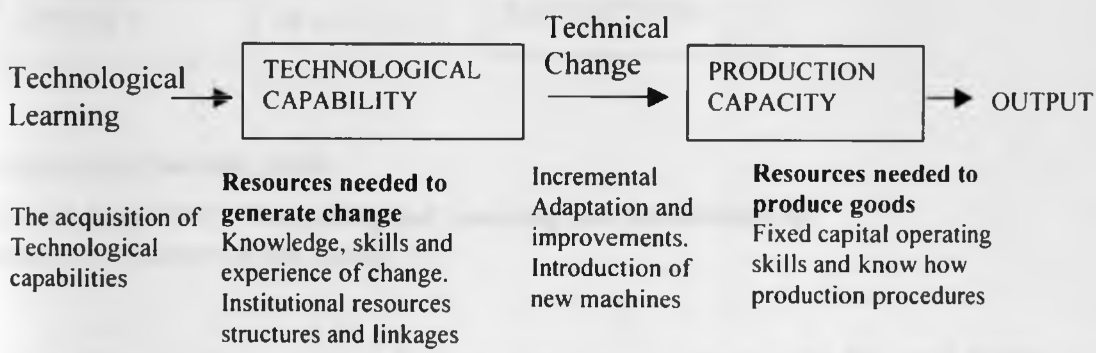


Figure 5: Bell and Pavitt Conceptual model

Source: Albu Michael (1997), **Technological Learning and Innovation in Industrial Clusters in the South,** p.9

2.6.6 Learning cycles

Jamberkar and Pelc (1996) describe and compare three examples of learning cycles as illustrated in Figures 6 to 8.These have been devised by Dewey, Deming, Kolb and Kofman. All these models share the idea that learning involves a moving back and forth between doing (action) and thinking (theory). By analogy, this cyclical process can be applied to learning in organisations and firms. Organisations which monitor their own performance, analyse their strengths and weaknesses, plan strategically etc. Are more likely to learn and improve than ones, which are constantly in fire-fighting mode.

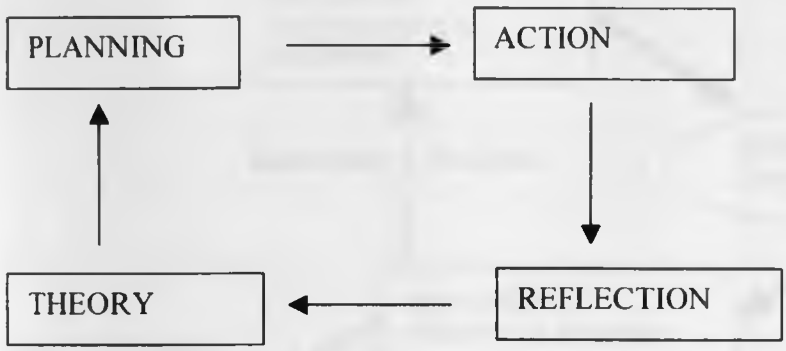


Figure 6: Archetypal learning cycle

Source: Albu Michael (1997), **Technological Learning and Innovation in Industrial Clusters in the South,** p.9

In Figure 7, the lower cycle represents the technical change process. At the very bottom, production capacity is used to convert material inputs into goods. A certain amount of production experience (knowledge feedback) may be derived from the production process. This production information is used to augment a process of technical change whose outcomes are improvements in productive capacity. One particularly important technological capability in this context is the ability to systematically gather information from one's own production experience (monitoring regimes) and use it to generate knowledge about underlying technological processes. The upper cycle represents the true technological learning process. Technological capabilities are used to generate and manage a process of technical change whose product is production capacity. A certain amount of change experience (knowledge feedback) may be delivered from the process of technical change as shown in Figure 7. This knowledge can be used to augment the process of technological learning whose outcomes are improvements in technological capabilities [Nadvi and Schmitz(1994)].

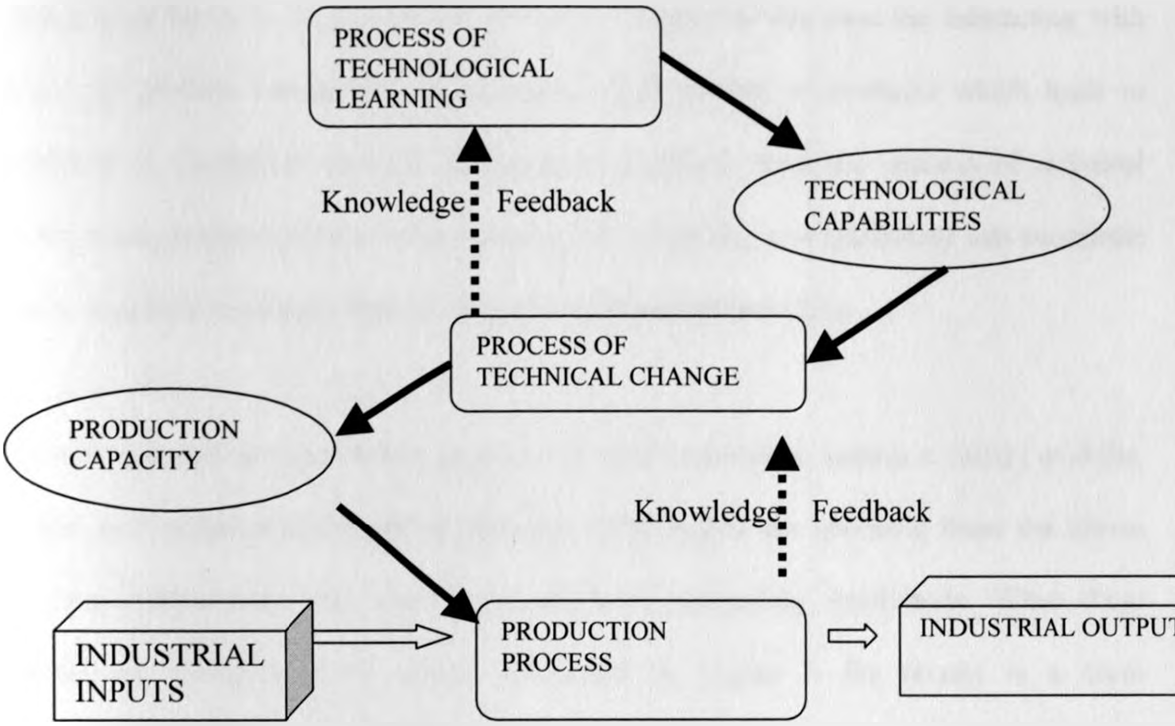


Figure 7: Technological Learning Cycles
Source: Albu Michael (1997), **Technological Learning and Innovation in Industrial Clusters in the South**, p.10

There are a number of separate tasks involved in investigating the acquisition of technological capabilities according to Romijin(1996:122). In principal, in any situation of technological learning, one would wish to know: Firstly, what stimulates or drives the learning process. Secondly, what internal knowledge feedback supports the learning process. Thirdly what external resources or inputs support the learning process. The stimuli or causes of technological learning are those external and internal pressures or ambitions that motivate a firm to increase its capabilities. The possibility of internal knowledge feedback has already been described in the learning cycle. Systematic feedback from the process of engaging in production and distribution contributes to the process of technical change. In this case the interaction with customers can provide information about desired modifications to products which leads to improvements in production capacity. Furthermore feedback from the process of technical change for example the experience of purchasing and installing new machinery can contribute to a firm's capability to manage future investments [(Romijin(ibid:122)].

The external resources or inputs which firms use to build capabilities include a variety of skills, knowledge, and technical and financial services. These inputs are available from the labour market, from interactions with other firms and from supporting institutions. When these components are included in the model developed in Figure 7, the results is a more comprehensive analytical model of what can be called the knowledge acquisition system of a firm, illustrated Figure 8. Illustrative example of the stimuli, inputs and feedback relevant to each level of learning are shown in the accompanying Table 1 [Romijin (ibid: 123)].

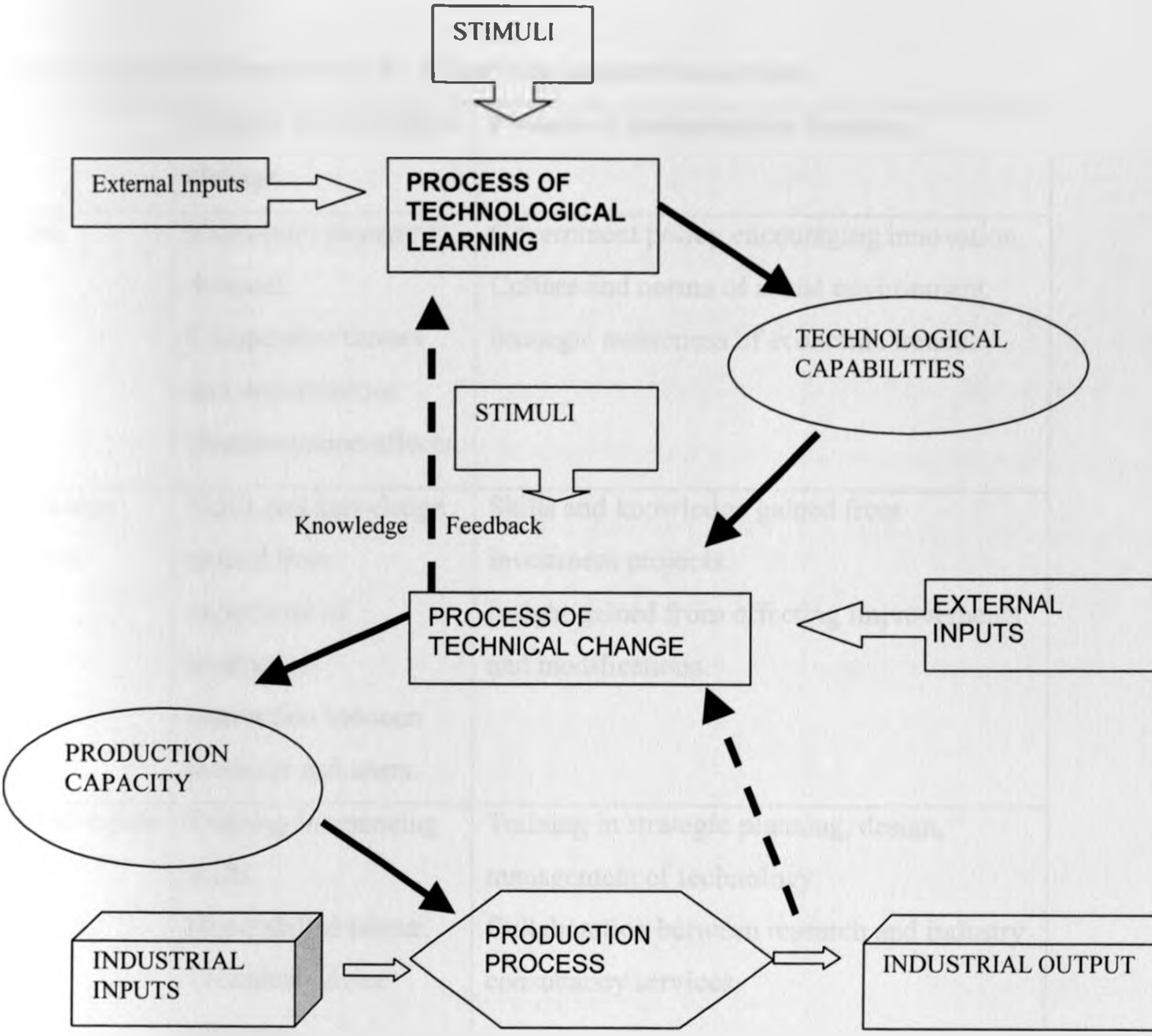


Figure 8: Firm level knowledge acquisition system

Source: Albu Michael (1997), **Technological Learning and Innovation in Industrial Clusters in the South**, p.12

Table 1: Illustrative framework for knowledge acquisition system

	Process of technical change	**Process of technological learning**
Stimuli	Short-term changes in demand. Competitive threats and opportunities. Demonstration effects.	Government policy encouraging innovation. Culture and norms of social environment. Strategic awareness of economic trends.
Knowledge feedback	Skills and knowledge gained from experience of production. Interaction between producer and users.	Skills and knowledge gained from investment projects. Insight gained from effecting improvements and modifications.
External inputs	Training in operating skills. Hired skilled labour. Technical advice services.	Training in strategic planning, design, management of technology. Collaboration between research and industry consultancy services.

Source: Albu Michael (1997), **Technological Learning and Innovation in Industrial Clusters in the South,** p.13

Note: the stimuli to technical change may also act as stimuli to the process of technological learning [Romijn(1996)].

2.6.7 The Model of Technology Transfer through FDI

Smali (1985) presents a basic model for examining technology transfer through FDI. In his model as shown in Figure 9, sender, receiver, technology aftermath and assessment are key components. This model shows its value in analysing technology transfer. However, it is incomplete. It does not recognise the channels used in technology transfer, which has been regarded as one of the most important factors affecting the degree of effective transfer by many studies [Oman (1989), Young (1988),UNCTC (1987)]. It does not include government in the participants of technology transfer either. In fact, as many scholars [Dunning (1994), OECD (1993), United Nations Conference on Trade and Development (1993), Shibusawa et al (1992), Kraemer et al (1992), and Gomulka (1990)] argue, governments, especially host governments, play an important role in the process.

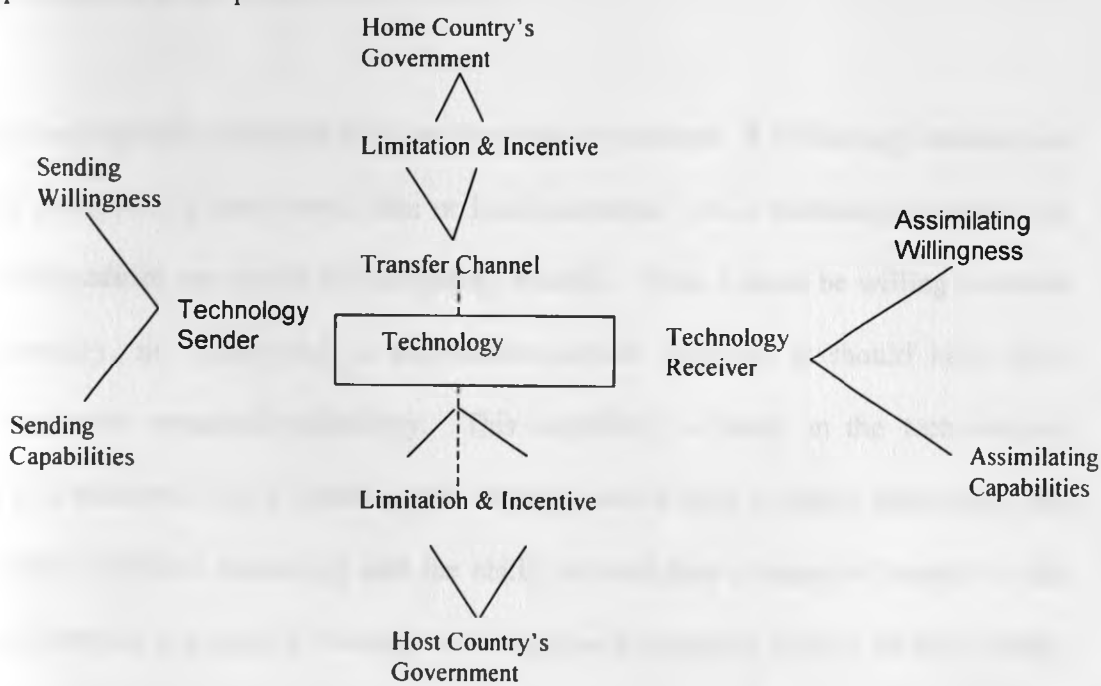


Figure 9: Technology Transfer through Foreign Direct Investment

Source: Lan Ping (1996), **Technology Transfer to China through Foreign Direct Investment,** p.57

Combining these discussions, a general model of technology transfer is formulated as shown above. There are six key components in this model; technology sender, technology receiver, government, technology itself, transfer barrier and transfer channel. Technology sender usually means a technology holder [Dunning (1989)], but in some cases, it may be a middleman of technology, as Lall (1989) reported in the "Outward Investment from the Third World". In the process of transfer through FDI, it refers to foreign investor. The behaviour of technology sender is regarded as more important than a technology receiver, since technology demand is assumed to have no constraints (Stewart, 1987). The sending willingness and sending capability are two basic features of a technology sender. When the sender's technology capability is higher than the technology receiver's, and its needs totally or partially coincides with receiver's technology transfer will take place [Goulet (1989)].

Technology receiver is the other end of technology transfer process. A technology receiver can be a private enterprise, a state owned firm or local personnel. As a technology receiver the following two qualities are crucial for technology transfer. First, it must be willing to obtain inward technology, no matter what is the motive behind. Second, it should have some capability to absorb contacted technology. This capability is based on the technological foundation of a receiver. This is shown as the ability to select from available technology, the ability to master imported technology and the ability to introduce a degree of novelty in the production of product or process [Training and Enterprise Programme (1991), Yankey (1988), OECD (1988)].

Technology transfer does not only involve the technology sender and receiver; government is also an important participant in this process. Compared with the host country's government, the impact of the home country's government is weak, because most countries do not impose limitation on outward investment except in certain high technology sector such as military strategic industries. Their concerns are mainly concentrated on job losses, tax evasion or avoidance, stagnant industrial productivity and inflation in the domestic economy. The role of host country's government is obvious and influencing. In most developing countries, especially Pacific Asian countries, the host country's government not only serves as an intervene by employing macro-economy policy, but also as a participant of technology transfer [TEP (1991), Yankey (1987), OECD (1988)]. Other studies such as OECD (1981), Dunning (1986), Young (1988), UNCTAD (1990) have suggested that the size of the technology package is proportional to the technological gap between the technology sender and the receiver. Therefore, technology is in itself a subject of technology transfer.

Although highly desirable, particularly for host countries, technology flow between a sender and a receiver is not easy process, and much knowledge cannot be transferred along with inward investment [Lall (1989) and Dunning (1988)]. The difficulties resulting from various aspects constitute transfer barriers. The barriers vary in the regions, sectors, participants, and adopted channels, but two types of conflicts usually cause them. First is the economic-price conflict. Foreign investors usually view technology as an expensive commodity with a very short commercial life. Therefore, it should be sold at a high price, while technology receivers treat it like a second hand goods, and often want to put as low a ceiling as possible on the transfer process [Goulet (1989)]. Secondly, the conflict over the control of technology.

Technology senders usually want to limit the scope of technology transfer by various measures, whereas the host country usually hopes to enlarge the results of every transaction or co-operation [Brown(1990)].

2.6.8 Possible results of Technology Transfer through FDI

The impact of FDI on the host country's technology development has drawn the attention of many writers, such as Smali (1985), Roman (1986) and Blomstrom (1990). From the long list of benefits, which host countries receive from FDI, we can divide them into the following three categories. First, stimulating role of FDI means that FDI forces indigenous existing firms to adopt more efficient methods. Second, to increase their R & D.Third, to adopt some specific technology more quickly, either because previously the firm were not aware of the existence of the technology or because it would not have been considered profitable for it to be acquired [Blomstrom (1990)]. The mechanism of stimulation can be observed by stimulating domestic entrepreneurship through purchasing, subcontracting, or operational demonstration. Furthermore, there is also initiating competition by brining competitive pressures to a local monopolist.

Short cut effect refers to the low cost of obtaining certain technology. Some researchers such as Young (1988) state that subsidiaries may draw on the research efforts of the parent organization, at low or zero explicit cost. Therefore, new products are made available at lower cost and are promoted more effectively. Based on this, local firms can get more opportunity to acquire new technology. One path is through the linkages of subsidiaries with their parent into R & D and technology resources. The other is through the research and development activity undertaken by many subsidiaries themselves. Generally speaking. FDI is more concentrated on new technology or on technology intensive sectors.

Spillover phenomenon is used to describe the externality brought about by FDI. In Smali's (1985) analysis, techniques are diffused mainly through mobility of personnel, contracts with suppliers and imitation through proximity. Some other studies such as UNCTC (1985, 1987) and Young (1988) also confirm that there are three channels of conducting technology diffusion into the indigenous sector from FDI. Firstly, formation of spin-off enterprises. Secondly, backward linkages through locally-procured inputs leading to the emergence of an indigenous supplier industry. Lastly, forward linkage into product manufacturers relation with the general scientific and business community.

Technology dependence and inappropriate technology are explored by scholars from the following aspects. The first is the repeat construction caused by FDI. Aggarwal (1984) argues that because of the technology transfer through multinationals, certain parallel industry may be developed. The second is the creation of a 'Halo effect". During the process of local industry development, coping with Multinational Corporations [MNCs] easily leads local firms to adopt inappropriate methods. The third is helplessness or destroying the innovation capability in local firms. Dunning (1988), based on this investigation in the United Kingdom points out that Japanese new establishment may fail to undertake research in the host region, or may disband research organizations in cases of take over. This causes the host country to be technologically more dependent on foreign investment. Young (1988) states that many transfers of technology are concentrated on standard technology, assembly operations and mature sectors, which are helpless to promote local technological development.

The restraints of FDI on local firms are shown at two levels. At micro level, Dunning (1988) points out that through take-overs, FDI's acquired property rights in the research achievements of local firms, and so gained the benefits of exploiting certain ideas. Far from encouraging competition, the foreign enterprise may itself become monopolists in the local market. At macro level, Aggarwal (1984) worries that the MNCs drain out the local capital and other scarce resources such as trained manpower and raw material which can be used by local firms, and that may destroy the local 'infant' industry.

2.7 Problems and Limitations of Technology Diffusion

Seaton and Cordey – Hayes (1993: 13(1), 45 – 53) argue that inward technology transfer can be successful. This can only occur if an organization has not only the ability to acquire but also the ability to effectively assimilate and apply ideas, knowledge, devices and artefacts. Research done by Oakley (1988) on the subject of the search for technical knowledge shows that small firms in particular do not recognise the importance of external technical contacts. The problem of management has been identified as a major obstacle to the advancement of SEs. The typical SE owners or managers develop their management through a process of trial and error. A consequence of poor managerial ability is that entrepreneurs are less prepared to respond to changes in the business environment and to plan appropriate changes in technology [Ngahu(1999)].

The entrepreneur's level of education affects their access to technological information and their ability to understand, respond to, use and control technologies [Anderson (1985)]. Ngahu (ibid) has also shown that the process of technology improvement at the enterprise level may also be affected by physical constraints such as lack of suitable premises, power and other infrastructure facilities. Lack of market information is another problem. SEs are unable to estimate market potential for their products and to determine product modifications or improvements sought by customers. Another problem that hinders technological improvements in this sector may be the lack of protection for the innovator. In a sector where imitation is so easy, entrepreneurs may lack the incentive to invest in technological improvement.

Godkin (1988:3(5), 597-603) carried out a comprehensive review of technology transfer literature and suggested that the following factors would foster technology transfer: First, high quality of incoming communication. Second, a readiness to look outside the firm. Third, a willingness to share knowledge. Fourth, a willingness to take on new knowledge as well as the ability to license and to enter joint ventures. Fifth, effective internal communication and co-ordination mechanisms. Sixth, a deliberate survey of potential ideas and an awareness of costs and profits in R & D departments. Seventh, use of management techniques. Eighth, identification of the outcome of investment decisions as well as good quality intermediate managers. Ninth, high status of science and technology on the board of directors. Lastly, high quality chief executives and a high rate of expansion.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter outlines the research design for this study. More specifically it discusses the following methodological issues in detail: research design, population and regions of study, sample size and design, data collection method, data analysis method and lastly some challenges encountered during fieldwork.

3.1 Research Design

The researcher employed cross-sectional survey in this study. Therefore, a visit to the Ministry of Vocational Training Science and Applied Technology whose offices are in Nyayo House 14th floor, was necessary. Thus the researcher was able to get the names and location of informal metalworking sector associations within Nairobi Province. However, the information from the Ministry was not elaborate on which of the registered informal sector associations dealt with metalworking activities. Hence, it was necessary to carry out a pilot survey on most of the associations in the province.

From these cross-sectional surveys, it was possible to identify associations that had metalworking activities such as fabrications, bending, forging and joining processes. After a period of research of about four months, which involved travelling, locating and talking to the artisans belonging to the particular associations, a total of about 1000 members of the metalworking sub-sector were identified.

3.2 Population and Regions of study

During the research the number of qualified and skilled owners of SMEs in the informal metalworking sector from fifteen zones was found to be 1,076. These zones are as follows: Kamkunji, Ziwani, Eastleigh, Kibera, Kenyatta market, Kariobangi North, Kariobangi South, Buruburu, Huruma, Ngara, Ngong Road, Madaraka, Otiende, Dagotetti Corner and Outering Road.

3.3 Sample Size and Design

The researcher used the statistical method of non-probability sampling. In this method a convenient percent of the total population for each zone that is 10% was used which realized a sample size of 112 owners of SMEs. Table 2 shows the zones, population size and sample size of owners of SMEs.

Table 2: Informal metalworking sector zones, population size and sample size of owners of SMEs

Zone	Population size	Sample size (10% of population size)
Kamukunji	720	72
Ziwani	73	7
Eastleigh	130	13
Kibera	30	3
Kenyatta Market	27	3
Karibangi North	23	2
Kariobangi South	4	1
Buruburu	20	2
Huruma	15	2
Ngong Road	15	2
Madaraka	5	1
Ngara (Parkroad)	5	1
Otiene/Langata	5	1
Dagoretti Corner	2	1
Outering Road	2	1
Total	1,076	112

Source: Field Survey

3.4 Data Collection Method

The primary method of data collection for this study was through cross-sectional survey. More specifically a survey was conducted on 15 zones in Nairobi Province which had informal metalworking sector associations registered with the government. Therefore, all the primary data for this research was collected by administering questionnaires to 112 owners of SMEs. A copy of the questionnaire is attached in the appendix.

Before commencing the fieldwork, the research assistant was thoroughly trained especially on the subject matter of the research. He was also briefed on the content of the questionnaire and how to use it. Furthermore, he was a graduate in Mechanical Engineering and also well versed in research methodology. Hence the research assistant guided the artisans on how to fill the questionnaire when the need arose and assisted in the appropriate collection of data.

The actual fieldwork took about six months. It commenced on October 2003 all through to March 2004. As the data collection progressed in the research sites a continuous examination and editing of the completed questionnaires was carried out on daily basis. I held many meetings with the research assistant to discuss issues that emerged from the field and which were considered important to the study. I made myself readily available to the research assistant and stayed close to him to monitor what was actually happening in the field. The survey questionnaire obtained both qualitative and quantitative data.

3.5 Data Analysis Method

Singleton et al (1993:526) defines a unit of analysis as "the entity about which the researcher gathers information". The unit may be individuals, groups, communities, nations, regions and facilities. This study has three units of analysis namely:

(1) Product development process (2) Production skills of the artisans

(3) Limitations to acquisition of production skills by artisans.

Therefore, the following is a brief explanation and definition of the three units of analysis and how they relate to the statement of the research problem. The first unit of analysis is product development process, which simply means the conversion process that an idea (or product in the mind) goes through until it is converted into a product by the producer. This is believed to be the foundation for any effective production work. The quality and the value of a product on the market directly depend on how adequately the product development process is carried out. If it is adequate, the final product will be of the required quality. However, if the process is inadequate the product is bound to be of relatively poor quality. Hence, the effectiveness of the current product development methods used by the informal metalworking sector in Kenya will be assessed in terms of achieving quality products in desired quantities and on schedule.

The second unit of analysis is production skills of the artisans. This is understood as the mental and intellectual capabilities of the artisans. Intellectual capability is a vital tool for effective production work. In this study, the researcher aims to prove that talents and skills for any work are only useful when proper knowledge acquisition in that field is attained. Therefore, a well-trained metalworking artisan is likely to produce quality work or products than an untrained artisan. At this stage of analysis the existing model of technology diffusion for new entrants in the SE informal sector will be determined.

The third unit of analysis is limitations to acquisition of production skills by artisans. This study therefore attempts to highlight all the factors that limit the upgrading of SE sector technologies that are related to production processes, skills and quality of output. From this analysis a model of technology diffusion that is most appropriate for the SE sector, in terms of achieving quality products in desired quantities and on schedule will be proposed.

Data analysis was conducted using Statistical Program for Social Sciences (SPSS for Windows). The data collected required both quantitative and qualitative analysis as well as inferential statistics. In this regard, descriptive statistics such as frequencies and percentages were used to identify the existing technology diffusion model for new entrants in the informal metalworking sector. Therefore, each channel of entry into the sector has been analysed. This is in order to identify the product development methods used and their effectiveness in terms of product quality, quantity and ability to produce products on schedule.

On the overall, aspects of technology diffusion have been investigated for all respondents to determine the type of limitations encountered in the sector. It is therefore in the consideration of the existing limitations that a model of technology diffusion has been proposed. Hence, the proposed model would be most appropriate for the sector in terms of achieving quality products in desired quantities and on schedule.

3.6 Challenges Encountered during Field Work

As with all surveys, during the research process I encountered some challenges and problems which are briefly outlined here: First of all, visits were used to locate and establish the existence of the informal sector associations registered with the government ministry. During the survey, you could reach the site of work but there were no relevant people to inquire from. Mostly, the chairmen and the secretary or treasurer of the associations had the full information concerning the associations. But hardly could I find them in their offices or place of work. Furthermore, most of them didn't have an office, so finding them was a problem. In addition, some people formed associations for the sole purpose of sourcing funds, plots and donations from the government and thereafter disbanded them and vanished. Moreover, it wasn't just a matter of getting a registered informal sector association. It had to be in particular, one having members dealing with metalworking. In this respect you could locate the association only to realize that it doesn't have metalworking members.

Secondly, demand for money from some respondents before filling the questionnaire was very common. Therefore, I had to sweet talk and promise something for their benefit before they agreed to fill the questionnaire. Further to this majority of the artisans could not answer all the questions on the questionnaire as most of them did not keep records about their production quantities, number of products that get rejected by customers and those that are delivered on schedule or with delays.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSIONS

The following is a presentation and discussion of the findings obtained from fieldwork as well as the analysis of data collected. Therefore, this chapter will deal with the following key areas of study: Firstly, product development methods used in the informal metalworking sector and how these methods relate to the routes of training that artisans in the informal sector undergo before self-employment. Secondly, to establish how the metal working processes used in the sector relate to material selection, choice of equipment and levels of training. Thirdly, the relationship that exists between the routes of training for the artisans in the informal metal working sector and the achievement of quality products in desired quantities and on schedule. Fourthly, to determine the effectiveness of product development methods used by the informal metalworking sector in achieving quality products in desired quantities and on schedule. Fifthly, to demonstrate how technology diffusion takes place in the informal metalworking sector in Kenya and assess its impact on product development in terms of achieving quality products in desired quantities and on schedule. Lastly, to identify the limitations of technology diffusion in the informal metalworking sector. Thereafter, in view of these limitations propose a model of technology diffusion that would be most appropriate for the sector in terms of achieving quality products in desired quantities and on schedule.

4.1 Product Development methods and Routes of training for the owners in the Informal Metalworking sector.

The relationship that exists between product development methods and routes of training of artisans in the informal metalworking sector is shown on Table 3. In this regard, the figures in Table 3 show the percentage of respondents who indicated the routes of training that they have undergone before self–employment and their choice of product development methods. It is evident from the data presented in Table 3 that the product development method C_{Dev} is commonly used by artisans in the informal metalworking sector. In this regard, 100% of respondents who have gone through the following routes of training that is C_{RT}, G_{RT}, H_{RT}, I_{RT} J_{RT}, and L_{RT} reported that they use the product development method C_{Dev} . Furthermore, 70% of artisans with routes of training A_{RT} and D_{RT} confirmed that they utilize C_{Dev} as a product development method. On the other hand, the product development method H_{Dev} that includes making a model of a product is the least used method of product development as evident by the very low percentage of respondents who indicated that they used the method as shown in Table 3. In this respect none of the artisans who have gone through routes of training A_{RT}, C_{RT}, G_{RT}, H_{RT}, and L_{RT}, use the product development method H_{Dev}

It is only a significant portion of 70% of artisans who have undergone the route of training J_{RT} who revealed that they employ H_{Dev} as a product development method. This shows that most owners of firms in the informal metalworking sector who have experienced wage employment after graduating from vocational institutions prefer to make use of product development method H_{Dev}. This choice of product development method H_{Dev} by these calibre of workers can be attributed to their work experience in wage employment that appreciates the benefits of model making before the final product is finalised.

The data in Table 3 shows that 2.7% of respondents who have undertaken the route of training B_{RT} informed the researcher that they utilize H_{Dev} as a product development method in their firms. Moreover, as shown in Table 3 it is evident that the following percentage of respondents which is 10%, 33.33%, 14.29% and 8.33% indicated that they have gone through routes of training D_{RT}, E_{RT}, F_{RT} and K_{RT} respectively and that they also use product development H_{Dev}. These very low percentages of artisans who utilize H_{Dev} as a product development method can be attributed to the lack of knowledge of conventional processes of product development by the artisans in the sector. However, in the course of this study it was observed that the stages of idea screening and concept testing are not included in the product development methods currently used in the informal sector by any of the artisans interviewed. Idea screening as a crucial stage in the conventional process of product development requires one to have prior knowledge on whether the perceived product will satisfy customers' needs and if there are adequate skills and machinery to produce the product. Concept testing on its part should be done by producing a prototype or model of the product and thereafter testing it against the required design specifications and quality levels of the target consumers.

There is the omission of idea screening and concept testing in the product development methods employed in the informal metalworking sector in Kenya as revealed by the research findings. This constitutes a major deviation of the methods used in the informal sector from the conventional product development process. The Chi-square analysis of the data in Table 3 was conducted at 95% confidence level and a significance or p-value of 0.123 obtained. This analysis therefore reveals that the differences in the choice of product development method among the different routes of training are not statistically significant since p-value of 0.123 is greater than the set significance level of 0.05. This finding therefore suggests that the use of a product development method is not influenced by the route of training before self-employment. Thus confirming the general observation that the most common product development methods in the informal sector are C_{Dev} and J_{Dev}. This shows that a product is made directly from customer's descriptions of the product or directly from the creativity of the artisan without idea screening, design drawings and prototype or model testing.

Table 3: Product Development Methods and Routes of Training Before Self – Employment

Product Dev. Methods	Route of Training before Self-Employment: Percent of respondents											
	A_{RT}	B_{RT}	C_{RT}	D_{RT}	E_{RT}	F_{RT}	G_{RT}	H_{RT}	I_{RT}	J_{RT}	K_{RT}	L_{RT}
A_{Dev}	9.09	27.03	0.00	0.00	33.33	14.29	100.00	33.33	0.00	10.00	25.00	75.00
B_{Dev}	54.55	45.95	0.00	40.00	0.00	28.57	100.00	33.33	0.00	60.00	54.17	50.00
C_{Dev}	70.00	86.49	100.00	70.00	66.67	85.71	100.00	100.00	100.00	100.00	87.50	100.00
D_{Dev}	22.22	16.22	0.00	0.00	33.33	14.29	100.00	33.33	0.00	10.00	25.00	25.00
E_{Dev}	72.73	81.08	100.00	70.00	66.67	100.00	100.00	100.00	0.00	10.00	70.83	75.00
F_{Dev}	18.18	29.73	0.00	20.00	0.00	14.29	100.00	0.00	0.00	100.00	20.83	50.00
G_{Dev}	45.45	72.97	100.00	70.00	66.67	85.71	100.00	100.00	100.00	20.00	75.00	100.00
H_{Dev}	0.00	2.70	0.00	10.00	33.33	14.29	0.00	0.00	0.00	70.00	8.33	0.00
I_{Dev}	36.36	5.41	0.00	20.00	33.33	14.29	0.00	33.33	100.00	0.00	12.50	25.00
J_{Dev}	36.36	13.51	100.00	40.00	0.00	14.29	0.00	33.33	100.00	10.00	25.00	25.00
K_{Dev}	72.73	10.81	100.00	50.00	66.67	42.86	0.00	66.67	100.00	20.00	29.17	25.00

Source: Field Data

Chi-square = 22.24 Degrees of freedom = 23 Significance = 0.123

Key for product development methods in the table :

A_{Dev} = Customer describes product → Drawing of product → Model of product → Final product.

B_{Dev} = Customer describes product → Model of product → Final product.

C_{Dev} = Customer describes product → Final product.

D_{Dev} = Customer presents a sample product → Drawings → Model product → Final product.

E_{Dev} = Customer provides drawings ——▶ Model of product ——▶ Final product.

F_{Dev} = Customer provides drawings ——▶ Final product.

G_{Dev} = Customer presents sample product ——▶ Final product.

H_{Dev} = Self creativity ——▶ Drawings ——▶ Model of product ——▶ Final product.

I_{Dev} = Self creativity ——▶ model of product ——▶ Final product.

J_{Dev} = Self creativity ——▶ Final product.

K_{Dev} = Self creativity ——▶ Comparison with other similar products ——▶ Final product.

Key for route of training in Table 3 :

A_{RT} = Below standard eight ——▶ Self employment.

B_{RT} = Standard eight (complete primary education) ——▶ Self employment.

C_{RT} = Standard eight ——▶ Vocational training ——▶ Self employment.

D_{RT} = Complete general education (secondary level) ——▶ Self employment.

E_{RT} = Complete general education ——▶ Tertiary training ——▶ Self employment.

F_{RT} = Complete general education ——▶ Tertiary training ——▶ Wage employment ——▶ Self employment.

G_{RT} = Complete general education ——▶ Enterprise based training (formal) ——▶ Self-employment.

H_{RT} = Complete general education ——▶ Enterprise based training (formal) ——▶ Wage employment ——▶ Self employment.

I_{RT} = Complete general education ——▶ Vocational training ——▶ Self employment.

J_{RT} = Complete general education ——▶ Vocational training ——▶ Wage employment ——▶ Self employment.

K_{RT} = Complete general education ——▶ Enterprise based training (informal) ——▶ Self employment.

L_{RT} = Complete general education ——▶ Enterprise based training (informal) ——▶ Wage employment ——▶ Self employment.

4.2 Metal working Processes, Material selection, Choice of Equipment and Levels of Training

The informal sector produces a wide range of metal products. However for this study, the steel wheelbarrow, aluminum kettle and steel axe were chosen to establish how metal working processes used in their production relate to material selection, choice of equipment and levels of training in the informal sector. The listed products were preferred to reveal the equipment used to carry out manufacturing processes that can be achieved through pressing, forging and bending operations.

4.2.1 Steel Wheelbarrow

The manufacturing process for a steel wheelbarrow was observed to be similar in all the 5 enterprises that were found to be engaged in its production. The research findings reveal that the sheet materials used in the production of the wheelbarrow tray is obtained from used steel drums and motor vehicle parts. Moreover, the production material is also sourced from new sheets purchased from local hardware shops. The artisans also informed the researcher that the choice of material used is determined by its availability and the cost the customer is willing to incur. The study shows that the manufacture of a wheelbarrow involves the following steps. The artisan first uses a chisel and a mallet to cut out the blank as illustrated in Figure 10, which is the surface development of a tray.

Figure 10: Blank for Production of wheel barrow Tray
Source: Field Data

The four edges of the blank are then folded upwards by hitting on an anvil using a mallet to form the tray as shown on Figure 11. Thereafter, the four corners of the tray are then joined using welding.

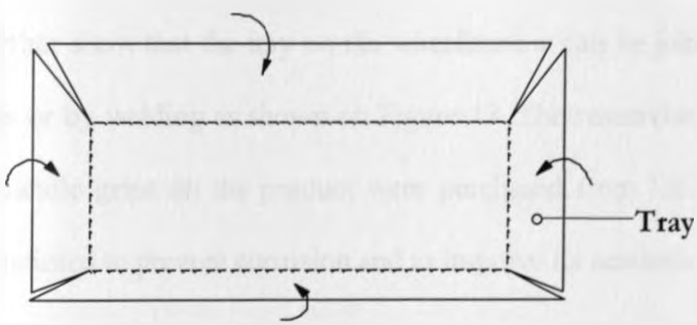


Figure 11: Production of wheel barrow Tray
Source: Field Data

The legs for the wheelbarrow are made using tubes from various sources. These are scrap material from construction sites or new material from local hardware shops. The artisan then bends the tubes into legs using a pipe-bending machine as illustrated in Figure 12.

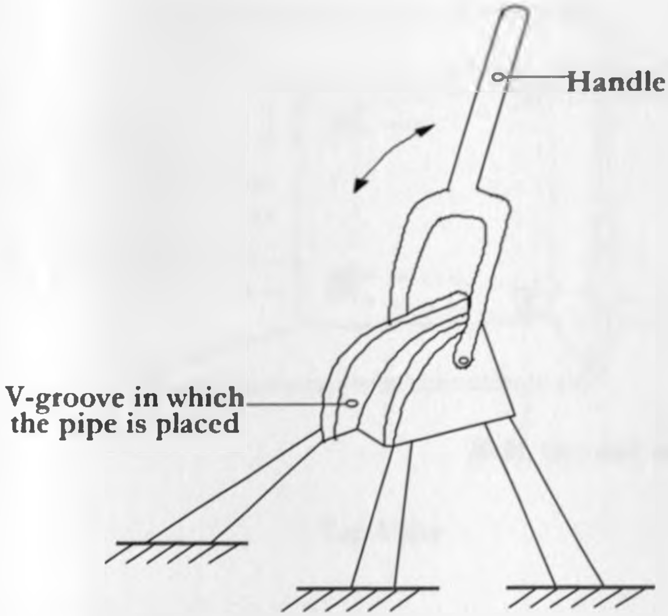


Figure 12: Pipe bending machine
Source: Field Data

The findings further show that the tray on the wheelbarrow can be joined to the chassis by use of bolts and nuts or by welding as shown on Figure 13. The researcher was also informed that the wheel and handle grips on the product were purchased from local hardware shops. The wheelbarrow is painted to prevent corrosion and to improve its aesthetic value.

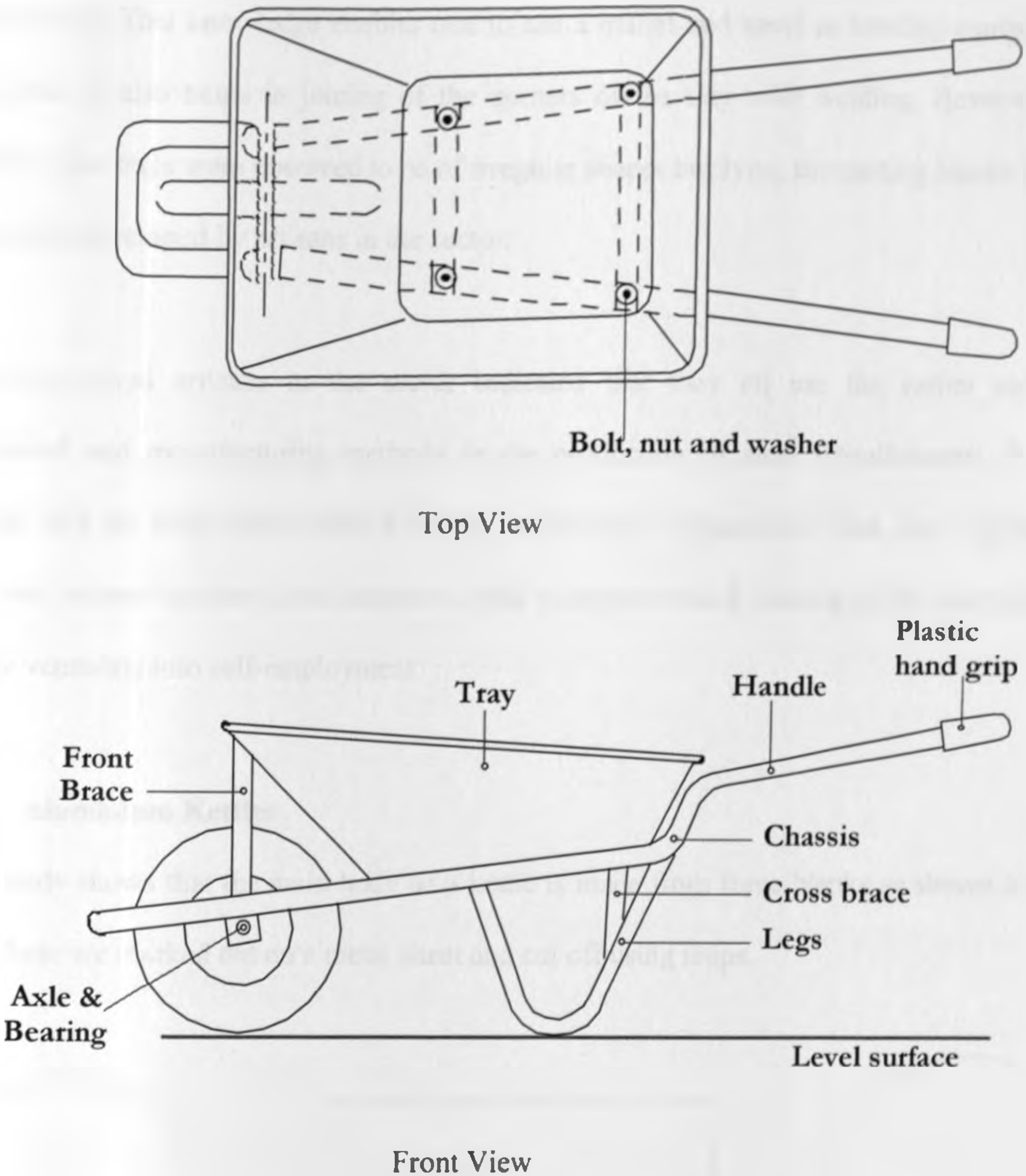


Figure 13: An assembled steel wheel barrow
Source: Field Data

The study reveals that a wheelbarrow is produced from the chosen materials without any testing to determine their mechanical properties and chemical composition. Therefore, the load carrying capacity of the final product is not determined and assured in advance. Furthermore, the knowledge of surface development is also needed to cut out the blank sheet for tray manufacture. This knowledge enables one to use a mallet and anvil as bending equipment for the blank. It also helps in joining of the corners of the tray with welding. However, some wheelbarrow trays were observed to be of irregular shapes implying the starting blanks were not accurately developed by artisans in the sector.

The interviewed artisans in the sector indicated that they all use the earlier mentioned equipment and manufacturing methods in the production of steel wheelbarrows. It is also evident that the respondents have the same educational background. Thus, they reported that they had attained primary level education with enterprise-based training in the informal sector before venturing into self-employment.

4.2.2 Aluminium Kettles

This study shows that the main body of a kettle is made from three blanks as shown in Figure 14. These are marked out on a metal sheet and cut off using snips.

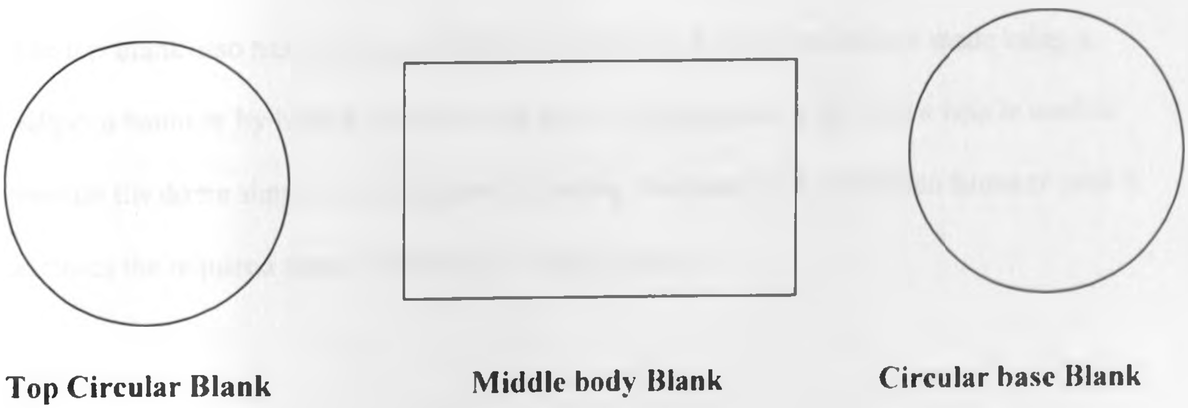


Figure 14: Blanks for manufacture of kettle
Source: Field Data

The middle blank has its ends folded as illustrated in Figure 15 to accommodate a seam. The seam is made using a ball peen hammer on an anvil. Moreover, the cylindrical part is ensured that it is a true round by working it with a mallet on a railroad track as shown in Figure 15.

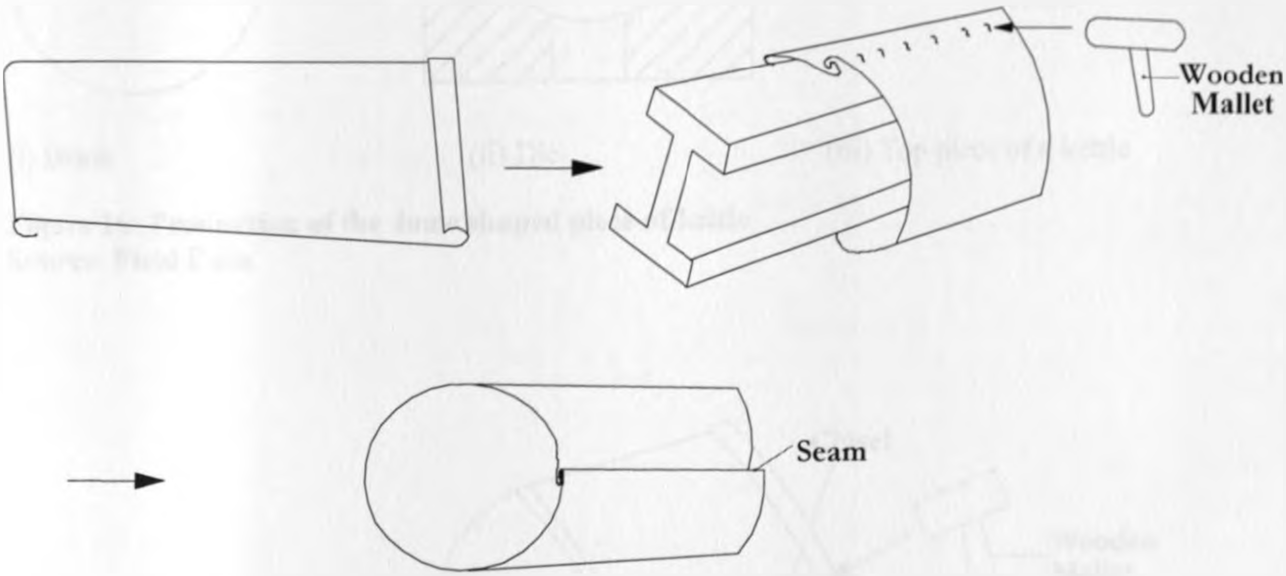
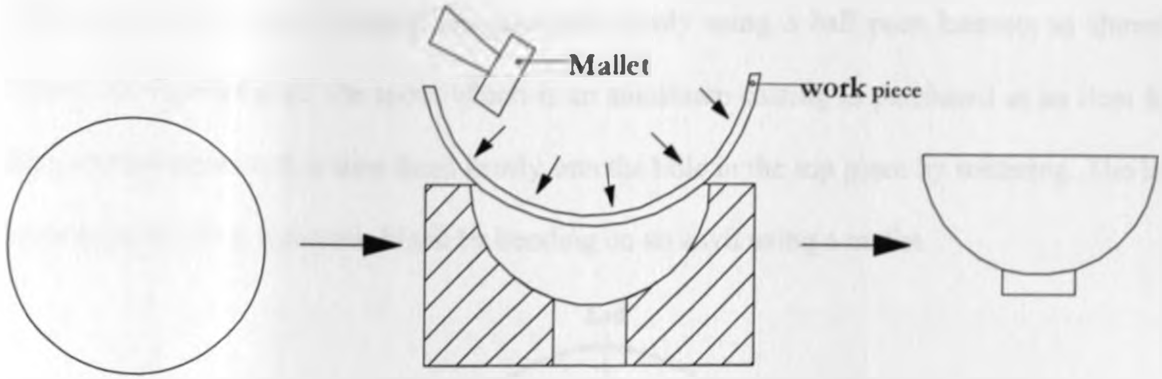


Figure 15: Seam making on a kettle
Source: Field Data

The top blank also has its edges folded to accommodate seams, which are made using a ballpeen hammer by hitting on a rail track beam. Furthermore, a die with a hole is used to provide the dome shape for the top part by hitting the blank with a ballpeen hammer until it assumes the required shape as shown in Figure 16 (iii).



(i) Blank (ii) Die (iii) Top piece of a kettle

Figure 16: Production of the dome shaped piece of kettle
Source: Field Data

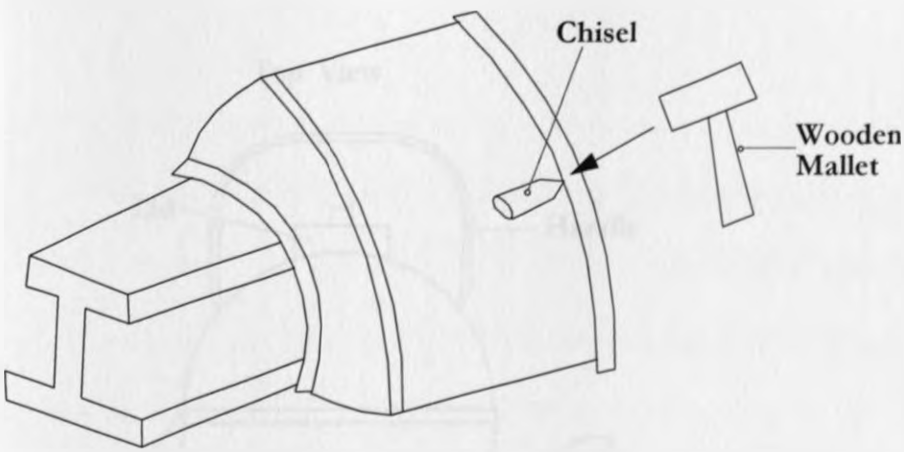
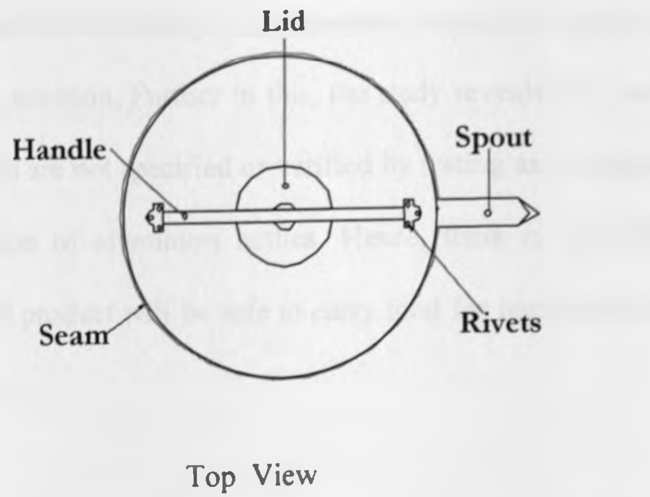


Figure 17: Assembling of a kettle using seams
Source: Field Data

The study shows that the top part and the middle cylindrical part of the kettle are joined by using a seam which is made by hammering on the anvil as shown in Figure 17. The base is similarly attached to the cylindrical part using a seam and the folding is aided using a chisel and by hammering with a mallet as illustrated in Figure 17. Thereafter, the holes for the spout and handle are made using dot punches and ball peen hammer. The handle is attached to the body using rivets which are flattened and anchored firmly using a ball peen hammer as shown in Figure 18. Furthermore, the spout which is an aluminum casting is purchased as an item from local manufacturers. It is then fixed firmly into the hole in the top piece by soldering. The lid is manufactured from a circular blank by bending on an anvil using a mallet.



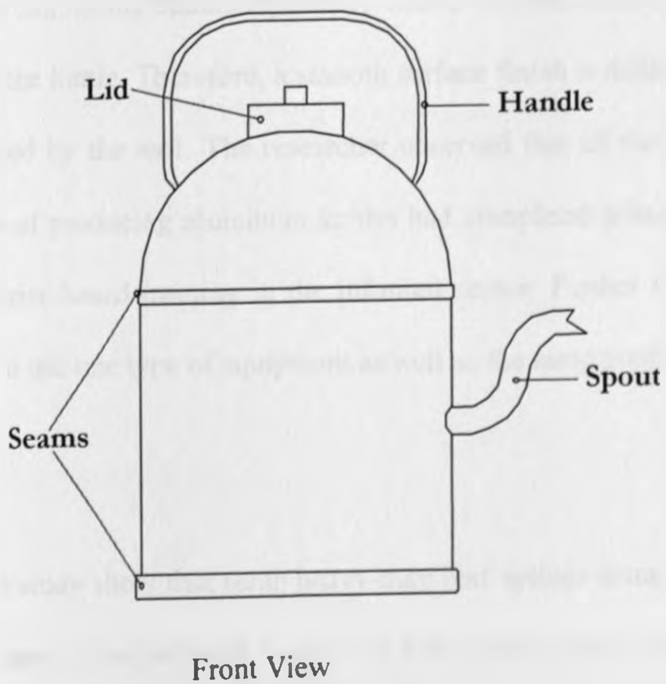


Figure 18: Assembly of an aluminum kettle
Source: Field Data

The artisans revealed that the material for making the main body of the kettle can be bought as new aluminum sheets from local hardware shops. They also get the material from scrap aluminum items such as pans or sheets. Moreover, the findings show that the type of material to be used is determined by customer specifications relating to the desired quality. The respondents also indicated that the ability of the customer to pay for the cost of production was also a factor in material selection. Further to this, the study reveals that mechanical properties and chemical composition are not specified or verified by testing as a requirement for choosing material in the production of aluminum kettles. Hence, there is no quantifiable basis for determining that the final product will be safe to carry food for human consumption as well as being of desired strength.

The findings also show that hitting blanks repeatedly with a wooden mallet is the method used in forming the parts of the kettle. Therefore, a smooth surface finish is difficult to achieve as a result of the dents caused by the tool. The researcher observed that all the artisans who were involved in the process of producing aluminum kettles had completed primary level education and experienced enterprise-based training in the informal sector. Further to this, all the firm owners were observed to use one type of equipment as well as the same production processes.

4.2.3 Steel Axes

The observations of the study show that scrap heavy-duty leaf springs from motor vehicles are used in the making of axes in the informal sector. The leaf spring is first heated to red hotness using a furnace in which charcoal is burnt as Figure 19 shows.

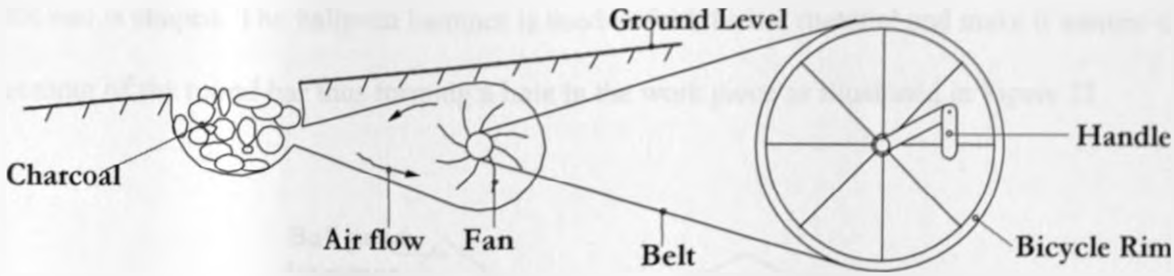


Figure 19: Charcoal blow furnace
Source: Field Data

Thereafter the leaf spring is removed from the furnace using tongs and placed on an anvil as illustrated in Figure 20. It is then cut using a blacksmith chisel and sledge hammer to the required size as also shown in Figure 20.

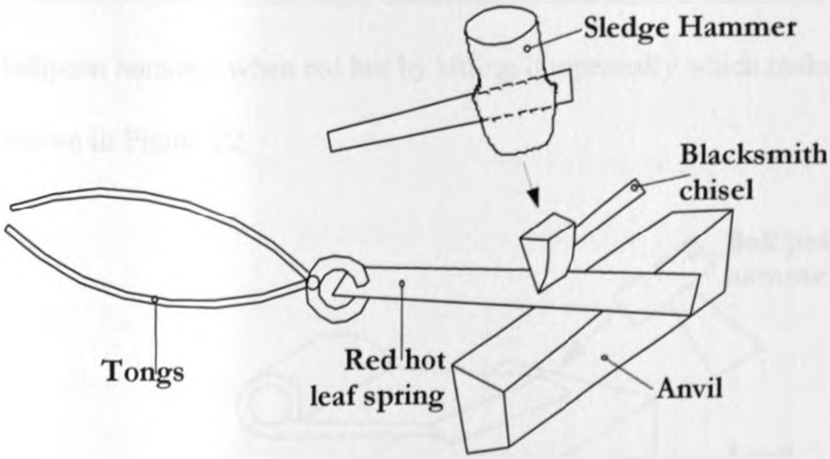


Figure 20: Cutting of red hot materials
Source: Field Data

The cut pieces are then cooled in water. Thereafter, the leaf spring piece is heated to red hotness and placed on the anvil. The artisan then places a round bar on one edge of the leaf spring and the end is shaped. The ballpeen hammer is used to fold the hot material and make it assume the contour of the round bar thus forming a hole in the work piece as illustrated in Figure 21.

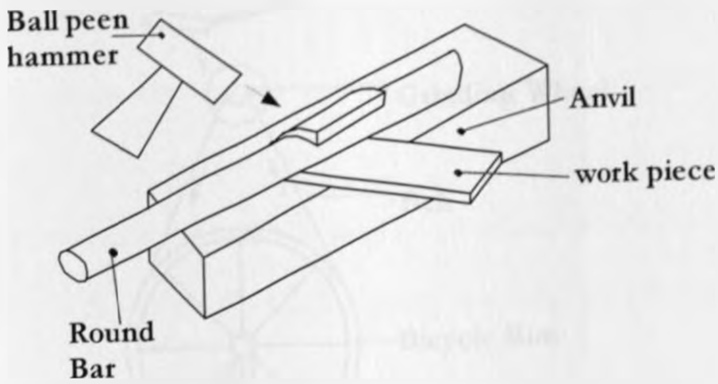


Figure 21: Formation of a hole in a Steel axe
Source: Field Data

The observations of the study further show that the flat section of the material is forged using a ballpeen hammer when red hot by hitting it repeatedly which makes the flat end to spread out as shown in Figure 22.

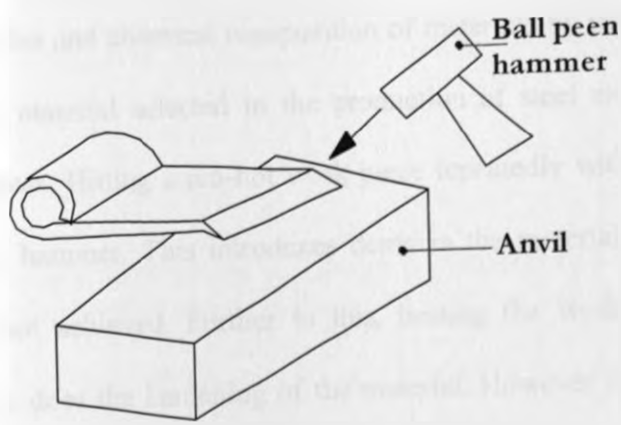


Figure 22: Forging of Steel axe with a hammer
Source: Field Data

The flat end is sharpened using a grinding wheel as shown in Figure 23. Finally, the finished product is painted black to prevent corrosion and to improve its aesthetic value.

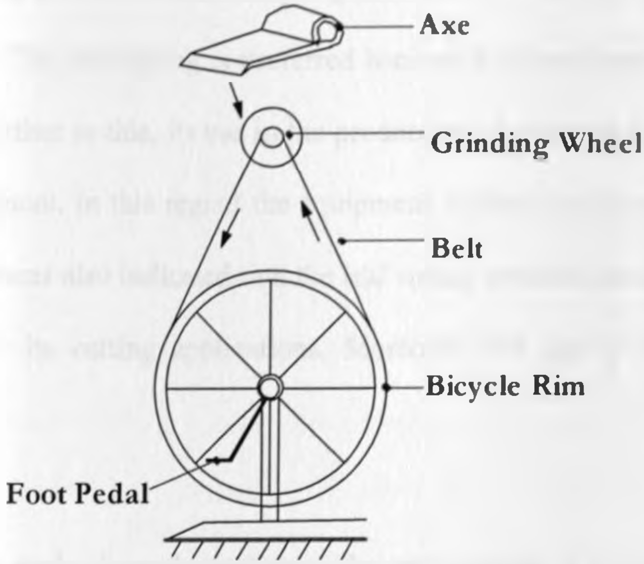


Figure 23: Sharpening of an Axe
Source: Field Data

The observations of the research show that artisans in the sector do not carry out verification of mechanical properties and chemical composition of materials by testing. Therefore, there is no assurance that the material selected in the production of steel axes will be of the required strength and hardness. Hitting a red-hot work piece repeatedly with a ball peen hammer does the forging of the hammer. This introduces dents in the material surface. Hence, a smooth surface finish is not achieved. Further to this, heating the work piece to red hotness and quenching in water does the hardening of the material. However the achieved hardness is not measured to confirm its compliance with the hardness values specified in the Kenyan Standard Specifications for Axes.

The investigated artisans who produce steel axes were observed to use same kind of equipment and had achieved primary level education with enterprise based training in the informal sector. It is also evident that motor vehicle leaf spring made from steel is the material of choice in the production of axes. The leaf spring is preferred because it is purchased as scrap material at an affordable price. Further to this, its use in the production of axes can be adapted quite easily to the available equipment. In this regard the equipment is used for heating, cutting and grinding operations. The artisans also indicated that the leaf spring produces an axe that has the required strength needed for its cutting applications. Moreover, the axe is readily accepted by the customers.

The findings of the study show that artisans who are engaged in the production of steel axes considered certain factors in the selection of equipment. These factors are affordable equipment cost, level of skill needed to operate the equipment and ability of the artisan to adapt the equipment to manufacturing of other products. Therefore, the methods of production in the informal sector are determined by the acquired equipment and type of training received by the operators.

4.3 Relationship between the routes of training for owners of SMEs and the achievement of quality products in desired quantities and on schedule

The following section deals with the relationship that exists between the routes of training for owners of SMEs and the achievement of desired product quantity, quality and on schedule.

4.3.1 Production quantities and route of training before Self-Employment.

The data in Table 4 gives the mean actual production quantity and mean ideal production quantity for all items produced by owners of firms with different routes of training before self-employment. As shown in Table 4 owners of SMEs who have experienced the route of training A_{RT} revealed that they produce a daily mean actual production quantity of 32.6 items as compared to the expected ideal mean production quantity of 44 items per day. Owners with the route of training B_{RT} reported that their firms produce a mean actual production quantity per day of 38.71 items which constitutes nearly a half of the anticipated daily mean ideal production quantity of 64.88. It has also been indicated in Table 4 that artisans who have undergone the route of training C_{RT} produce a mean daily actual production quantity of 160 items as compared to the expected ideal mean production quantity per day of 220.

The analysis of variance (ANOVA) for mean actual daily production quantity has given a p-value of 0.213 at 95% confidence level. Similar analysis for mean ideal daily production quantity has yielded a p-value of 0.126. Therefore, both actual and ideal mean production quantities do not vary significantly across the various routes of training since their p-values are greater than the set significance level of 0.05. Hence, the routes of training do not influence both actual and ideal production quantities. This suggests that quantities produced are mainly determined by other factors other than route of training. These factors include availability of materials to use in production and available number of operators for the amount of work to be done. Moreover, production capacity of the equipment and the existing market demand for the products also affect production quantities in tbe informal sector.

Table 4: Production Quantities and Route of training before self-employment.

Route of training	Actual daily production quantity		Ideal daily production quantity	
	Mean	Standard Deviation	Mean	Standard Deviation
A_{RT}	32.6	61.4	44.0	61.2
B_{RT}	38.7	54.6	64.9	90.3
C_{RT}	105.0	135.8	147.0	173.4
D_{RT}	30.5	6.4	50.0	51.1
E_{RT}	6.3	7.9	25.5	26.1
F_{RT}	20.0	0.0	30.0	0.0
G_{RT}	60.0	86.9	98.0	136.7
H_{RT}	7.0	0.0	8.0	0.0
I_{RT}	11.4	16.7	27.7	56.0
J_{RT}	32.1	66.0	52.5	115.4
K_{RT}	60.0	0.0	49.3	71.7
L_{RT}	160.0	0.0	320.0	0.0
Total	41.3	72.5	63.6	103.5

Source: Field data

Analysis of variance for actual daily production:

Confidence level = 95% F statistic = 1.357 P-value = 0.213

Analysis of variance for Ideal daily production:

Confidence level = 95% F statistic = 1.555 P-value = 0.126

Key for route of training in Table 4

A_{RT} = Below standard eight → Self employment.

B_{RT} = Standard eight (complete primary education) → Self employment.

C_{RT} = Standard eight → Vocational training → Self employment.

D_{RT} = Complete general education (secondary level) → Self employment.

E_{RT} = Complete general education → Tertiary training → Self employment.

F_{RT} = Complete general education → Tertiary training → Wage employment → Self-employment.

G_{RT} = Complete general education → Enterprise based training (formal) → Self employment.

H_{RT} = Complete general education → Enterprise based training (Formal) → Wage employment → Self employment.

I_{RT} = Complete general education → Vocational training → Self employment.

J_{RT} = Complete general education → Vocational training → Wage employment → Self employment.

K_{RT} = Complete general education → Enterprise based training (Informal) → Self employment.

L_{RT} = Complete general education → Enterprise based training (Informal) → Wage employment → Self employment.

Figure 24 shows that ideal mean production quantity per day was observed to be higher than the average daily actual production quantity for all routes of training except for route L_{RT}. Moreover, actual production quantity was expected to be less than ideal production quantity for all routes of training. This is because artisans in the sector use equipment which is mainly operated manually and hence it exerts physical strain leading to exhaustion of workers. Furthermore, sourcing of suitable scrap material is time consuming and thus production will be delayed until materials are obtained. However as already stated in this report, quantities produced are mainly determined by other factors other than route of training such as existing market demand for the products. Therefore, artisans who have gone through L_{RT} as a route of training were working overtime during the period of this study to be able to deliver required product quantities on schedule.

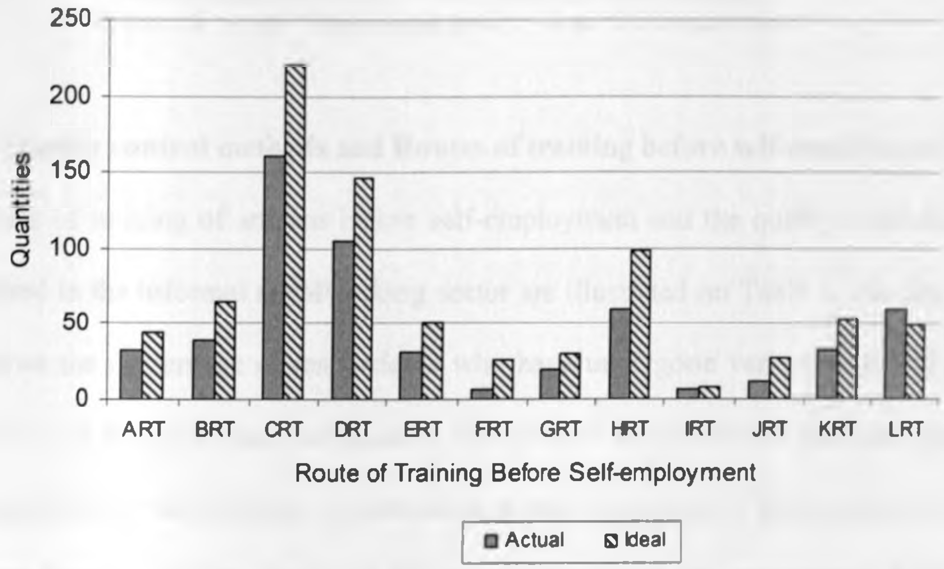


Figure 24: Actual and Ideal production quantities and Route of Training before self-employment.

Source: Field Data

Key for route of training in Figure 24

A_{RT} = Below standard eight → Self employment.

B_{RT} = Standard eight (complete primary education) → Self employment.

C_{RT} = Standard eight → Vocational training → Self employment.

D_{RT} = Complete general education (secondary level) → Self employment.

E_{RT} = Complete general education → Tertiary training → Self employment.

F_{RT} = Complete general education → Tertiary training → Wage employment → Self-employment.

G_{RT} = Complete general education → Enterprise based training (formal) → Self employment.

H_{RT} = Complete general education → Enterprise based training (formal) → Wage employment → Self employment.

I_{RT} = Complete general education → Vocational training → Self employment.

J_{RT} = Complete general education → Vocational training → Wage employment → Self employment.

K_{RT} = Complete general education ⟶ Enterprise based training ⟶ (informal) ⟶ Self employment.

L_{RT} = Complete general education ⟶ Enterprise based training (informal) ⟶ Wage employment ⟶ Self employment.

4.3.2 Quality control methods and Routes of training before self-employment

The routes of training of artisans before self-employment and the quality control methods that are utilized in the informal metalworking sector are illustrated on Table 5. The data in the table also shows the percentage of respondents who have undergone various routes of training and their choice of quality control methods. In this context Table 5 shows that more than 97.3% of the respondents in the informal metalworking sector, regardless of their route of training carry out some form of quality checks on the materials used in the production of their products. Furthermore, the data given shows that above 80% of owners of firms in the sector regardless of their route of training informed the researcher that they employ qualified and skilled staff who help in quality control of the products developed in the sector. However, the quality checks carried out on materials in many cases were limited to visual inspections. The artisans for example used a magnet to confirm stainless steel. Stainless steel gets attracted to a magnet. Therefore, the artisan's knowledge of material that was suitable for a particular product was based on past experiences of its use in product manufacture. It is also observed on Table 5 that over 33% of artisans in the informal sector with various routes of training ensure that all their machines and equipments are in excellent working condition.

Table 5 also reveals that none of the artisans who have gone through the following routes of training A_{RT}, C_{RT}, D_{RT}, E_{RT}, G_{RT}, I_{RT}, J_{RT} and L_{RT} confirmed that they use national or institutional standards in the design of products. It is relatively small percentage of artisans which is 2.7%, 33.3% and 20.83% and who have undergone routes of training B_{RT}, F_{RT}, H_{RT}, and K_{RT} respectively who indicated that they use national or institutional standards in the quality control of products. Supervised measurements of all measurable specifications were done by 100% of interviewed artisans with routes of training C_{RT}, G_{RT}, and I_{RT}. A significant percentage of 66.67% of artisans with routes of training H_{RT} also reported that they carry out supervised measurements. Hence, the tendency to achieve customer specifications through use of supervised measurements and national or institutional standards was observed to increase with the level of education attained at secondary schools, vocational training institutes, tertiary institutions and at other enterprises.

The findings of the research show that measurements of mechanical properties and chemical composition as a requirement for product design is not done in the informal metalworking sector except by some artisans who have undergone training at tertiary institutions. The observations also show that some manual operations in the sector such as bending, forging and chisel cutting are carried out by hammering. Therefore, the desired smooth surface finish and dimensional accuracy may not be achieved as the working load resulting from the use of hammers is not evenly distributed over the work piece leading to variations in surface texture. Further to this, the artisans reported that improper verbal specifications by customers made them to produce products that were eventually rejected by the same buyer.

The analysis of variance of the data in Table 5 has further shown that F statistic = 0.396 and F critical = 1.952. Moreover, F statistic is less than F critical which shows that there are no significant differences in the use of quality control methods across the routes of training. Therefore, as already observed the firms generally use similar quality control methods that depend mainly on visual inspections. This is because the route of training that the artisans in the informal sector go through does not involve education on the use of modern quality control methods. Moreover, national institutions that ensure production of quality products in the country such as Kenya Bureau of Standards do not regulate the sector due to lack of government policy.

Table 5: Quality control methods and Route of Training before Self-Employment.

Quality Control Method	Route of Training before Self-Employment: Percent of Respondents											
	A_{RT}	B_{RT}	C_{RT}	D_{RT}	E_{RT}	F_{RT}	G_{RT}	H_{RT}	I_{RT}	J_{RT}	K_{RT}	L_{RT}
A_{QC}	100	97.3	100	100	100	100	100	100	100	100	88.33	100
B_{QC}	72.73	78.38	100	60.00	33.33	100	100	100	0.00	100	58.33	75
C_{QC}	90.91	94.59	100	80.0	66.67	100	100	100	100	80.00	83.33	100
D_{QC}	0.00	2.70	0.00	0.00	0.00	14.29	0.00	33.33	0.00	0.00	20.83	0.00
E_{QC}	100	97.3	100	100	100	100	100	100	100	100	87.50	100
F_{QC}	27.27	18.92	100	30.00	33.33	42.86	100	66.67	100	20	37.50	25

Source: Field Data

Analysis of Variance:

Confidence level = 95% F statistic = 0.396 P-value = 0.952 F critical =1.952

Key for quality control methods and route of training in Table 5:

A_{QC} = Quality checks of all materials used in production.

B_{QC} = Ensuring all machines and equipment are in excellent working condition.

C_{QC} = Employing qualified and skilled staff.

D_{QC} = Using national or institutional standards in design of products.

E_{QC} = Use of measurements by operators to achieve specifications.

F_{QC} = Supervised measurements of all measurable specifications.

A_{RT} = Below standard eight → Self employment.

B_{RT} = Standard eight (complete primary education) → Self employment.

C_{RT} = Standard eight → Vocational training → Self employment.

D_{RT} = Complete general education (secondary level) → Self employment.

E_{RT} = Complete general education → Tertiary training → Self employment.

F_{RT} = Complete general education → Tertiary training → Wage employment → Self employment.

G_{RT} = Complete general education → Enterprise based training (formal) → Self employment.

H_{RT} = Complete general education → Enterprise based training (formal) → Wage employment → Self employment.

I_{RT} = Complete general education → Vocational training → Self employment.

J_{RT} = Complete general education → Vocational training → Wage employment → Self employment.

K_{RT} = Complete general education → Enterprise based training (informal) → Self employment.

L_{RT} = Complete general education → Enterprise based training (informal) → Wage employment → Self employment.

4.3.3 Number of orders delivered without delays and Route of training before self-employment

Table 6 shows the relationship between the routes of training of owners of SMEs before self employment and the average number of orders delivered without delays for every ten customers served. The data in Table 6 indicates that the average number of orders delivered without delays by artisans who have undergone routes of training A_{RT} and B_{RT} is 7.00 and 7.07 respectively. Further to this, respondents who have experienced routes of training D_{RT}, F_{RT} and J_{RT} revealed that the mean number of orders delivered to their customers on time was 8.00, 8.00 and 8.13 respectively. In the case of artisans who have gone through route of training K_{RT} the researcher was informed that the mean number of orders delivered without delays by their firms was 8.00. However, it is evident from the data in Table 6 that respondents who have experienced vocational or enterprise-based training reported a relatively higher number of orders delivered without any delay.

The observations of the study further show that equipment in the informal sector is mainly operated manually which exerts physical strain on the artisans. Moreover, the manual production steps are also many and take a long time. These factors are usually not taken into consideration when promising date of delivery of products to the customer. It is also evident that sourcing of materials particularly scrap material is time consuming in the sector. Further to this, orders made by customers in the sector are not considered in relation to time taken to acquire materials and to produce the item. Therefore the dates given by artisans for delivery of products are not likely to be accurate. The analysis of variance of the data in Table 6 shows that the F statistic is 1.095 and the P-value is 0.378. Thus the p-value is greater than the set significance level of 0.05. This implies that there are no significant differences in the mean number of orders delivered without delay across the various routes of training. Hence as already noted, the general trend in the informal sector is that factors affecting delivery date are not taken into account. This makes the artisans not to meet delivery deadlines.

Table 6: Number of orders delivered without delays and Routes of training before Self-employment.

Route of training before self-employment	Number of respondents	Mean number of orders delivered without delays	Standard deviation
A_{RT}	8	7.00	1.604
B_{RT}	30	7.07	1.982
C_{RT}	6	8.17	0.408
D_{RT}	2	8.00	0.00
E_{RT}	6	6.33	2.251
F_{RT}	1	8.00	0.00
G_{RT}	1	6.00	0.00
H_{RT}	1	5.00	0.00
I_{RT}	9	7.44	1.590
J_{RT}	16	8.13	1.408
K_{RT}	3	8.00	1.732
L_{RT}	1	9.00	0.00

Source: Field Data

Analysis of Variance:

Confidence level = 95% F statistic = 1.095 P-value = 0.375

Key for route of training in Table 6:

A_{RT} = Below standard eight → Self employment.

B_{RT} = Standard eight (complete primary education) → Self employment.

C_{RT} = Standard eight → Vocational training → Self employment.

D_{RT} = Complete general education (secondary level) → Self employment.

E_{RT} = Complete general education → Tertiary training → Self employment.

F_{RT} = Complete general education → Tertiary training → Wage employment → Self-employment.

G_{RT} = Complete general education → Enterprise based training (formal) → Self employment.

H_{RT} = Complete general education → Enterprise based training (formal) → Wage employment → Self employment.

I_{RT} = Complete general education → Vocational training → Self employment.

J_{RT} = Complete general education → Vocational training → Wage employment → Self employment.

K_{RT} = Complete general education → Enterprise based training (informal) → Self employment.

L_{RT} = Complete general education → Enterprise based training (informal) → Wage employment → Self employment.

4.4 Effect of Product Development methods on Product Quantity, Product rejection and Product delivery deadline

The effects of the various product development methods used in the informal metalworking sector have been measured in this study. This has been done by establishing a relationship between product development methods used and the quantities produced, quality and the ability to deliver to the customer on schedule. The statistical method of analysis of variance has therefore been used to test the existing relationship between product development methods and the quantities of products produced, number of products rejected by the customers and ability to deliver products on schedule.

Although the firms produced varying quantities of different products, the procedure of summing up units of all products was used to determine the total quantity of products produced by a firm with a given product development method. Since this method of determining quantity produced was applied to all product development methods, it was therefore feasible to compare them by the total quantities produced.

4.4.1 Product Development Methods and the Quantities of Products Produced

Table 7 was prepared by computing the means of the total quantities of products produced in one day, one week, one month, six months and one year by the various product development methods. The analysis of variance for the data in Table 7 has shown that the means of actual production quantities are significantly different across the product development methods at a significance level of 0.05. This applies to production quantities produced in one week, six months and one year. Hence, product development methods do influence production quantities. It was also observed that the most common product development methods in the sector are mainly C_{Dev} and J_{Dev} . In these methods the product is made directly from customer's descriptions or directly from creativity of the artisan without idea screening, design drawings and prototype or model testing. Hence apart from the product development methods used, there are other factors that affect production quantities. These factors are availability of materials to use in production, available number of operators, production capacity of the equipment and existing market demand.

Table 7: Product Development Methods and the Quantities of Products Produced

Description	Product development method	Number of respondents	Mean	Standard Deviation	Test for Significance (ANOVA)
Actual Quantity produced in one day	A_{Dev}	8	43.25	68.418	F = 0.679
	B_{Dev}	10	10.50	15.065	DF = 7
	C_{Dev}	52	48.17	114.438	Sig = 0.690
	D_{Dev}	1	3.00	-	Com = NS
	G_{Dev}	1	32.00	-	
	I_{Dev}	3	148.67	239.500	
	J_{Dev}	4	92.25	94.905	
	K_{Dev}	1	17.00	-	
Actual Quantity produced in one week	A_{Dev}	7	142.14	46.067	F = 2.078
	B_{Dev}	13	39.31	91.977	DF = 7
	C_{Dev}	63	85.52	184.203	Sig = 0.054
	D_{Dev}	2	11.50	2.121	Com = *
	G_{Dev}	1	182.00	-	
	I_{Dev}	3	382.67	557.112	
	J_{Dev}	4	339.25	447.805	
	K_{Dev}	1	57.00	-	
Actual Quantity produced in one month	A_{Dev}	7	427.86	922.098	F = 1.727
	B_{Dev}	14	122.50	216.067	DF = 7
	C_{Dev}	59	276.90	553.967	Sig = 0.114
	D_{Dev}	2	37.50	13.435	Com = NS
	G_{Dev}	1	700.00	-	
	I_{Dev}	3	177.00	115.659	
	J_{Dev}	4	1288.50	1809.640	
	K_{Dev}	1	150.00	-	
Actual Quantity produced in six months	A_{Dev}	4	4287.50	7169.023	F = 2.702
	B_{Dev}	11	647.18	1270.761	DF = 7
	C_{Dev}	55	1370.73	2876.948	Sig = 0.015
	D_{Dev}	2	167.50	102.530	Com = **
	G_{Dev}	1	3500.00	-	
	I_{Dev}	2	825.50	147.785	
	J_{Dev}	4	8700.00	10668.958	
	K_{Dev}	1	400.00	-	
Actual Quantity produced in one year	A_{Dev}	4	11350.00	12882.417	F = 3.536
	B_{Dev}	12	1102.25	2115.667	DF = 7
	C_{Dev}	54	1851.96	3623.233	Sig = 0.003
	D_{Dev}	2	340.00	268.701	Com = **
	G_{Dev}	1	6800.00	-	
	I_{Dev}	2	1621.00	253.144	
	J_{Dev}	4	75975.00	141390.060	
	K_{Dev}	1	1000.00	-	

Source : Field Data

Key for significance level and product development methods in Table 7:

1) "* " indicates significant at 0.05.

2) "* * " indicates significant at 0.01.

3) Sig = Significance level.

4) NS = Not significant at least at the 0.05 level.

5) Com = Comment

6) F = F statistic

7) DF = Degrees of freedom

8) A_{Dev} = Customer describes product → Drawing of product → Model of product → Final product.

9) B_{Dev} = Customer describes product → Model of product → Final product.

10) C_{Dev} = Customer describes product → Final product.

11) D_{Dev} = Customer presents a sample product → Drawings → Model product → Final product.

12) E_{Dev} = Customer provides drawings → Model of product → Final product.

13) F_{Dev} = Customer provides drawings → Final product.

14) G_{Dev} = Customer presents sample product → Final product.

15) H_{Dev} = Self creativity → Drawings → Model of product → Final product.

16) I_{Dev} = Self creativity → model of product → Final product.

17) J_{Dev} = Self creativity → Final product.

18) K_{Dev} = Self creativity → Comparison with other similar products → Final product.

4.4.2 Product Development methods and the number of Products rejected.

Table 8 was prepared by determining the means of the numbers of products rejected by customers for each product development method. The analysis of variance of the data obtained has shown that the means of the numbers of products rejected are not significantly different across the product development methods at a significant level of 0.05. Therefore, product rejection is not influenced by product development method. This implies that other factors may be contributing to the rejection of products. These are namely production skills and inadequate quality control methods.

Table 8: Product Development methods and the number of products rejected by the customers

Description	Product development method	Number of Respondents	Mean number rejected	Standard Deviation	Test for Significance (ANOVA)
Number of products rejected in the last one month	A_{Dev}	1	1.00	-	F = 0.09
	B_{Dev}	2	1.00	.000	DF = 4
	C_{Dev}	9	1.11	.333	Sig = 0.894
	D_{Dev}	1	1.00	-	Com = NS
	I_{Dev}	0	.	-	
	J_{Dev}	1	1.00	-	
	K_{Dev}	1	1.00	-	
Number of products rejected in the last six months	A_{Dev}	1	1.00	-	F = 0.268
	B_{Dev}	4	1.75	.957	DF = 4
	C_{Dev}	19	1.84	1.463	Sig = 0.895
	D_{Dev}	0	-	-	Com = NS
	I_{Dev}	0	-	-	
	J_{Dev}	1	3.00	-	
	K_{Dev}	1	2.00	-	
Number of products rejected in the last one year	A_{Dev}	1	1.00	-	F = 0.458
	B_{Dev}	2	3.00	2.828	DF = 4
	C_{Dev}	15	3.87	5.397	Sig = 0.765
	D_{Dev}	0	-	-	Com = NS
	I_{Dev}	0	-	-	
	J_{Dev}	1	10.00	-	
	K_{Dev}	1	2.00	-	

Source: Field Data

Key for significance level and product development methods in the table.

1) Sig = Significance level.

2) NS = Not significant at least at the 0.05 level.

3) Com = Comment

4) F = F statistic

5) DF = Degrees of freedom

6) A_{Dev} = Customer describes product → Drawing of product → Model of product → Final product.

7) B_{Dev} = Customer describes product → Model of product → Final product.

8) C_{Dev} = Customer describes product → Final product.

9) D_{Dev} = Customer presents a sample product → Drawings → Model product → Final product.

10) E_{Dev} = Customer provides drawings → Model of product → Final product.

11) F_{Dev} = Customer provides drawings → Final product.

12) G_{Dev} = Customer presents sample product → Final product.

13) H_{Dev} = Self creativity → Drawings → Model of product → Final product.

14) I_{Dev} = Self creativity → model of product → Final product.

15) J_{Dev} = Self creativity → Final product.

16) K_{Dev} = Self creativity → Comparison with other similar products → Final product.

4.4.3 Product Development methods and Product delivery deadline.

Table 9 was prepared by determining the means of numbers of customers whose deadlines were not met in the last one day, one week, one month, six months and one year. The data obtained for the means of customers whose deadlines are not met in the last one day was inadequate due to poor response mainly as a result of lack of records for delivery deadlines. The adequacy of the data improved for estimates of deadlines not met that were given for one week, one month, six months and one year. The data obtained for number of customers whose deadlines for product delivery were not met in the last one week showed that product delivery methods B_{Dev} and C_{Dev} had means of 10.0 and 11.3 respectively.

The results in Table 9 further reveal that Product development A_{Dev} has the highest mean of 30.0 customers whose deadlines were not met in the last one week. On the other hand, product development methods B_{Dev}, I_{Dev}, J_{Dev}, and K_{Dev} have the least mean of 10.0 customers whose deadlines were not met in the last one week. Product development methods B_{Dev}, I_{Dev} and J_{Dev} have the highest mean of 20.0 customers whose deadlines were not met in the last one month.

However, product development method K_{Dev} has the least mean of 10.0 customers whose products are not delivered on time in the same period.

In the case of customers whose deadlines are not met in the last six months, product development method J_{Dev} has the highest mean of 180.0 customers. In contrast product development method D_{Dev} has the least mean of 10.0 customers in the six month period whose products are delayed beyond the agreed delivery date. The product development method J_{Dev} has the highest mean of 370 customers whose deadlines are not met in the last one year. Product development method B_{Dev} has the least mean of 36.0 customers whose delivery was not done at the right time in the period of one year. On the overall, it is observed that the mean number of customers whose orders are not delivered on time is significantly different across the product development methods. This is at a significance level of 0.05. This applies for the data obtained in the last one week, six months and one year. Hence, delayed orders are influenced by the product development method that is used.

The results of the research have further shown that the equipment in the informal sector is mainly operated manually which exerts physical strain on the artisans. This then leads to exhaustion of the workers. Moreover, the manual production steps are also many and take a long time. Further to this, sourcing of scrap material is time consuming. The findings of the study also reveal that delivery dates are given by artisans without assessing time taken to acquire materials and to produce an item that takes into account operator fatigue.

Table 9: Product Development methods and Product delivery deadline.

Description	Product development methods	Number of Respondents	Mean of delayed orders	Standard. Deviation	Test for Significance (ANOVA)
Number of customers whose deadlines are not met in the last one week	A_{Dev}	1	30.0	-	F = 6.442
	B_{Dev}	2	10.0	.000	DF = 5
	C_{Dev}	16	11.3	.342	Sig = 0.002
	D_{Dev}	0	-	-	Com = **
	I_{Dev}	1	10.0	-	
	J_{Dev}	1	10.0	-	
	K_{Dev}	1	10.0	-	
Number of customers whose deadlines are not met in the last one month	A_{Dev}	2	15.0	.707	F = 0.177
	B_{Dev}	6	20.0	1.265	DF = 5
	C_{Dev}	22	18.6	1.167	Sig = 0.969
	D_{Dev}	0	-	-	Com = NS
	I_{Dev}	2	20.0	.000	
	J_{Dev}	2	20.0	1.414	
	K_{Dev}	1	10.0	-	
Number of customers whose deadlines are not met in the last six months	A_{Dev}	3	36.7	2.309	F = 2.547
	B_{Dev}	8	22.5	2.550	DF = 6
	C_{Dev}	34	30.6	3.275	Sig = 0.033
	D_{Dev}	1	10.0	-	Com. = *
	I_{Dev}	3	36.7	2.309	
	J_{Dev}	3	180.0	27.731	
	K_{Dev}	1	40.0	-	
Number of customers whose deadlines are not met in the last one year	A_{Dev}	3	66.7	5.132	F = 3.111
	B_{Dev}	5	36.0	3.286	DF = 5
	C_{Dev}	28	46.8	5.457	Sig = 0.019
	D_{Dev}	0	-	-	Com = **
	I_{Dev}	3	103.3	7.234	
	J_{Dev}	3	370.0	54.745	
	K_{Dev}	1	100.0	-	

Source : Field Data

Key for significance level and product development methods in the table.

1) " *" indicates significant at 0.05 level.

2) " **" indicates significant at 0.01 level.

3) Sig = Significance level.

4) NS = Not significant at least at the 0.05 level.

5) Com = Comment

6) F = F statistic

7) DF = Degrees of freedom

8) A_{Dev} = Customer describes product → Drawing of product → Model of product → Final product.

9) B_{Dev} = Customer describes product → Model of product → Final product.

10) C_{Dev} = Customer describes product → Final product.

11) D_{Dev} = Customer presents a sample product → Drawings → Model product → Final product.

12) E_{Dev} = Customer provides drawings → Model of product → Final product.

13) F_{Dev} = Customer provides drawings → Final product.

14) G_{Dev} = Customer presents sample product → Final product.

15) H_{Dev} = Self creativity → Drawings → Model of product → Final product.

16) I_{Dev} = Self creativity → model of product → Final product.

17) J_{Dev} = Self creativity → Final product.

18) K_{Dev} = Self creativity → Comparison with other similar products → Final product.

4.5 Technology Diffusion

The literature of this study shows the primary bodies which have been providing support for technology transfer in the informal metalworking sector in Kenya. These are the Ministry of Labour and Human Resource Development, World Bank, Kenya Industrial Research Development Institute (KIRDI), Kenya Industrial Estates, Japan International Co-operation Agency in conjunction with Jomo Kenyatta University of Agriculture and Technology. The support given by these bodies involve promotion of training programmes, research and adoption of technologies suitable to the sector. In this regard, the following is a presentation of data collected in the informal metalworking sector in Kenya concerning technology diffusion in the sector.

4.5.1 Methods of technology diffusion

Table 10 was constructed from the scores ranging from 1 to 5 that rated the effectiveness of the various sources of skills for product development by owners of SMEs. The score of 5 had the greatest extent and the score of 1 the least extent in describing the source as a method of technology diffusion. The mean scores of each method and standard deviations were also determined and included in the tables. It is therefore evident from the analysis given in Table 10 that skills acquisition from friends or colleagues is the most common method of technology transfer in the informal metal working sector as confirmed by its high mean score of 4.35. Non-governmental organizations as a means of technology diffusion are rated with a mean score of 1.17. This shows that NGOs play a minor role in the transfer of technology in the informal metalworking sector.

Government training as a medium of skills acquisition for product development has a mean score of 1.51 which is relatively low when compared with the mean scores of other methods of technology transfer in the informal metal working sector that are shown in Table 10. This shows that the Kenyan government plays a minor role in the process of technology diffusion in the informal metal working sector. Furthermore, research institutions such as Polytechnics and Universities which have a mean score of 1.24 are also not actively involved in the transfer of technology in the informal metalworking sector when compared with other methods of technology diffusion as illustrated on Table 10. Moreover, participation in research by the firms in the informal sector as a medium of technology diffusion has a low mean score of 1.79 which shows that carrying out of research is rarely done in the informal metalworking sector.

It is also evident that other sources of skills for product development which are not listed on Table 10 have a high mean score of 3.79 which shows their popularity among the artisans in the informal sector. These other methods of technology diffusion were reported to include: existence of training programmes for the employees, consultations with experts, co-operation with other firms both in the informal and formal sectors as well as getting ideas from customers.

Table 10: Rating of methods of technology diffusion

Sources of skills for product development	Number of respondents	Mean score	Standard deviation
Research institutions e.g. polytechnics	101	1.24	0.666
Participation in research	104	1.79	0.844
Non-government organizations	104	1.17	0.565
Government training	103	1.51	1.056
Friends or colleagues	105	4.35	0.679
Others	19	3.79	1.182

Source: Field Data

Note: Other sources of skills for product development include the following:

i. Existence of training programmes for employees.

ii. Consulting of experts in the informal metal working sector.

iii. Cooperation with other firms both in the informal and formal sectors

iv. Customers.

4.5.2 Output Rating of Employees and Routes of Training

The performance of employees with different routes of training in day-to-day activities in the informal metalworking sector in terms of output is illustrated in Table 11. The data from Table 11 shows that 66.7% of owners of SMEs in the informal metalworking sector who have employed workers with the route of training A_{RT} informed the researcher that the output of these employees was reasonable but it did not meet the required standards. Moreover, only a small percentage of 3.7% of this category of workers with A_{RT} route of training were reported to be hard working and able to achieve right standard output. This shows that a majority of artisans that is 96.3% with an educational level below standard eight cannot be relied upon to achieve products of desired quantity.

The results in Table 11 show that 67.9% of firm owners in the informal sector who have workers that have undergone B_{RT} route of training reported that the output of their employees was reasonable but not yet up to standard. Moreover, it is a relatively low percentage of owners that is 28.2% in the informal sector who reported that their employees who have undergone B_{RT} route of training produce products that are satisfactory and up to a standard. It is therefore evident that artisans who have attained complete primary education that is up to standard eight level do not possess the necessary training to give the desired output.

The data in Table 11 further reveals that 100% of respondents who have employed workers with C_{RT} route of training informed the researcher that their workers' output was not up to the expected standard. Furthermore 75% of owners in the informal sector who have employed workers with the route of training C_{RT} indicated that they produce products with a few mistakes.

Therefore, it can be inferred from these statistics that a majority of artisans who have experienced vocational training after they have completed their primary education are not able to give an output that is up to the required standard.

Table 11 shows that 71% of owners whose employees have undergone D_{RT} as a route of training reported that the output of their workers was satisfactory. This reveals that a majority of artisans who have complete general education that is up to secondary level possess adequate knowledge and skills. This enables them to produce products that are relatively satisfactory when compared to other products produced by other artisans with lower levels of education and training. It has also been determined as shown in Table 11 that 75% of firm owners who have workers that have undergone route of training H_{RT} reported that the output of their employees is satisfactory. The other 25% of owners with the same kind of employees revealed that the output in their firms was of the required level.

The findings for workers with the route of training K_{RT} show that they are rated lowly by their employers when compared with their counterparts with the route of training H_{RT} as indicated in Table 11. It is therefore evident that employees who have acquired complete general education and enterprise based training in the formal manufacturing sector are rated better than those with enterprise based training provided by the informal sector. This is observed when it comes to the achievement of products of the desired quantity. Moreover, it has been illustrated that the rating of employees by their employers in the informal sector tends to improve with the levels of education and technical training of the workers. Therefore, those artisans who have undergone higher levels of technical training at tertiary institutes were rated highly by more than 85.7% of their employers. These respondents felt that their workers do guarantee production of products of desired quantity.

The Chi-square analysis of the data in Table 11 gives Chi-square of 27.256 and Significance of 0.021 at 95% confidence level. Since the p-value of 0.021 is less than the set siginificance level of 0.05, it therefore implies that the rating characteristic is influenced by the route of training of an employee before employment. The rating of the employees by their employers becomes more favourable to production of the desired quantity at higher levels of education and technical training.

Table 11: Output rating of Employees and Routes of training

Route of Training of Employees	Rating characteristic									
	OR_1		OR_2		OR_3		OR_4		OR_5	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
A_{RT}	1	3.7	18	66.7	6	22.2	1	3.7	1	3.7
B_{RT}	0	0	53	67.9	22	28.2	2	2.6	1	1.3
C_{RT}	0	0	4	100	0	0	0	0	0	0
D_{RT}	0	0	4	12.9	22	71	5	16.1	0	0
E_{RT}	0	0	0	0	0	0	1	100	0	0
F_{RT}	0	0	0	0	0	0	6	85.7	1	14.3
G_{RT}	0	0	0	0	0	0	1	100	0	0
H_{RT}	0	0	0	0	3	75	1	25	0	0
I_{RT}	0	0	0	0	0	0	3	100	0	0
J_{RT}	0	0	1	10	8	80	1	10	0	0
K_{RT}	0	0	4	15.4	20	76.9	2	7.7	0	0
L_{RT}	0	0	2	100	0	0	0	0	0	0

Source: Field Data

Confidence level = 95% Chi-square = 27.256 Degrees of Freedom =15 Significance = 0.021

Key for Route of training and Output Rating in Table 11.

A_{RT} = Below standard eight ⟶ Self employment.

B_{RT} = Standard eight (complete primary education) ⟶ Self employment.

C_{RT} = Standard eight ⟶ Vocational training ⟶ Self employment.

D_{RT} = Complete general education (secondary level) ⟶ Self employment.

E_{RT} = Complete general education ⟶ Tertiary training ⟶ Self employment.

F_{RT} = Complete general education ⟶ Tertiary training ⟶ Wage employment ⟶ Self-employment.

G_{RT} = Complete general education ⟶ Enterprise based training (formal) ⟶ Self employment.

H_{RT} = Complete general education ⟶ Enterprise based training (formal) ⟶ Wage employment ⟶ Self employment.

I_{RT} = Complete general education ⟶ Vocational training ⟶ Self employment.

J_{RT} = Complete general education → Vocational training → Wage employment → Self employment.

K_{RT} = Complete general education → Enterprise based training (informal)→ Self employment.

L_{RT} = Complete general education → Enterprise based training (informal) → Wage employment → Self employment.

OR_1 = Slow

OR_1 = Reasonable but not yet up to standard

OR_3 = Satisfactory output to standard

OR_4 = Works hard

OR_5 = Exceptionally quick

4.5.3 Rating of ability of Employees to produce products of desired quality and Route of Training

The rating of employees with different routes of training in terms of their ability to produce desired quality products is shown in Table 12. The data from Table 12 shows that 59.3% of respondents who have employed workers with route of training A_{RT} revealed that the quality of the products produced in their firms was satisfactory with very few mistakes. Moreover, 62.8% of owners in the informal sector who have undergone B_{RT} route of training reported that their employees produced products that had few mistakes. Hence, these products were not completely reliable. This shows that artisans who have attained standard eight level of education do not possess the necessary knowledge and skills to achieve quality products.

The results in Table 12 show that 75% of owners in the informal sector who have employed workers with the route of training C_{RT} indicated that they produce products with a few mistakes. It can therefore be inferred from these results that a majority of artisans who have experienced vocational training after standard eight are not able to produce products of the desired quality. Table 12 shows that 77.4% of firm owners whose employees have undergone D_{RT} as a route of training informed the researcher that the quality of their products was satisfactory. This indicates that a majority of artisans who have graduated from secondary schools possess adequate training. Thus enabling them to produce products of better quality when compared to other products produced by artisans with lower levels of education and training.

The data in Table 12 shows that 50% of the owners who employ workers who have undergone route of training H_{RT} reported that the quality of products produced was completely reliable and accurate. The remaining 50% of the owners also indicated that their employees who have experienced route of training H_{RT} make very few mistakes and their products are satisfactory in quality. Furthermore, the findings show that workers with H_{RT} route of training were rated highly by their employers when compared with those artisans who have undergone K_{RT} route of training. This indicates that artisans who have achieved secondary level education and experienced enterprise based training in the formal manufacturing sector are rated better. This is when they are compared with those artisans who have acquired enterprise based training in the informal sector when it comes to the production of products of the desired quality.

The Chi-square analysis of the data in Table 12 gives Chi-square of 21.689 and Significance of 0.018 at 95% confidence level. Since the p-value of 0.018 is less than the set significance level of 0.05, it therefore implies that the rating characteristic is influenced by the route of training of an employee before employment. The rating becomes more favourable to production of desired quality products at higher levels of education and technical training.

Table 12: Rating the ability of employees to produce desired quality products

Route of training of employees	Rating characteristic									
	QR_1		QR_2		QR_3		QR_4		QR_5	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
A_{RT}	2	7.4	8	29.4	16	59.3	1	3.7	0	0
B_{RT}	0	0	49	62.8	26	33.3	2	2.6	1	1.3
C_{RT}	0	0	3	75	0	0	1	25	0	0
D_{RT}	0	0	2	6.5	23	77.4	5	12.9	1	3.2
E_{RT}	0	0	0	0	0	0	1	100	0	0
F_{RT}	0	0	0	0	0	0	5	71.4	0	0
G_{RT}	0	0	0	0	0	0	1	100	0	0
H_{RT}	0	0	0	0	2	50	2	50	0	0
I_{RT}	0	0	0	0	0	0	3	100	0	0
J_{RT}	0	0	3	30	6	60	1	10	0	0
K_{RT}	0	0	14	53.8	10	38.5	2	7.7	0	0
L_{RT}	0	0	1	50	1	50	0	0	0	0

Source: Field Data

Confidence level = 95% Chi-square = 21.689 Degrees of freedom = 11 Significance = 0.018

Key for Routes of training and Rating of Employees' ability to produce quality products in Table 12.

A_{RT} = Below standard eight ⟶ Self employment.

B_{RT} = Standard eight (complete primary education) ⟶ Self employment.

C_{RT} = Standard eight ⟶ Vocational training ⟶ Self employment.

D_{RT} = Complete general education (secondary level) ⟶ Self employment.

E_{RT} = Complete general education ⟶ Tertiary training ⟶ Self employment.

F_{RT} = Complete general education ⟶ Tertiary training ⟶ Wage employment ⟶ Self-employment.

G_{RT} = Complete general education ⟶ Enterprise based training (formal) ⟶ Self employment.

H_{RT} = Complete general education ⟶ Enterprise based training (formal) ⟶ Wage employment ⟶ Self employment.

I_{RT} = Complete general education ⟶ Vocational training ⟶ Self employment.

J_{RT} = Complete general education ⟶ Vocational training ⟶ Wage employment ⟶ Self employment.

K_{RT} = Complete general education → Enterprise based training (informal) → Self employment.

L_{RT} = Complete general education → Enterprise based training (informal) → Wage employment → Self employment.

QR_1 = Inclined to make mistakes

QR_1 = Makes only a few mistakes

QR_3 = Very few mistakes, satifactory

QR_4 = Completely reliable and accurate

QR_5 = Unusually good

4.6 Limitations of Technology Diffusion

The following is a presentation of the limitations of technology transfer in the informal metalworking sector as identified by this study. Therefore, the key areas to be covered in this section are as follows: First, problems that hinder exchange of new ideas for product development with research institutions. Second, impediments to the use of employment of staff from other firms as a method of technology diffusion. Third, difficulties in implementing new ideas. Fourth, consultation with experts. Fifth, barriers to the role of seminars in technology diffusion. Lastly, hindrance to technology diffusion through co-operation with other firms.

4.6.1 Problems that hinder exchange of new ideas with research institutions

The data in Table 13 and Figure 25 highlights the problems that artisans in the informal metalworking sector face while attempting to get new ideas for product development from research institutions. In this regard, 75.9% of respondents informed the researcher that they encountered several problems when trying to get new ideas for product development. Therefore, Table 13 and Figure 25 show that 35.7% of artisans in the informal sector indicated that research institutions were not willing to share ideas. This was an obstacle in that the respondents could not benefit from ideas of institutions that carry out research such as Universities and polytechnics. Furthermore, 45.5% of firm owners in the informal sector indicated that they lacked funds to buy new ideas. Therefore, because of this financial constraint in getting new knowledge and skills from the research institutes. The majority of artisans in the sector have been compelled in continuing to use technology that is obsolete and ineffective.

The findings of the study show that 18.8% of the respondents pointed out other problems that hinder the acquisition of new ideas for product Development. These problems are lack of spare time to reach research institutions and refusal by research institutes to recognize the informal sector as partners in the process of technology diffusion. Further to this owners of firms do not have the information in regards to which institutions they should approach for ideas required for product development. These problems that have been presented do not allow artisans in the sector to get new ideas for product development so as to achieve quality products in desired quantities and on schedule.

Table 13: Problems encountered while getting new ideas for product development

Problem	Number of Respondents	Percentage of Respondents
Research institutions not willing to share ideas.	40	35.7
Lack of funds to try ideas.	51	45.5
Others	21	18.8
Total	112	100

Source: Field Data

Note: Other problems that hinder getting of new ideas for product development are as follows: -

(i) Lack of spare time to reach research institutes.

(ii) Lack of recognition by research institutes as partners in the process of technology diffusion

(iii) Lack of awareness of existing research institutes.

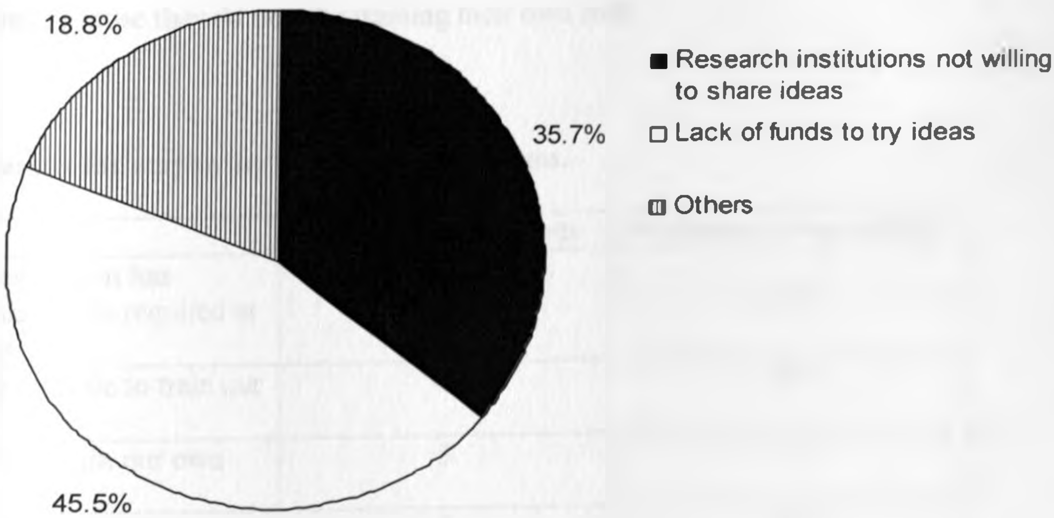


Figure 25: Problems encountered while getting new ideas for product development

Source: Field Data

4.6.2 Impediments to the employment of staff from other firms

The reasons which make firm owners in the informal sector to employ staff from other firms are clearly shown on Table 14 and Figure 26. Data analysis in this study shows that 90% of artisans covered during the research indicated that they employ staff from other firms. Therefore, the data on Table 14 shows that 82.4% of respondents employ staff from other firms when the given person has particular skills required in their workshops. This enables firm owners to benefit from the skills provided by the new employees when it comes to production of products. Furthermore, 9.9% of artisans interviewed pointed out that they employ new workers form other firms because they do not possess the capacity to train their own staff in regards to use of modern technology in the product development process. Further to this it is only an insignificant percentage of respondents which is 3.3% who indicated that they employ staff from other firms because they do not like training their own staff.

Table 14: Reasons for employing staff from other firms.

Reason	Number of respondents	Percentage of respondents
When the given person has skills, particular skills required at our workshops	75	82.4
Because we are unable to train our own staff	9	9.9
We do not like to train our own staff	3	3.3
To assist in periods of peak demands	4	4.4
TOTAL	91	100

Source: Questionnaire Analysis

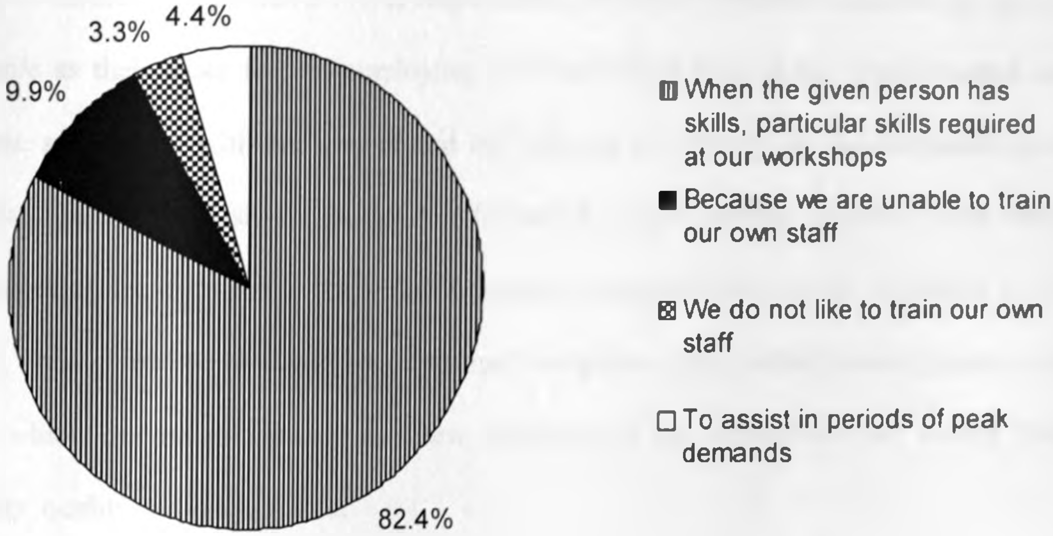


Figure 26: Reasons for employing staff from other firms

Source: Field Data

Artisans who were interviewed in the informal metalworking sector indicated several reasons for not employing staff from other firms as shown on Table 15 and Figure 27. Therefore, 22.7% of respondents reported that they do not like dealing with people who have worked with their competitors. The probable reason for this answer was that firm owners in the informal sector are always suspicious of their competitors whom they believe can do anything to steal their product development ideas. In addition, 31.8% of those artisans interviewed considered their training programmes to be the best and hence they could only employ those people they have trained on their firms. The data on Table 15 and Figure 27 further shows that 36.4% of firm owners who were interviewed, felt that it was expensive to hire an already trained person.

Table 15 further reveals that 9.1% of respondents gave other reasons which are not shown on the table as their basis for not employing new staff from other firms. These reasons are as follows: satisfaction with one's work and self-reliance in carrying out the production process. The data on Table 15 shows us that the failure of a good number of firms in the informal metalworking sector to employ new staff has greatly hampered the transfer of technology in the sector. This is because new staff members may bring into a firm valuable skills gained in other firms which can be utilized by the new employer in the achievement of desired product quantity, quality and on schedule.

Table 15: Reasons for not employing staff from other firms.

Reason	Number of Respondents	Percentage of Respondents
We don't like dealing with people who have worked with our competitors.	5	22.7
We have the best training programmes and only staff trained in our firms can be accepted.	7	31.8
It is expensive to hire an already trained person.	8	36.4
Others	2	9.1
Total	22	100

Source: Field Data

Note: Others include: -

(i) Satisfaction with one's work.

(ii) Self-reliance in the carrying out of the production process.

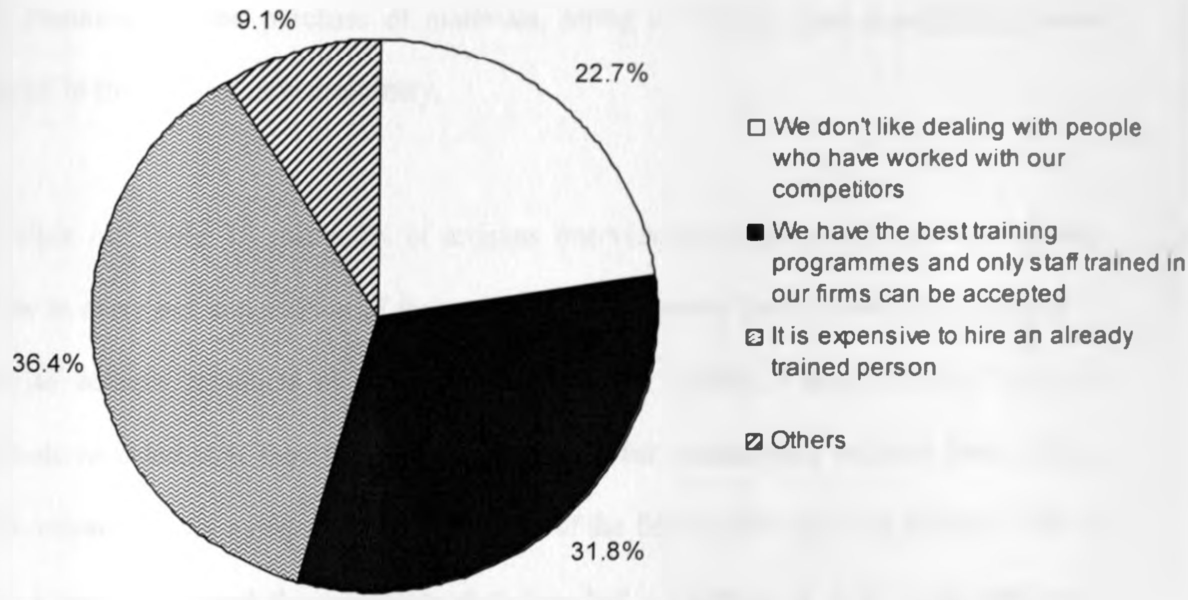


Figure 27: Reasons for not employing staff from Other firms
Source: Field data

The operational areas in which firm owners in the informal metalworking sector lack the required staff are shown on Table16 and Figure 28. In this regard, 37% of respondents indicated that they lacked skilled staff in the area of production. This shortage could explain why many firms in the informal sector encounter difficulties in implementing new idea designs or copying of products seen elsewhere. Moreover, 11% of artisans interviewed revealed that they lacked the required staff to carry out quality control on their products. Therefore, this inability to carry out effective quality controls by firms in the sector gives rise to customer dissatisfaction. This in many cases will lead to rejection of the product by the customer. The data on Table 18 shows that 13.7% of firm owners covered indicated that they lack the necessary staff in finance and accounting. Hence the firm owners cannot effectively keep records concerning their profits and expenditure. These records are a vital source of information required in sustaining operations as regards planning for the purchase of materials, hiring of workers and acquisition of new technology in the form of new machinery.

It is evident on Table 16 that 8.2% of artisans interviewed pointed out the lack of skilled personnel to carry out supervision of their production processes. Hence these artisans found it difficult to achieve products of the right quantity and quality. Further to this, 5.5% of respondents revealed that they lack the required staff for maintenance on their firms. Thus, machine maintenance is a major problem for some of the firms in the sector. In addition 19% of the firm owners informed the researcher that they had a shortage of staff in the sales and marketing area. This could explain why products in the informal sector have a small customer base when compared to products produced in the formal sector. It should therefore be noted that the lack of skilled staff in certain operational areas has greatly limited the diffusion of the required technology into the informal metalworking sector in Kenya. These critical areas are supervision of production processes, maintenance, quality control, sales and Marketing, purchasing, finance and accounting as well as actual production.

Table 16: Operational areas in which staff is lacking in the informal metalworking Sector

Operations area lacking the required staff	Number of Respondents	Percentage of respondents
Purchasing	1	1.4
Packing and labeling	3	4.1
Maintenance	4	5.5
Supervision of production process	6	8.2
Quality control	8	11.0
Finance and accounting	10	13.7
Sales and Marketing	14	19
Production	27	37.0
Total	73	100

Source: Field Data

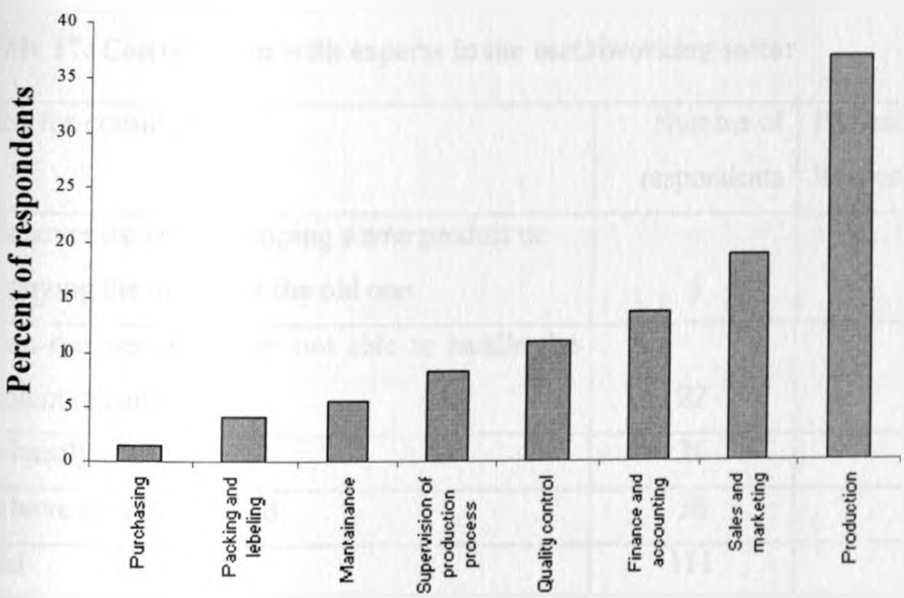


Figure 28: Operational areas in which staff is lacking in the informal metalworking sector
Source: Field Data

4.6.3 Consultation with experts in the metalworking sector

The instances whereby artisans in the informal metalworking sector consult with experts is illustrated on Table 17 and Figure 29. Therefore, the data on the table shows that 4.5% of respondents consult with experts whenever they are developing a new product or improving the design of the old one. Furthermore, 19.8% of firm owners covered in this study indicated that they consult when their personnel are not able to handle the problem at hand. In addition 23.4% of artisans interviewed informed the researcher that they hardly consult. Further, to this 52.3% of respondents revealed that they have never consulted with experts in the metalworking section. It can therefore be inferred from this data that nearly a half of the firms in the informal, metalworking sector do not engage in any form of consultation with experts. This means that artisans in the sector do not have access to expert knowledge and skills to achieve quality products in desired quantities and on schedule.

Table 17: Consultation with experts in the metalworking sector

Need for consulting	Number of respondents	Percentage of Respondents
Whenever we are developing a new product or improving the design of the old one.	5	4.5
When our personnel are not able to handle the problem at hand	22	19.8
We hardly consult	26	23.4
We have never consulted	58	52.3
Total	111	100

Source: Field Data

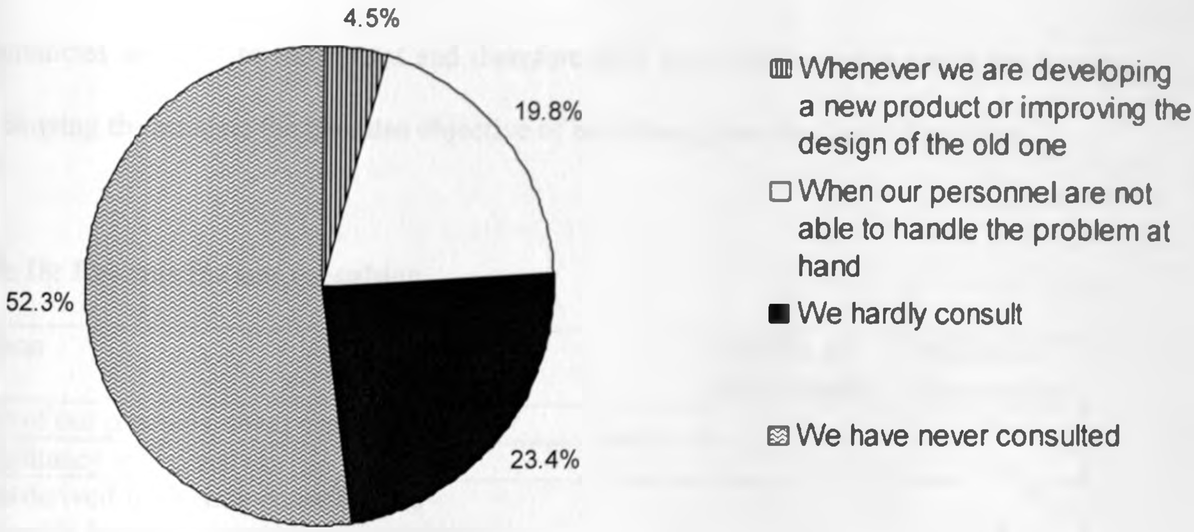


Figure 29: Consultation with experts in the metal working sector

Source: Field Data

The artisans covered in the research gave various reasons as to why they do not consult with experts are described on Table 18 Figure 30. The data from the table shows that 50% of respondents have not come into contact with consulting services of any kind in the sector.

This has greatly limited the transfer of technology in the sector as the artisans are not able to access useful knowledge and skills from the people who have expertise in the area of metalworking. Furthermore, 33.3% of firm owners interviewed indicated that consultancy is expensive. Thus, they did not attempt to engage in it. In addition 5.6% of the respondents indicated that they were satisfied with their own work. Further to this another 5.6% of the respondents revealed that most of their products never change in design.

Thus these two categories of artisans did not require to consult hence failing to take advantage of new ideas from consultants that would be beneficial for product development. Moreover, an additional 5.6% of the artisans interviewed informed the researcher that ideas derived from such consultancies are hard to implement and therefore they were impractical to use in production thus denying the artisans the intended objective of benefiting from new production ideas.

Table 18: Reasons for not consulting

Reason	Number of Respondents	Percent of Respondents
Most of our products never change in design	1	5.6
Consultancy is expensive	6	33.3
Ideas derived from such consultancies are hard to implement or rather impractical	1	5.6
We have not come into contact with such services yet	9	50.0
Satisfied with own work/customers satisfied with our products	1	5.6
Total	18	100

Source: Field Data

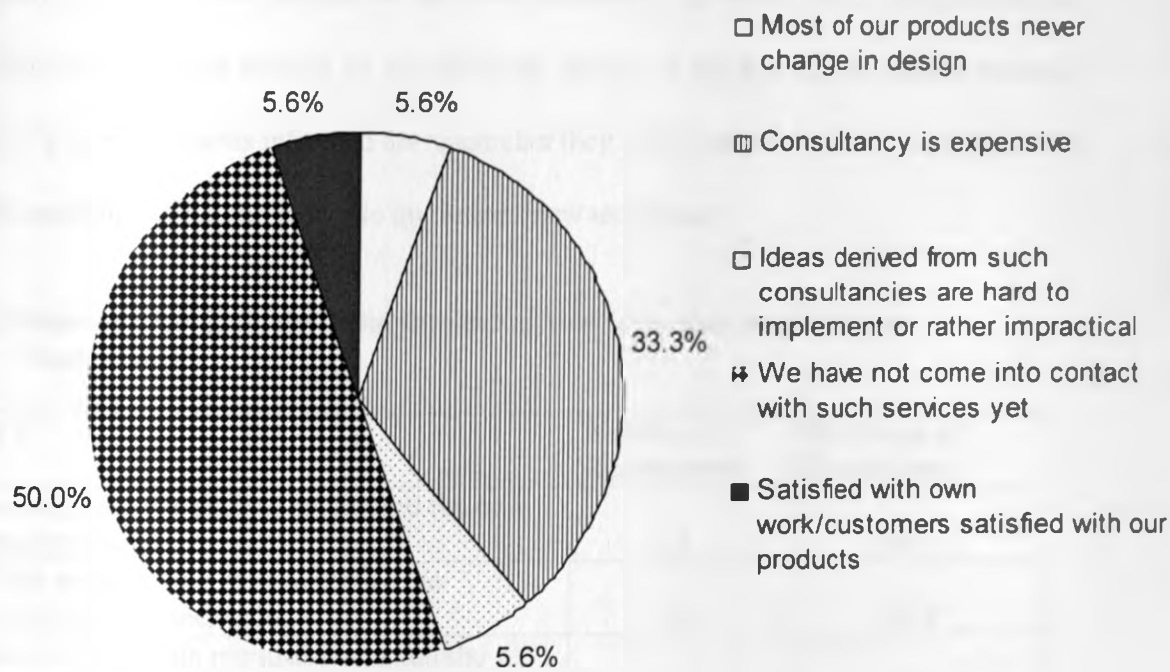


Figure 30: Reasons for not consulting

Source: Field Data

4.6.4 Difficulties in implementing new ideas and adopting new technology

The firm owners interviewed in the study reported that they face certain difficulties in the implementation of new ideas and adoption of new technology. Therefore, Table 19 and Figure 31 gives the reasons for difficulties in implementing new ideas and adopting new technology. The data shows that 62.1% of respondents revealed to the researcher that it took a long time for their staff to understand the new techniques involved in production. This is due to the inability of most artisans in the sector to assimilate and apply new ideas quickly.

Further to this, 28.8% of firm owners covered in the research indicated they have to hire more skilled staff to realize the objectives of the new technology. However, this is not possible for many firms in the sector as they do not have the money to employ highly skilled workers. Lastly, 9.1% of respondents informed the researcher they could not afford the costs required for materials, equipment and manpower to implement new technology.

Table 19: Reasons for difficulty in implementing new ideas and adopting new technology

Reason	Number of Respondents	Percentage of Respondents
It took a long time for staff to understand the new technique involved	41	62.1
Had to hire more skilled staff to realize the objective of the new technology	19	28.8
Not able to afford costs required for materials, equipment and manpower	6	9.1
Total	66	100

Source: Field Data

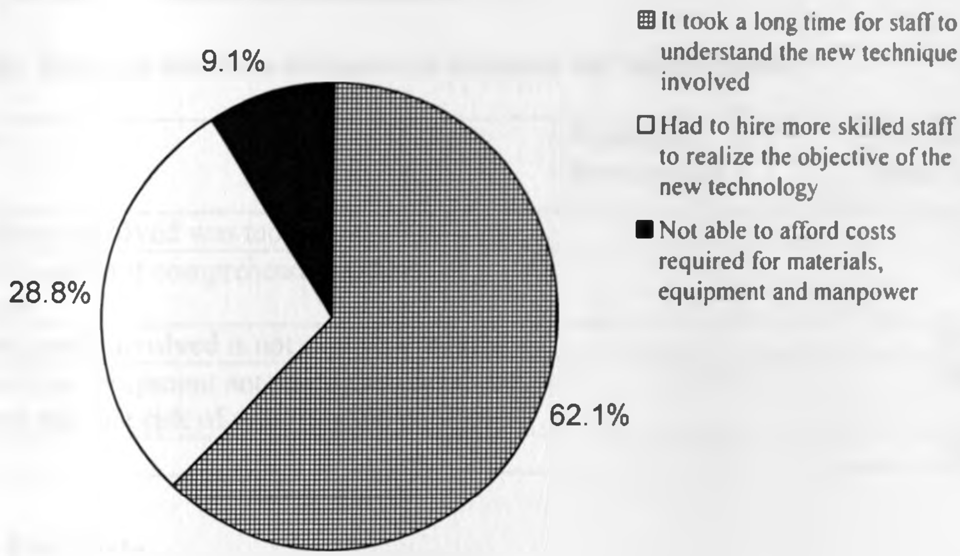


Figure 31: Reasons for difficulties in implementing new ideas and adopting new technology

Source: Field Data

4.6.5 Barriers to the role of seminars in Technology diffusion

The artisans in the informal metalworking sector who informed the researcher that they attended seminars felt that ideas discussed in these forums were not feasible. Thus, the data on Table 20 and Figure 32 illustrates the reasons, given by the respondents as to why ideas discussed in seminars cannot be implemented in the informal sector. In this regard, 71.4% of artisans indicated that technology proposed in the seminars was too expensive to adopt. Moreover, 14.3% of the respondents informed the researcher that their staff could not comprehend the ideas presented in the seminars. Therefore they could not implement the new technology in the product development process in their firms. In addition, 14.3% of artisans interviewed indicated that the equipment suggested in the seminars to upgrade the technological level of the informal sector was not available locally.

Table 20: Reasons for ideas discussed in seminars not being feasible

Reason	Number of Respondents	Percentage of Respondents
Technology involved was too expensive to adopt	5	71.4
My staff could not comprehend the ideas presented	1	14.3
The equipment involved is not available locally	1	14.3
Spares of the equipment not readily available and could not take the risk of acquiring the equipment	0	0.00
Total	7	100

Source: Field Data

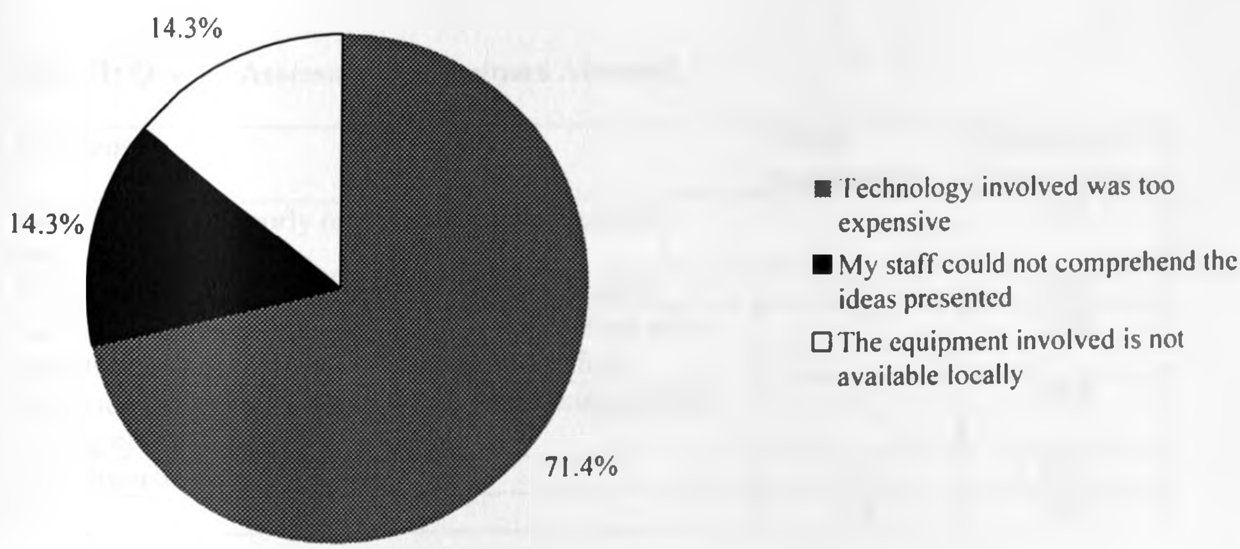


Figure 32: Reasons for ideas discussed in seminars not being feasible

Source: Field Data

The respondents who indicated that they attend seminars in the informal metalworking sector also gave an overall assessment of the seminars as forums for technology diffusion as shown on Table 21 and Figure 33. The data from the table shows that 16.6% of artisans interviewed informed the researcher that the ideas discussed in the seminars were not feasible. Further to this, 27.8% of respondents revealed to the researcher that the seminars presented good ideas. However, the organizers did not take enough time to explain the ideas to facilitate their implementation. It can therefore be inferred from the statistics presented on Table 21 that a majority of artisans in the informal metalworking sector do not possess the ability and knowledge to implement ideas learnt during seminars. The findings also show that the Kenyan government and non-governmental organizations use seminars as forums for the process of technology diffusion.

Table 21: Overall Assessment of seminars Attended.

Assessment	No of Respondents	Percentage of Respondents
The seminar was poorly organized/unfair selection of participants.	1	5.6
The ideas discussed in the seminar were not feasible	3	16.6
The seminar presented good ideas but they did not take enough time to explain/help us to understand fully	5	27.8
Discussed things that we were already practicing and had nothing new to learn	5	27.8
Ideas discussed were obsolete	4	22.2
Total	18	100

Source: Field Data

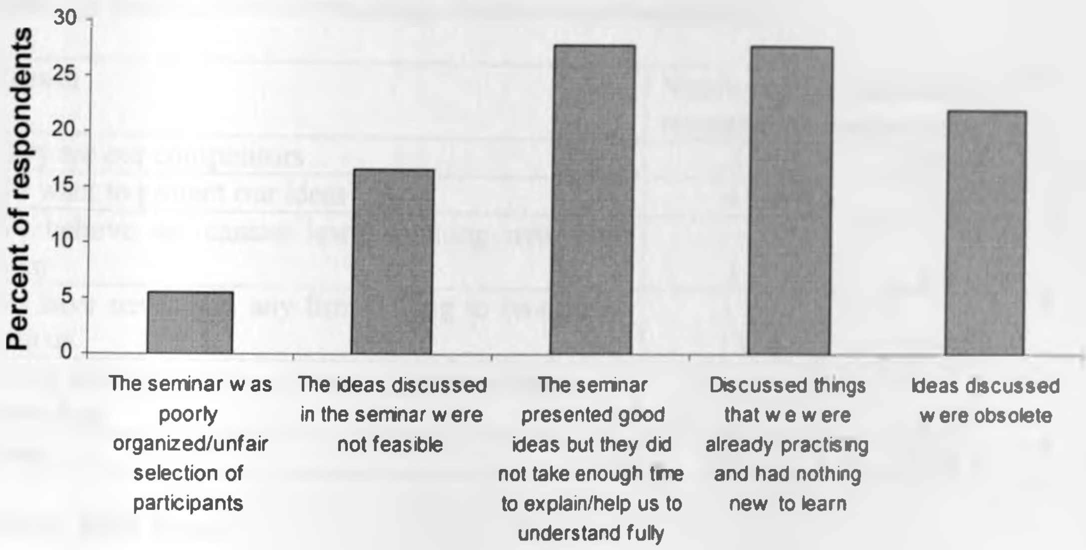


Figure 33: Overall assessment of seminars attended
Source: Field Data

4.6.6 Hindrance to technology diffusion through co-operation with other firms.

The respondents who were interviewed in the field gave several reasons for not working with other firms as shown on Table 22 and Figure 34. Firstly 54.2% of artisans interviewed indicated that they have never had any firm willing to co-operate with them. Therefore, this lack of co-operation between firms in the sector has greatly inhibited technology diffusion in the sector.

Secondly, 20.8% of respondents revealed that they also do not work closely with other firms due to competition for customers. Hence no meaningful exchange of ideas can take place among firms in the sectors that see themselves as competitors. Thirdly, the data from Table 22 shows that 16.6% of artisans interviewed do not work closely with other firms because they want to protect their ideas. This results in the limitation of technology diffusion in the sector.

Table 22: Reasons for not working closely with other firms.

Reason	Number of respondents	Percentage of respondents
They are our competitors	5	20.8
We want to protect our ideas	4	16.6
We believe we cannot learn anything new from them	1	4.2
We have never had any firm willing to co-operate with us.	13	54.2
Likely disagreements in sharing proceeds from new ideas	1	4.2
Total	24	100

Source: Field Data

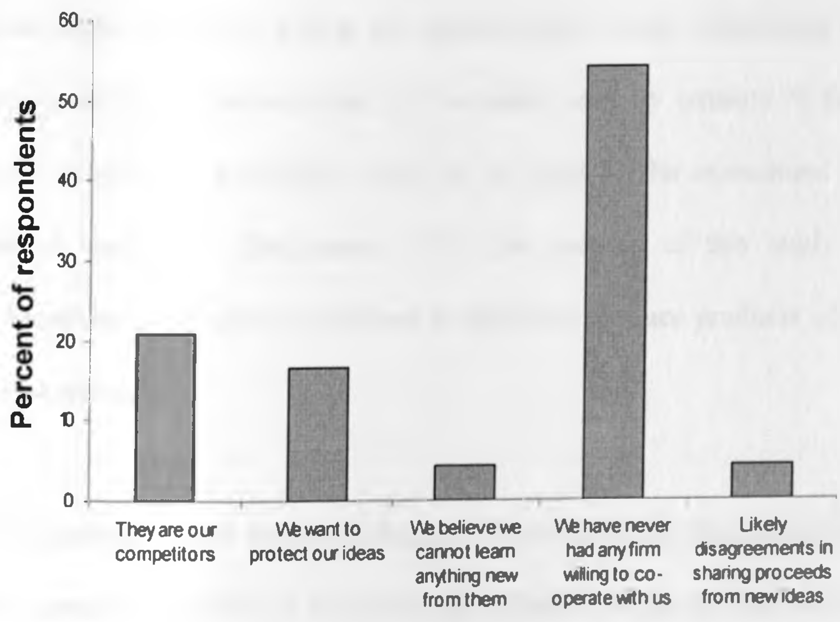


Figure 34: Reasons for not working closely with other firms
Source: Field Data

CHAPTER FIVE

CONCLUSION

This chapter will focus on the following key areas. These are summary and conclusions, limitations of the study, recommendations for further research as well as suggestions for policy and practice.

5.1 Summary and Conclusions

This study focused on technology diffusion and its impact on product development in the informal metalworking sector in Nairobi Province, the capital city of Kenya. The literature review of this research discussed various issues related to product development and technology diffusion in the informal sector in Kenya. The review dealt with conventional product development models to help in the determination of any relationship that exists between these models and those methods that are currently used by artisans in the sector. The literature review considered parameters that can be used in the assessment of product development methods and their effectiveness. For the purpose of this study, assessment of product development methods was confined to ability to produce products of desired quantity, quality and on schedule.

The literature review further highlighted those problems and limitations that are likely to be encountered in the process of technology diffusion within the informal sector in Kenya. It was then hypothesised that existence of inadequate production skills is a product of a deficient education and skill acquisition processes. Moreover, the absence of an appropriate model of technology diffusion applicable to the metalworking sector is the main drawback to effective production of marketable quality products.

It emerged from the literature review and pilot survey of the sector that issues of technology diffusion and product development in the informal sector have not been adequately addressed. Hence, the continued lack of technological growth in this sector. On the basis of this overview the primary purpose of this study was identified and specific objectives of the study were set. In this respect the objectives of this study were as follows: Firstly, to identify product development methods in use by small and medium enterprises in the informal metalworking sector and to show how these relate to conventional product development methods and routes of training that artisans in the sector undergo before self-employment. Secondly, to establish how the metal working processes used in the sector relate to material selection, choice of equipment and levels of training. Thirdly, to determine the relationship that exists between the routes of training for the artisans in the informal metal working sector and the achievement of quality products in desired quantities and on schedule.

Fourthly, to determine the effectiveness of product development methods used by the informal metalworking sector in achieving quality products in desired quantities and on schedule. Fifthly, to demonstrate how technology diffusion takes place in the informal metalworking sector in Kenya and assess its impact on product development in terms of achieving quality products in desired quantities and on schedule. Lastly, to identify the limitations of technology diffusion in the informal metalworking sector and propose a model of technology diffusion that would be most appropriate for the sector in terms of achieving quality products in desired quantities and on schedule

The researcher employed cross-sectional survey in this study whereby data was collected through interviews and questionnaires from 112 firms out of a population of 1,076 firms. The analysis of data was both quantitative and qualitative. It focused on three units of analysis namely: product development process, production skills of the artisans and lastly limitations to acquisition of production skills by artisans. From this study the following conclusions were reached: Firstly, the literature review showed that conventional product development process involves idea generation, idea screening, concept development and concept testing. The subsequent stages involve decisions such as how best to manufacture the product, what materials to use, possible designs and market evaluations. This conventional process of product development was not practised by any of the interviewed artisans or owners of the firms in the informal sector. Furthermore, idea screening and prototype testing are hardly practiced by any of the firms in the informal sector.

The chi-square analysis of the data reveals that the differences in the choice of product development method among the different routes of training are not statistically significant. This finding therefore suggests that the use of a product development method is not influenced by the route of training before self-employment. In the case of production quantities, the analysis of variance (ANOVA) has shown that both actual and ideal mean production quantities do not vary significantly across the various routes of training. Hence, the routes of training do not influence both actual and ideal production quantities. This suggests that quantities produced are mainly determined by other factors other than route of training. These factors include availability of materials to use in production and available number of operators for the amount of work to be done. Moreover, production capacity of the equipment and the existing market demand for the products also affect production quantities in the informal sector. The ANOVA has further demonstrated that there are no significant differences in the use of quality control methods across the routes of training. The firms generally use similar quality control methods that depend on visual inspections.

The sector reported that the type of material to be used in production is determined by customer specifications relating to the desired quality. The respondents also indicated that the ability of the customer to pay for the cost of production was also a factor in material selection. Further to this, the study reveals that mechanical properties and chemical composition are not specified or verified by testing as a requirement for choosing material to use in production. Hence, there is no quantifiable basis for determining that the final product will be safe to carry food for human consumption as well as being of desired strength. The ability of the customer to pay for the cost of production was also a factor in material selection.

The observations of the study further show that equipment in the informal sector is mainly operated manually which exerts physical strain on the artisans. Moreover, the manual production steps are also many and take a long time. These factors are usually not taken into consideration when promising date of delivery of products to the customer. It is also evident that sourcing of materials particularly scrap material is time consuming in the sector. Further to this, orders made by customers in the sector are not considered in relation to time taken to acquire materials and to produce the item. Therefore the dates given by artisans for delivery of products are not likely to be accurate. The analysis of variance of the data also shows that there are no significant differences in the mean number of orders delivered without delay across the various routes of training. Hence as already noted, the general trend in the informal sector is that factors affecting delivery date are not taken into account. This makes the artisans not to meet delivery deadlines.

The ANOVA has shown that product rejection is not influenced by product development method. This implies that other factors may be contributing to the rejection of products. These are namely production skills and inadequate quality control methods. It is also concluded in the ANOVA analysis that the mean number of customers whose orders were not delivered on time are significantly different across the product development methods. Hence delayed orders are influenced by the product development method that is used.

The rating of the employees by their employers with regard to production of products of desired quantity and quality has been determined to become more favourable at higher levels of education and technical training. Chi-square analysis has also shown that rating characteristics that were used are affected by route of training. Inadequate production skills are therefore associated with relatively lower levels of education and technical training. Hence, this proves the hypothesis that inadequate production skills is a product of a deficient education and skill acquisition processes.

The primary bodies which have been providing support for technology transfer in the informal metalworking sector have been identified. These are the Ministry of Labour and Human Resource Development, World Bank, Kenya Industrial Research and Development Institute, Kenya Industrial Estates, Japan International co-operation Agency in conjunction with Jomo Kenyatta University of Agriculture and Technology. The support given by these bodies involves promotion of training programmes, research and adoption of technologies suitable to the sector. It is also evident from the study that ideas for product development are obtained from the following sources: Friends or colleagues, consultation with experts in the metalworking sector, co-operation with other firms both in the informal and formal sectors, customers and existence of training programmes for employees. The data analysis also reveals that skills acquisition from friends or colleagues is the most common method of technology transfer in the informal sector.

The research findings show that transfer of technology in the informal sector is limited by ineffective exchange of new ideas between informal sector firms and research institutions. Moreover, there is a failure by some owners in the sector to employ skilled staff from other firms. Furthermore, artisans experience difficulties in implementing new ideas due to inadequate skilled staff and money to buy materials as well as equipment. The study also shows that technology transfer is hindered by artisan's inability to consult with experts and ineffectiveness of seminars. Further to this lack of cooperation between firms in the informal metalworking sector in terms of sharing ideas for product development is a barrier to technology diffusion.

It is also evident from the data collected in this research, that 62.1% of all categories of owners with different educational backgrounds experience difficulties in implementing new product ideas and adopting new technology. The reason for this is that it took a long time for them to understand new production techniques. Further to this, 52.3% of respondents revealed that they have never consulted with experts in the sector. This failure by artisans in the informal sector to effectively access and implement new product ideas proves the researcher's hypothesis that, the absence of an appropriate model of technology diffusion applicable to the informal metalworking sector is the main drawback to effective production of marketable quality products. Based on the findings of this study it is deduced that the weak areas of product development in the informal metalworking sector are product design, material and equipment selection, production scheduling and product quality assurance. Hence to address these shortcomings in the sector the researcher proposes the model shown in Figure 35.

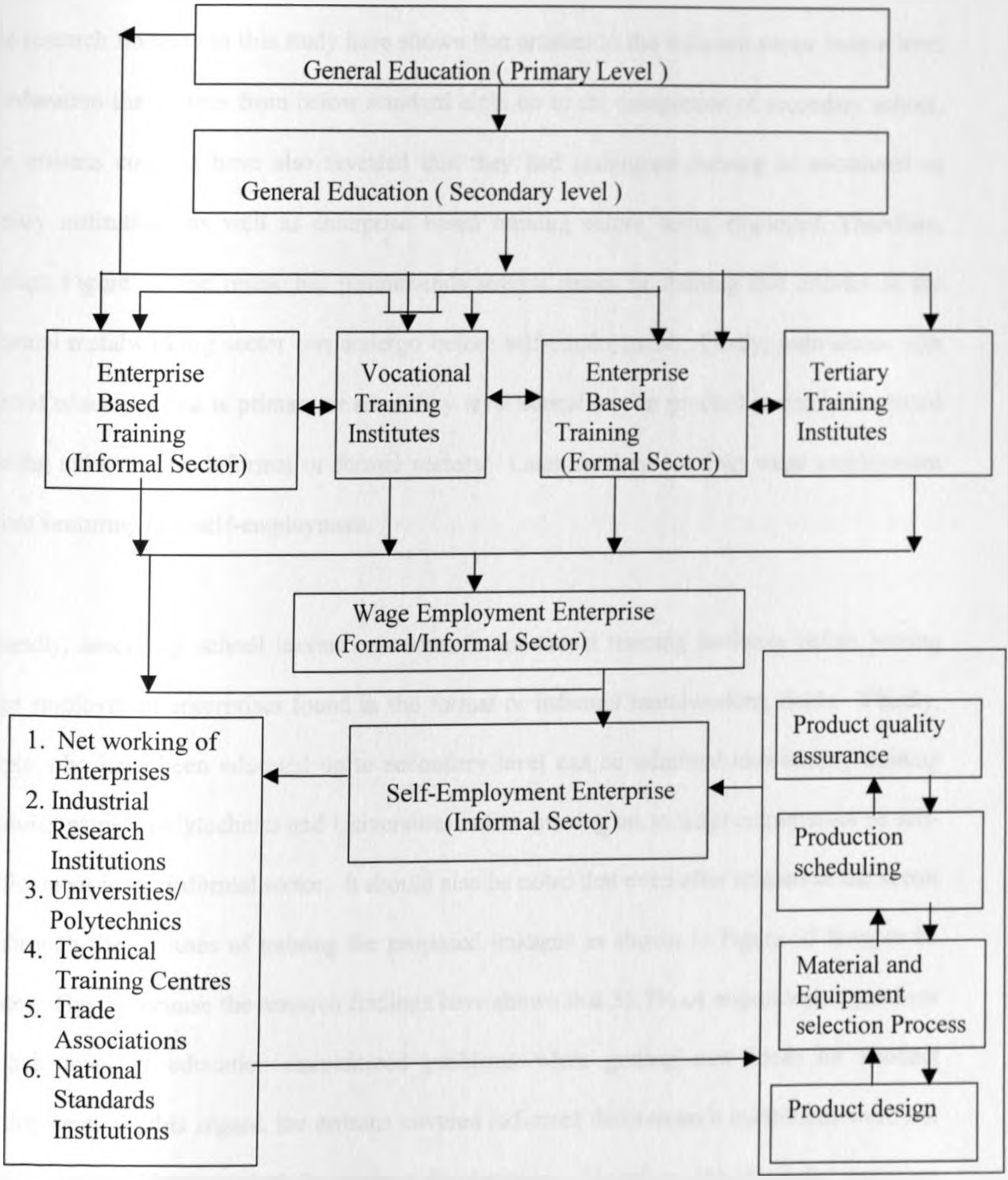


Figure 35: Proposed model of Technology Transfer for Product development in the Informal metalworking sector in Kenya

Source : Author of Study

The research findings in this study have shown that artisans in the informal sector have a level of education that ranges from below standard eight up to the completion of secondary school. The artisans covered have also revealed that they had undergone training in vocational or tertiary institutions as well as enterprise based training before being employed. Therefore, through Figure 35 the researcher recommends several routes of training that artisans in the informal metalworking sector can undergo before self-employment. Firstly, individuals with general education that is primary or secondary level education can proceed to enterprise based training either in the informal or formal sectors. Later on they can join wage employment before venturing into self-employment.

Secondly, secondary school leavers can enrol in vocational training institutes before joining wage employment enterprises found in the formal or informal metalworking fields. Thirdly, people who have been educated up to secondary level can be admitted into tertiary training institutes namely polytechnics and Universities before moving on to wage employment or self-employment in the informal sector. It should also be noted that even after artisans in the sector go through these routes of training the proposed linkages as shown in Figure 35 have to be created. This is because the research findings have shown that 35.7% of respondents regardless of their level of education encountered problems while getting new ideas for product development. In this regard, the artisans covered indicated that research institutions were not willing to share ideas required for product development. Therefore, the researcher proposes that Industrial research institutions should pass on ideas to artisans in the informal metalworking sector to help in the process of product development as indicated in Figure 35.

Further to this, the results of this study show that delivery of products on schedule by the respondents is affected by time taken to source materials and type of equipment used. Thus, on this basis the researcher recommends that artisans in the sector should be trained in production scheduling at tertiary institutions such as Universities, polytechnics and other Technical training centres as illustrated in Figure 35. This will enable firm owners in the informal sector to achieve desired product quantity and on schedule. In addition to this, a low percentage of 33% of the respondents attempted to use national product standards in their quality control. Hence this results in the production of goods that vary in terms of design, variety and overall quality. Therefore, the researcher proposes that national standards institutions such as Kenya Bureau of Standards should be involved in the control of product quality in the informal sector as shown in Figure 35. This will enable artisans in the sector to achieve desired product quality.

It is evident from the research findings that ideas for product development in the informal metalworking sector are obtained from friends or colleagues, consultation with experts in the metalworking sector, co-operation with other firms both in the formal and informal sectors, customers and existence of training programmes for employees. Thus, as clearly shown in the figure the researcher recommends that technical training institutes, industrial research institutes, local industrial sector (both formal and informal), National standards institutions like Kenya Bureau of Standards should be linked to the informal sector through policy formulation to facilitate sharing of product design ideas, production skills and quality management procedures. Moreover, formation of trade associations made up of artisans in the informal sector should be encouraged to help in the setting up of technology information centres which should be reference points for consultants, trainers and non-governmental organizations who are involved in technology diffusion.

5.2 Limitations of the Study

This study is limited in the following ways: Firstly, due to financial constraints this research only focused on the informal metalworking sector in Nairobi Province the capital of Kenya. This is a limitation as other major towns such as Mombasa and Kisumu where informal metalworking firms are found were not covered. It is therefore the researcher's view that collection of data from other towns would have given more information on the education qualifications of a majority of artisans in the informal metalworking sector as well as their routes of training within Kenya. Furthermore, a study of other major towns in the country would have shown whether the percentage of artisans who utilize conventional product development methods such as idea screening and prototype testing outside Nairobi province is higher or lower than that found within the capital city.

Secondly, institutions that offer tertiary or vocational training to artisans in the informal sector were not investigated. The main reason for this was that the researcher only focused on artisans in the sector by using their training backgrounds as basis for the process of technology diffusion and its impact on product development. If these tertiary or vocational training institutes had been investigated, the findings would have enabled the researcher to identify the shortcomings in the training of artisans in the given institutions. The reason for this is that the training results in graduates who cannot implement conventional product development procedures.

5.3 Recommendations for Further Research

This research has only focussed on the informal metalworking sector in Nairobi Province. The study has then shown that technology diffusion to the sector has not been adequate to ensure production of products of desired quantity, quality and on schedule. However, this research should be extended to other provinces of Kenya to determine the extent to which results obtained for Nairobi province are representative for the whole of the sector in Kenya. It has also been observed that this research used the training backgrounds of owners of SMEs in the informal sector as a basis for determining levels of technology attained in the sector. It is therefore recommended that a study of institutions through which owners of SMEs and their employees acquire their general education and technical training should be carried out. This should focus on technological levels of their training programmes as well as their appropriateness to ensure production of products of desired quantity, quality and on schedule.

5.4 Recommendations for Policy and Practice

The research findings for this study show that the conventional process for product development which involves idea generation, idea screening, concept development and concept testing was not practised by any of the interviewed artisans or owners of firms in the informal sector. Therefore, the government's education policy framework should encourage the teaching of conventional product development procedures and technology diffusion methods at all levels. This should start from primary up to University to provide a starting point for technological learning and development of capabilities to assimilate and apply appropriate production technologies.

It is also evident from the study that ideas for product development are obtained from the following sources: friends or colleagues, consultation with experts in the metalworking sector, co-operation with other firms both in the informal and formal sectors, customers and existence of training programmes for employees. In this regard the researcher recommends that technical training institutes, industrial research institutes, local industrial sector (both formal and informal), National standards institutions such as Kenya Bureau of Standards should be linked to the informal metalworking sector through policy formulation to facilitate sharing of product development ideas as well as quality management procedures. Formation of trade associations made up of artisans in the informal sector should be encouraged to help in the setting up of technology information centres which should be reference points for consultants, trainers and non-governmental organizations who are involved in technology diffusion.

The data collected in this research shows that the actual mean daily production quantity is less than the expected ideal production quantity for all product development methods. The findings revealed that desired product quality is not attained all the time by all routes of training. The study has further shown that delivery of products on schedule is not achieved always by the respondents regardless of their routes of training. Therefore, the key areas of product development in the informal metalworking sector that will ensure quality products in desired quantities and on schedule are product design, material and equipment selection, production scheduling and quality assurance. Hence these areas should form the basis of technology diffusion to the sector.

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APPENDIX: QUESTIONNAIRE

Section 1: Product development methods

1.1.1 Do you do any designing of the products before production?

Yes [ ] No [ ]

1.1.2 If yes, which design procedure(s) do you use from the following choices?

a) Customer describes the product → Drawings of the product → Model or copy of product → Final product [ ]

b) Customer describes the product → Model product → Final product [ ]

c) Customer describes the product → Final product [ ]

d) Customer presents a sample product → Drawings → Model or copy of product → Final product [ ]

e) Customer presents a sample product → Final product [ ]

f) Drawings from the customers → Model of copy of product → Final product [ ]

g) Drawings from customer → Final product [ ]

1.1.3 If no, in 1.1.1 above, then what helps you to make your products?

a) Self creativity [ ]

b) Copy from others [ ]

c) Customer [ ]

1.1.4 While using self-creativity or imagination, what procedure(s) do you use until you get a final product?

a) Self creativity → Drawings → Model of product → Final product [ ]

b) Self creativity → Model or copy of product → Final product [ ]

c) Self creativity → Final product [ ]

d) Self creativity → Comparison with other similar products → Final product [ ]

1.1.5 Do you sub-contract production of part/whole of your product to other producers?

Yes [ ] No [ ]

1.1.6 If yes, what reasons make you to sub-contract your production?

a) When the demand is more than what we can produce [ ]

b) When sub-contracts are selling products at a price lower than our production cost [ ]

c) When sub-contractors are producing products of higher quality [ ]

d) Others (specify) ______________________________

____

1.1.7 Is there a quality control programme in your organization?

Yes [ ] No [ ]

1.1.8 If yes, who carries out the exercise?

a) Every operator [ ]

b) Inspectors [ ]

c) Self [ ]

1.1.9 Which of the following quality control procedures do you use?

a) Checking quality of all materials used in production [ ]

b) Ensuring that all machines and equipment are in excellent working conditions [ ]

c) Employing qualified and skilled staff [ ]

d) Using national/institutional standards in design of products [ ]

e) Testing products against national/ institutional standards [ ]

f) Others (specify) ______________________________

____

1.2.0 Do you produce products of the required specifications and quality throughout?

Yes [ ] No [ ] Somewhat [ ] Not Sure [ ]

1.2.1 If yes, in 1.2.0 above, how do you ensure that the required product specifications are attained?

a) By operators achieving specifications through use of measurement [ ]

b) By having supervised measurements of all measurable specifications [ ]

c) By comparing with specification of our catalogue drawings [ ]

d) By using the natural senses of sight and mental judgment to tell the right product specification ☐

e) By comparing with other finished products and making necessary adjustments ☐

f) Others (specify) ____

____

1.2.2 Are you able to know at the time a specification for a certain product(s) is given by a customer, when the delivery date would be?

Yes ☐ No ☐

1.2.3 If yes in 1.2.2 what considerations do you take into account before agreeing on a delivery date?

a) Quantity of materials at hand ☐

b) Quantities of materials on order and when they are likely to be received ☐

c) Number of workers available to produce the items ☐

d) Types of machines available and the quantities they can produce per day ☐

e) Pending orders from other customers ☐

f) Possibility of sub-contracting work that cannot be done in our workshop. ☐

g) Production schedule at hand. ☐

h) Others (specify) ____

____

Section 2: Metal working processes, material selection and choice of equipment

2.1.1 What is the mode of operation for your production?

a) Manual ☐

b) Mechanized ☐

c) Both manual and mechanized ☐

2.1.2 Describe the manufacturing processes used in the production of your metal products:

ITEM	NAME OF PRODUCT	DESCRIPTIONOF STEPS INVOLVED IN THE MANUFACTURING PROCESS	TYPE OF MATERIAL USED	SOURCE OF MATERIAL

2. 1.3 How do you know that you have the desired quality of materials to use in your production? ____________________

____

____

____

2.1.4 What factors do you consider in material selection?

a) Material cost ☐

b) Availability of the materials ☐

c) Suitable mechanical properties ☐

d) Safety of the materials so as not to affect the health of the users of the products ☐

e) Others (Specify)

____

____

____

____

Section 3: Effectiveness of the product development methods

3.1.1 In the table below fill in the types of products that you make and their quantities in the given periods.

Item number.	Name of Product	Average Quantity Produced in the last:					Production quantity per day while working at your best
		One day	One week	One month	Six months	One year	

3.1.2 What has been your production trend for the last 5 years?

a) Regular ☐

b) Irregular ☐

c) Varies with the season ☐

d) Others (specify) ____________________

____

____

3.1.3 Do you incur any production loss due to irregularities in production?

Yes ☐ No ☐

3.1.4 If yes, which losses do you incur from the ones below?

a) Loss of customers ☐

b) Loss of manpower (i.e. skilled workers) ☐

c) Reduced sales ☐

d) Reduced profits ☐

e) Others (specify)

____

____

3.1.5 What is the average operation time per day?

a) As planned________________ hrs / day

b) Actual ________________ hrs /day

3.1.6 Give reasons for the difference in 3.1.5 above

i) Some workers get tired and stop working before the planned period of work ends or elapses ☐

ii) Disruptions in supply of electrical power ☐

iii) Unreliable supplies of materials needed for production ☐

iv) The available number of operators is not enough for the amount of work to be done. ☐

v) Machines break down quite often ☐

vi)Others(specify)____

____

____

____

3.1.7 If capacity were increased, would there be demand for extra production?

Yes ☐ No ☐

3.1.8 If yes, why?

a) Because our products are of good quality and attractive to customers ☐

b) We intend to reduce prices to get more customers ☐

c) Because we are continuously improving the quality of our products ☐

d) The customer demand for our products has always exceeded our production Output ☐

e) Others (specify)____

____

3.1.9 If no in 3.1.7 above, why?

a) Customers prefer the imported similar products ☐

b) The market is already flooded with these products from our competitors ☐

c) The demand for these products has been reducing ☐

d) Others(specify) ____

3.2.0 When a customer gives you specifications for a product, what do you do to ensure that you produce exactly what the customer wants?

a) The specification are converted into drawing and used to produce final product ☐

b) The operator listens carefully, pictures the product and finally produces the product ☐

c) Short notes are taken from the customer's descriptions, and then used to make a sketch or drawing with appropriate dimensions, then a model and finally a product agreeable to the customer. ☐

d) Others (specify)

____

____

____

3.2.1 Have you had cases where customers give you their specifications and then they end up rejecting the end product?

Yes ☐ No ☐

3.2.2 If yes at what frequency?

Item No.	Name of Product	Number of Products rejected in the last:				
		One day	One week	One month	Six months	One year

3.2.3 In general how many of your products are rejected on average by all your customers?

Item No.	Name of product	Average quantity rejected in the last:				
		One Day	One Week	One Month	Six months	One year

3.2.4 How do you know that you have the right quality?

a) It is certified by quality control bodies. ☐

b) By physically inspecting all supplies ☐

c) Because we are supplied from known high quality suppliers [ ]

d) By testing samples in reputable laboratories [ ]

e) Because we give right specifications to the suppliers [ ]

3.2.5 Do you have all the machinery required for production?

Yes [ ] No [ ]

3.2.6 If no, how do you get machines?

a) Borrow/share with working partners [ ]

b) Hire from other workshops [ ]

c) Others (specify) ______________________________

____

3.2.7 What are the reasons that hinder you from possessing all the tools and machinery required for production?

a) Lack of money needed to purchase the tools and machinery [ ]

b) The tools and machinery needed are not locally available [ ]

c) Having many tools and machinery attracts thieves [ ]

d) It would be uneconomical to buy all the tools since they are not required all the time [ ]

e) Others (specify) ______________________________

3.2.8 Do you have any maintenance programme for your machines?

Yes [ ] No [ ]

3.2.9 If yes, how often?

a) After breaking down [ ]

b) The machines are serviced regularly [ ]

c) When machine performance deteriorates [ ]

d) When we feel like servicing a machine [ ]

e) Others (specify)______________________________

____

3.3.0 In general, how many customers, on average, is your firm unable to meet deadlines for?

Item number	Name of product	Average number of customers whose deadlines are not met in the last:					
		One day	One week	One month	Six months	One year	Out of customers per month

3.3.1 When a customer places an order what would be the best estimate of number of orders that are delivered without any delays for every ten customers served?

____

____

3.3.2 What would you describe as the main reason for not being able to deliver customers orders in time rather to what extent attribute failure to meet dead lines to the following reasons?

(Use a 5-point rating scale, where 1= no extent at all and 5=Very great extent)

	1	2	3	4	5
a) Delayed delivery of materials from our suppliers	( )	( )	( )	( )	( )
b) Break down of our machinery	( )	( )	( )	( )	( )

		1	2	3	4	5
c)	Workers absenteeism	( )	( )	( )	( )	( )
d)	Injuries	( )	( )	( )	( )	( )
e)	Many orders from different customers	( )	( )	( )	( )	( )
f)	Others (specify) ______________________________	( )	( )	( )	( )	( )
	______________________________					

Section 4: Technology diffusion

4.1.1 From which of the following sources do you get new ideas for product making?

a) Research Institutes [ ]

b) Participation in Research [ ]

c) Non Governmental Organizations (NGOs) [ ]

d) Government Training [ ]

e) Friends or Colleagues [ ]

f) Others (specify) ______________________________________

____

4.1.2 Do you carry out any research activities?

Yes [ ] No [ ] Somewhat [ ]

4.1.3 What are the main objectives of your research?

a) To produce better products [ ]

b) To improve on quality of products [ ]

c) To increase sales [ ]

d) To be more competitive [ ]

e) Others (specify) ______________________________________

____

4.1.4 Who finances your research programme?

a) Government (specify Ministry) ☐

b) NGO's or donor bodies (specify) ☐

c) Research institutions (specify) ☐

d) Self ☐

e) Others (specify)________________________________

____

4.1.5 Do you do any research on product development?

Yes ☐ No ☐

4.1.6 If yes what impact has this research had on the final product?

i) Change in the number of quantities produced:

Item number	Name of product	Average quantities before research per day	Average quantities after research per day

ii) Change in the number of defective products.

Type of defect	Initial frequency per:			Frequency after research per:		
	Day	Week	Month	Day	Week	Month

iii) Operation scheduling improved

Number of jobs finished in time before research per:			Number of jobs finished in time after research		
Day	Week	Month	Day	Week	Month

4.1.7 Which route of training did you follow before you got into self-employment?

a) Below standard eight ⟶ self-employment. [ ]

b) Standard eight (complete primary education) ⟶ self -employment. [ ]

c) Standard eight ⟶ Vocational training ⟶ self- employment. [ ]

d) Complete general education (Secondary level) ⟶ self-employment. [ ]

e) Complete general education ⟶ tertiary training ⟶ Self employment [ ]

f) Complete general education ⟶ Tertiary training ⟶ Wage employment ⟶ Self-employment. [ ]

g) Complete general education ⟶ enterprise based training (formal sector) ⟶ Self-employment [ ]

h) Complete general education ⟶ enterprise based training (Formal) ⟶ Wage employment ⟶ self –employment. [ ]

i) Complete general education ⟶ vocational training ⟶ Self employment [ ]

j) Complete general education ⟶ Vocational training ⟶ Wage employment ⟶ Self employment [ ]

k) Complete general education ⟶ enterprise based training (informal sector) ⟶ self- employment. [ ]

l) Complete general education ⟶ Enterprise based Training (informal) ⟶ Wage employment ⟶ self-employment. [ ]

m) Others (specify) ____

____

4.1.8 Given below are the possible routes for workers entrance into the informal sector:

A = Below standard eight ⟶ Self employment.

B = Standard eight (complete primary education) ⟶ Self employment.

C = Standard eight ⟶ Vocational training ⟶ Self employment.

D = Complete general education (secondary level) ⟶ Self employment.

E = Complete general education ⟶ Tertiary training ⟶ Self employment

F = Complete general education ⟶ Tertiary training ⟶ Wage employment ⟶ Self employment

G = Complete general education → Enterprise based training (formal) → Self employment.

H = Complete general education → Enterprise based training (formal) → Wage employment → Self employment.

I = Complete general education → Vocational training → Self-employment.

J = Complete general education → Vocational training → Wage employment → Self employment.

K = Complete general education → Enterprise based training (informal) → Self employment.

L = Complete general education → Enterprise based training (informal) → Wage employment → Self employment.

M = Other (Specify)____

____

Give the number of your employees who have passed through each route as described above:

Route	Number of employees
A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
Total	

4.1.9 Do you have any training programme for your employees?

Yes ☐ No ☐

4.2.0 If yes, at what institutions and/or organizations do they un

____

____

4.2.1 Has the above training programme for your staff b

organization?

Yes ☐ No ☐

If yes to what extend has the training influenced the perfor

given below to complete the table).

Types of training/institutions	Skills acquired	Rating of em after training
		Out put

d) Delivery of products at the required time [ ]

e) Others (specify) ______________________________

____

4.2.4 To what extent do you acquire knowledge or skills for ma each of the following? Use a 5-point rating scale (wher extent):

	1	2
Research institutions e.g. polytechnics	( )	( )
Participation In research	( )	( )
NGOs or donor bodies	( )	( )

4.2.5 Which of the above products did you learn to make through use of knowledge or ideas from the following:

Research institutions

Participation in research

Government training

Colleagues

Others (specify below)

4.2.6 Which products have you learned to make better as a result of ideas or skills gained or learned from the following:

Research institutions

____
____
____

Participation in research

____
____
____

NGOs

____
____
____

Government training

____
____
____

Colleagues

____
____
____

Others (specify below)

____
____
____

Section 5: Limitations of current Technology diffusion methods

5.1.1 Do you encounter any problems while getting new ideas for product making?
Yes [ ] No [ ]

5.1.2 If yes in 5.1.1 above, which of the following problems do you encounter?

a) Research institutions not willing to share ideas [ ]

.1.3 Fill in the table below by the group description of your employees (as in 3.1.8 above) to show how they perform in their day-to-day production activities at the work place; write the affected groups in the columns marked with *

FACTOR	Does not yet meet requirement		Needs some improvement		Meets job requirements		Good performance		Excellent performance	
Out put	* Slow		*Reasonable but not yet up to standard		Satisfactory out put to standard		Works hard Gets through most of the work		Exceptionally quick and Industrious worker	
Quality/accuracy	*Inclined to make mistakes. Needs checking/close supervision		*Makes only few mistakes. Work reasonable.		Reliable and accurate. Very few mistakes. satisfactory		Good worker Completely reliable and accurate.		Unusually good	

.1.4 Do you have any problem in getting qualified and skilled manpower?

Yes ☐ No ☐

.1.5 If yes, in which of the following areas are you lacking the required staff?

a) Supervision of production processes ☐

b) Production ☐

c) Quality control ☐

d) Maintenance ☐

e) Packaging and labelling ☐

f) Sales and marketing ☐

g) Purchasing ☐

h) Finance and accounting ☐

i) Others (specify) ______________________________
____
____
____
____

5.1.6 Do you ever employ staff from other firms (say your competitors)?

Yes ☐ No ☐

5.1.7 If yes in 5.1.6 why?

a) When the given person has particular skills required at our work shop ☐

b) Because we are unable to train our own staff ☐

c) We don't like training staff ourselves ☐

d) Any other specify
____
____
____

5.1.8 If No in 5.1.6 why?

a) We don't like dealing with people who have worked with our competitors ☐

b) We have the best training program and thus only staff trained in our firm can be accepted. ☐

c) It is expensive to hire an already trained person. ☐

d) Any other (specify)
____
____
____
____

5.19 How often do you consult with experts in the metal working sector?

a) We consult whenever we are developing a new product or improving the design of the old one ☐

b) We consult when ever our personnel is not able to handle the problem at hand ☐

c) We hardly consult ☐

d) We have never consulted ☐

e) Any other (specify)

____

____

____

5.2.0 If you rarely or never consult what are the reasons?

a) Most of our products never change their design ☐

b) Consultancy is very expensive ☐

c) Ideas derived form such consultancies are hard to implement or rather impractical ☐

d) We have not come in contact with such services yet ☐

e) Any other ____

____

____

5.2.1 Have you ever had difficulty in implementing a new idea, design, copying a product seen elsewhere or adopting a new technology?

Yes ☐ No ☐

5.2.2 If yes why?

a) It took a long time for my staff to understand the new technique involved ☐

b) We hard to hire more skilled staff to realize the objective of the new technology ☐

c) Any other (specify)

____

____

____

5.2.3 Have you ever send your staff to seminars, conferences or training workshop?

Yes ☐ No ☐

5.2.4 If yes, who organized the seminar(s) or workshop(s)?

a) University /college or polytechnic (give the names of the institutions) ☐

b) Government ministry or department (give the names) ☐

c) Union or association (give the names) ☐

d) Non governmental organization (give the names) ☐

e) Individuals' initiative (give the names) ☐

f) Any other (specify)

____

____

____

5.2.5 What is your overall assessment of the seminar(s) attended ?

a) The seminar was poorly organized explain ☐

b) The ideas discussed in the seminar were not feasible ☐

c) The seminar presented good ideas but they did not take enough time to explain/help us understand fully ☐

d) The seminar discussed only things that we were already practicing and thus we had nothing new to learn ☐

e) The ideas discussed were obsolete ☐

f) Any other (specify)

____

____

____

5.2.6 In a brief statement how would you like such seminars, conferences or workshops to be conducted so that they can be of more value to the informal metal working sector.

____

____

____

5.2.7 If the ideas discussed in the seminar were not feasible what could be the reason for this?

a) The technology involved was too expensive to adopt ☐

b) My staff could not comprehend the ideas presented ☐

c) The equipment involved is not available locally ☐

d) Spare parts for the equipment was not readily available and thus we could not take the risk ☐

e) Any other

____

____

____

5.2.8 Do you have other informal/formal sector firms with which you work closely?

Yes ☐ No ☐

5.2.9 If yes which one(s)?

Name of firm	Classification (formal/informal)

5.3.0 If No what are the reasons for not working closely with others?

a) They are our competitors ☐

b) We want to protect our ideas ☐

c) We believe we can not learn any thing new from them ☐

d) We have never had any firm willing to co-operate with us ☐

e) Any other

____

____

____

____