

Conceptual Design in Metalworking Microenterprises: An Empirical Study in Tanzania

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Abstract

Product design is a key aspect of human intelligence and creativity, attracting not only experts but also workers and self-employed without any formal design training. Although numerous people in developing countries design and manufacture simple products in metalworking microenterprises, there is very little systematic knowledge about their design process. This paper aims to fill this gap in design knowledge. We aim at investigating some aspects of design process in the metalworking microenterprises in Tanzania. The findings reveal how they identify needs, and generate and evaluate concepts.

Keywords: design practice, conceptual design, design creativity, informal sector, developing countries

1. Introduction

The products that surround us — furniture, electronic gadgets, kitchen utensils, bicycles, etc. — are outcomes of design processes. These design processes have a major impact on our well-being and on the economic growth of enterprises designing and manufacturing products (e.g. [Papalambros, 2015](#)). Although people who are formally trained in designing products might have highly developed design abilities, those without such training also possess some aspects of design ability (e.g. [Cross, 2006](#)).

An accumulating body of research shows that design processes provide maximum scope to create successful products (e.g. [Ulrich and Eppinger, 2007](#)). The growing scientific discipline of ‘design research’ aims at developing deeper scientific knowledge about design processes (e.g. [Papalambros, 2015](#)). In order to develop this knowledge, there is a profound need to study design processes in many fields, including informal microenterprises in developing countries. Knowledge about the design process in informal microenterprises is also important to develop effective methods and training programmes to assist them in designing more successful products, and thereby in supporting their income opportunities and wellbeing. Over the last three decades, researchers from several disciplines — such as anthropology, economics, sociology, etc. — have studied the informal sector. About one-third of the global non-agricultural workforce has a main job in an informal enterprise (e.g., [Williams et al., 2015](#)). Previous studies estimate that microenterprises constitute a large proportion of the informal sector. A microenterprise typically employs fewer than 10 people ([GDRC, 2020](#)), and most of them are involved in the manufacture of some kind of products (e.g., [Donaldson, 2006](#); [Kabecha, 1998](#)).

In general, there is limited design research in developing countries ([Jagtap et al., 2014](#)) and virtually no systematic knowledge about design processes in microenterprises. Most design research focuses on developed country enterprises (e.g. [Cross et al., 1996](#)), which in fact are distinctly different from informal microenterprises in developing countries (e.g. [Jagtap, 2019a](#); [Donaldson, 2006](#); [Nichter and Goldmark, 2009](#)).

The purpose of this research is to fill this gap in design knowledge through a qualitative investigation of how metalworking microenterprises operating in the informal sector of developing countries design products. To address this overall goal, we intend to address the following key questions. (1) How do informal metalworking microenterprises identify consumer needs and requirements? (2) How do they generate and evaluate alternative product concepts, and define product details such as materials, finishes, etc.? To address these questions, semi-structured interviews were carried out in ten informal metalworking microenterprises in Tanzania.

2. Methodology

Many design studies have used interviews to explore many different topics (e.g., Jagtap, 2021). In this research, we conducted interviews to investigate how informal metalworking enterprises identify customers' needs and requirements, and to investigate how they generate and evaluate product concepts and specify product details. In the paragraphs that follow, we provide information on sampling, data collection and data analysis, while taking into account the constraint on the number of pages.

Table 1. Firm attributes and information on two participants from each firm

	Firm attributes			Information on participants (two from each firm)		
	Firm age (years)	Products manufactured	Staff	Education	Age (years)	Total experience (years)
1	1-5	Agricultural machines, metal windows, door frames, etc.	4	Bachelors degree (engineering) and O level	26-30, 31-35	1-5, 1-5
2	1-5	Agricultural machines, door frames, etc.	3	Bachelors degree (engineering) and Vocational training	26-30, 16-20	1-5, 1-5
3	15-20	Furnitures (metal and wood), tables, chairs, beds, couches	4	Vocational training and STD II	26-30, 21-25	6-10, 1-5
4	5- 10	Furniture (chairs, bed frames), doors, shoes-stands, window grills	5	Both subjects - Primary School leaving certificate	26-30, 21-25	6-10, 1-5
5	10-15	Door and window grills, furniture	3	Both subjects - STD VII	31-35, 21-25	11-15, 1-5
6	1-5	Aluminium windows, doors, aluminium-frame furniture	6	Both subjects - STD VII	21-25, 26-30	6-10, 1-5
7	5- 10	Charcoal stoves, barbeque ovens, water gutters, metal suitcases	2	Both subjects STD VII	26-30, 21-25	6-10, 1-5
8	5- 10	Bed frames, door grills, steel gate	2	Bachelors degree (business administration) and STD VII	31-35, 15-20	6-10, 1-5
9	1-5	Door and window grills, bed frames, chair/couch frames, movable kiosk	4	Both subjects - STD VII	21-25, 21-25	1-5, 1-5
10	1-5	Chicken feeding utensils, charcoal stoves, metal suitcases	2	Both subjects - STD VII	26-30, 11-15	6-10, 1-5

We used direct communication and chain referral sampling to recruit participants from ten informal metalworking microenterprises in Dar es Salaam and Coastregions of Tanzania (e.g., Bryman 2004; Jagtap, 2018). Table 1 presents information on the ten firms as well as participants in the study. We used random sampling technique to select the interviewed firms. Therefore, the interviewed firms were chosen randomly to avoid biased representation of the total population and to ensure that the results obtained from this study approximate that of the entire population. The firms have manufactured a broad range of products such as agricultural equipment, furniture, window grills, doors, charcoal stoves, barbeque ovens, water gutters, kitchen utensils, etc. Figure 1 shows a few

examples of products manufactured in the firms. All the participating firms are informal microenterprises, with less than ten employees. Semi-structured interviews were conducted with two participants from each of the ten microenterprises (e.g., Gray, 2013; Breakwell, 2006). Whilst two subjects from each firm participated in the study at the same time, one served as a spokesperson and the other as a resource personnel. It is imperative to point out that the focus of this qualitative research was not to gather individual opinions of the interviewees, but rather was on understanding actual design practices in the firms. It was therefore important to corroborate the accounts given by involving a resource person during the interview session to provide clarifications, etc. whenever required. As such, 20 subjects—who routinely meet clients and subsequently design products—participated in the interviews. Of the 20 subjects, three hold bachelor's level degrees. Most of the participants have completed primary or secondary school education, and lack formal design training. All participants are males.

All participants were interviewed at their place of work. This permitted informal observation of their working culture and practices. The mean duration of the ten semi-structured interviews was approximately 58 minutes, excluding briefing and debriefing. Before each interview, we followed the process of seeking informed consent. The subjects consented first to participate in the study. They also gave consent to audio-record the interview for transcription and analysis.

The conversations during each interview centered around a particular project involving design and manufacturing of a product. The discussions focused on objectives and outcomes of the project as well as experiences of using methods and techniques in those projects, including identification of customers' needs and activities of concept generation and evaluation. The discussions also considered how they specified product details such as dimensions and materials of various components and assemblies. All interviews were conducted in the local language 'Swahili'. Audio recordings of all interviews were transcribed and then translated into English. The translated transcripts were then analysed using a general inductive and iterative approach (e.g., Gray 2013). The analysis of the data was content-driven, with the aim of investigating how the firms identify customers' needs, how they engage in conceptual design, and how they specify materials and dimensions of product concepts. In the data analysis, we also examined various methods and tools they use in these activities. The findings of the analysis are presented in the next section.



Figure 1. Some examples of products manufactured in the microenterprises

3. Identification of Consumer Needs and Specifications for Products

Informal metalworking microenterprises in which interviews were conducted routinely design, manufacture and assemble basic simple products made from sheet metal and various types of steel and aluminium profiles. There is little knowledge about how they identify the needs and formulate the requirements and specifications for their products. This part of the interview aimed to fill this gap in design knowledge by investigating how this early-stage design process progresses in these firms. Specifically, the goal was to explore and understand how the designers elicit the needs and identify requirements, how they interact with customers and document the needs and the requirements, which sources they use to identify the needs and the requirements, how they organize and prioritize the needs and the requirements, how they arrive at the requirements and specifications, and the difficulties they

face in identifying the needs and requirement specifications. Each respondent was asked to respond to several specific questions whilst referring to a particular recently completed new project that entailed working out a new product from scratch.

The conversations during each interview centered around a particular product. The ten products that were referred to during interviews are: foldable multipurpose furniture, special door gate, door with both grill and door top mounted on one frame, aluminium windows and doors, charcoal stoves, window and door grills, movable kiosk, palm oil filter, peanut peeling machine, and chicken feeding utensils. All these products were ordered by customers either as singular units or in small batches, and were developed from scratch. Generally, their development processes entail gathering raw needs data and requirements specification, design, manufacturing and assembling of the final product.

3.1. Elicitation of Needs

Elicitation of needs is the vital early-stage design process whose success depends on the technique adopted and used. The respondents were asked to explain how they identified the needs of the customers. Most of the respondents (five out of ten microenterprises) indicated that the requirements for their products originated from interactions with customers. Some customers articulated their wishes and ideas about the intended products verbally whilst others used sketches, engineering drawings or publicly available pictures to explain how they wished their products to function or be like. Two out of ten respondents (i.e., microenterprises) indicated that the requirements for their products were derived from existing competitors' products, whose pictures were used as stimuli for discussion. Having seen pictures of existing competitors' products, customers specified new additional requirements and features, which were in turn incorporated in final designs. One microenterprise indicated that they started with a small set of key requirements derived based on their own past experiences and expert judgments, and then produced a physical prototype which was subsequently showcased to potential end-users. The requirements list was eventually finalized by coalescing the initial set of requirements and the set of requirements obtained from potential end users.

The main technique used to reach out to customers was visiting them at their sites, which allowed for interactions to happen at the actual product "use environment". Specifically, the majority of the microenterprises (eight out of ten) indicated that they visited customers either at their own locations or interacted with customers when they visited the firm or during public exhibitions. As for the number and nature of visits, the respondents indicated that between two and three outgoing and incoming visits took place per project. Two respondents indicated that they paid three visits, while three indicated that they paid two visits. Three respondents indicated that interactions with the potential customers and end-users occurred entirely during exhibitions either at the firm's premises and during scheduled national exhibitions.

3.2. Scenarios of Interviews with Customers

Interviewing customers is the technique which is commonly used to gather needs data. It provides an opportunity for the firm to meet the customer and get a glimpse into the wishes and knowledge of how they would interact with the product. Five out of ten respondents indicated that meetings with their customers entailed hosting them at their premises and holding one-on-one discussions on various aspects of the product such as the dimensions, aesthetic features, cost and delivery time. Three out of ten respondents indicated that meetings with their customers took place during public exhibitions and at the firms' premises where they showcase their products with a view to gathering feedback on the acceptability of products, while two out of ten respondents indicated that they visited customers' locations to be acquainted to the use environment of the product and to take measurements. Overall, the interactions and conversations with customers helped the firms gather first-hand needs data, which was subsequently used as the basis for formulation of requirements and specifications for the product.

The interviewees were also asked to indicate how the conversations with the customer were documented. Four out of ten respondents indicated that they took notes and drew rough sketches; and two respondents, apart from notes, took photos during their conversations. Four out of ten respondents did not document their conversations. They only listened plainly and recollected the discussions later on. When asked to show the documentations, only one out of ten respondents showed simple sketches

used during conversations. The respondents indicated that this was due to the absence of a culture of documenting and archiving conversations or keeping minutes of the meetings with their customers in their firms and nonexistence of enforcing operational guidelines.

On the kinds of documentations used to describe requirements, three out of ten respondents indicated that they regularly used hand-sketches complemented with hand-written text; and three out of ten respondents indicated that they used pictures of products accompanied with hand-written notes.

3.3. Sources of Requirements

It is well understood that requirements typically originate from different sources. We asked the informal metalworking microenterprises which sources, other than the techniques mentioned in above Sections 3.1 and 3.2, they used to identify requirements. Standards, past experiences, technical constraints, and expert knowledge were also the main sources of requirements. Five out of ten respondents indicated that brainstorming was also the main method used to identify requirements.

Furthermore, interviewees were asked to indicate if the identified requirements had any political, economic, social, technological or legal association. Apparently, most requirements had technological, social and economic associations and none had political association.

3.4. Organization of Requirements

After collecting raw needs data and formulation of requirements, it is common practice to organize and to prioritize requirements. The respondents were asked to enlist the requirements they identified. The interviewees enlisted between four and eight requirements. The requirements were not formally documented. The respondents merely listed those which they could recollect. Most of the requirements listed were neither specific in terms of describing the qualities or quantities associated with the product nor worded properly. Wording of requirement statements varied from implied to strict. The specification requirements describing cost and product's affordability, functionality of the product and dimensional quantities featured in the lists provided by all respondents.

Furthermore, we also wanted to know whether the requirements were organized and prioritized. Six out of ten microenterprises indicated they organized and prioritized the requirements. Priorities were determined in consultation with the customers. Requirements that were given higher priority by most customers were those that describe functionality and dimensions of the products.

3.5. Difficulties Faced in Identifying Needs, Requirements and Specifications

Identification of needs and formulation of requirements and specifications for products is typically a painstaking and tedious early-stage design process. Informal metalworking microenterprises were asked to indicate the major difficulties they faced in identifying the needs. There were varied responses to this question. Whilst most respondents indicated there were no major difficulties, two respondents indicated that their customers only itemized the needs superficially and could not specify the values associated with some requirements or specifications. The firms addressed this difficulty by first producing initial sample products and used them as stimuli for invoking discussion with customers. Also, two respondents indicated that the needs identified and the requirements specified by the customers were unmeetable due to limitation of capabilities of manufacturing equipment in their enterprises. This was resolved by embracing the needs and requirements, and subcontracting some of the manufacturing operations. One respondent indicated that:

“... it was rather a monotonous undertaking ... we spent significant amount of money ... it took a very long time to gather right requirements.”

Another interesting observation was that one customer disputed some of the technical requirements for the product citing economic reasons. All these technical requirements described issues that had to be considered and addressed fully to successfully complete the project. Therefore, the informal metalworking microenterprise had to delve into educating the customer on the consequences of not meeting the technical requirements in question, and the customer eventually embraced them.

4. Generation and evaluation of concepts

This section presents the findings about how the informal microenterprises generate and evaluate concepts.

4.1. Generation of alternative product concepts

Three firms reported generating up to four alternative concepts. According to one firm,

"For this project, there were at least two alternative concepts for each sub function which were derived from the existing products. This was actually done by the clients."

One firm reported doing multiple iterations for one concept. The remaining firms did not generate alternative concepts, as according to them, the solution was either standard or provided by the client. They also mentioned that the client ordered the product from the existing products made by the firm that closely matched their requirements, so ideation was not required.

"The clients visited our showplace and chose the product that closely matched the products they envision."

The following two excerpts from the transcripts exemplify the discretionary outlook of these firms towards the ideation phase of design process:

"Four alternative concepts were generated, namely ovens with single or multiple ovens and differing appearances."

"After gathering requirements, I took measurements (overall dimensions), agreed on other requirements such as appearance, cost; and then manufactured the product straight away."

For ideation, these firms drew inspiration from web resources such as YouTube (six firms) and Facebook (seven firms), existing competitor's products (seven firms) and discussion with colleagues. All the firms accessed the Internet using mobile phones due to affordability and mobility reasons. None of the firms reported using the design methods such as brainstorming. For concept representation, all the firms used concept-sketches, three firms used AutoCAD and one firm used clay models.

4.2. Evaluation of alternative product concepts

As mentioned earlier, most firms (seven firms) did not generate alternative concepts. So concept selection was not required. The remaining firms that did concept generation, grounded concept selection on the following attributes: a) cost; b) functionality; c) durability; and d) attractiveness. According to one interviewee,

"In this project, the final concept was selected by the client after being shown pictures of alternatives and discussions on associated costs. Concepts for the frame were selected by the client by considering cost."

Overall, the client's preference decided the final concept, and cost was a major criterion in finalizing the concept.

4.3. Definition of product details

Selection of Materials: All the firms reported that material cost was a major criterion for material selection. The other criteria were functionality and availability. For most of their projects, all firms except one reported using the steel and aluminium tubes of square and circular cross sections. One firm reported using scrap material only.

Determination of Dimensions: Six firms reported that the critical dimensions were taken by visiting the site and the remaining dimensions were decided based on the past experience.

“The main dimensions of window and door grills were taken on site. Decoration feature dimensions were established based on experience.”

Two firms reported that their product is standard, so they are using the dimensions of the existing products.

“We used standard dimensions for stoves that conform with the dimensions of the pots and other commonly used home cooking utensils.”

Two firms mentioned the use of ergonomic standards, ease of maintenance and assembly, as well as technical skills as the key factors in deciding the product dimensions. They also reported the difficulties in arriving at the new dimensions. As quoted by an interviewee,

“A customer can bring a drawing or a photo which can either be smaller or larger. By just looking at the photo, it makes you wonder what the actual dimension of the product are, in order to fabricate the intended product.”

A probable cause of this difficulty might be that these firms are unaware of the design methods such as QFD which systematically convert customer requirements into the product specifications. Further, as the clients are unwilling to pay more, these firms have to negotiate with them on the product cost and the product dimensions. For this, they revise the concept, choice of materials and the size of the product after discussion with the client.

5. Discussion and conclusions

In this work, we investigated the design process followed by informal metalworking microenterprises with a view to understand how these firms identify customer needs and requirements, generate and select concepts, select materials and dimensions, and use design tools and methods.

Just like in well-established firms, the designers in informal metalworking microenterprises seek to ensure that the eventual final products meet the real needs of customers derived from the actual “use environment” of the products and that the products are affordable. Therefore, these firms strive to ensure that the needs are exhaustively identified. Traditionally, needs elicitation in well-established firms is a structured process, which typically has four distinct steps, which are (i) defining the scope, by writing mission statement; (ii) gathering raw data through methods such as interviews, focus group discussions, and observation; (iii) interpretation of raw data and formulation of needs statements; (iv) ordering of wishes and establishing hierarchy and importance of needs by using methods such as surveys and weighing factor to distinguish the importance of each wish numerically. This study, however, revealed that elicitation of needs is undertaken in unstructured ways in most of the surveyed informal metalworking microenterprises. Needs are identified without following any explicit and recognizable order of execution of activities.

In these microenterprises, activities such as gathering of needs data through interviews and observations, data interpretation, organization of wishes and establishing hierarchy and importance of needs prevailed in the early-stage design processes, but only instinctively. The information gathered during this study does not point to any particular patterns or steps being followed during needs elicitation and analysis. It is widely argued that structured methods and disciplined approaches usually deliver better results (see, e.g., [Opiyo et al., 2002](#)), and could therefore enable identification of exhaustive sets of needs and wish lists. Disciplined approaches would have provided consistency in managing and controlling the execution of needs elicitation and analysis activities and ensure that essential guidelines and best practices are followed.

As for concept generation and selection, choice of materials and dimensions, it has been determined in this study that the majority of the microenterprises adapt existing solutions to address client’s requirements. Concept generation and concept selection are done informally and are deemed as optional design tasks. Informal hand-drawn concept sketches seem to be widely adopted means of concept representation. Just a few microenterprises use CAD tools. Methods such as clay modelling, paper modelling seem to be unknown to designers in these microenterprises. Existing products, YouTube and Facebook are the key resources for idea stimulation. Cost seems to be the governing

criteria for most decisions on the design process and the final product. Functionality seems to be another important product attribute in design processes. It has also been found that critical dimensions are determined by visiting the site, while the other dimensions are determined using prior experience or referring to the existing products. Generally, the customer has the final say in determining the solution with regard to the materials and product features. The designers in these microenterprises seem to be aware that 'innovativeness' involves attributes like newness, uncommon features, different features – the attributes identified as the key characteristics of novelty by the researchers (see, e.g., Sternberg and Lubert, 1999; Shah et al. 2003; Jagtap, 2018). They also seem to be aware of function and sub function concepts.

This study revealed a number of shortcomings in the processes of identification of consumer needs, requirements, specifications, and concept generation and selection in the surveyed informal metalworking microenterprises. The main inadequacies are discussed below.

Absence of Mission Statements: It was observed that all design processes of the products that were referred to during interviews did not entail writing mission statements. It is typically desirable to define the scope of the product development effort by writing a project's mission statement. Usually this is a brief description of the intended product, which specifies key business goals, target market(s) and secondary market for the product, assumptions that constrain the development effort and the stakeholders of the product such as the end-users and retailers.

Over-reliance on One-on-One Interviews: One of the findings of the study is that in most of the metalworking microenterprises, gathering raw needs data from customers was conducted mostly by using one-on-one interview method. The one-on-one interview method have some drawbacks (see— e.g., Bryman 2004; Breakwell, 2006) including, e.g., sample size being limited by the number of qualified interviewers and the area in which interviews were conducted, interviewers' biases that could have influenced responses, and reliance of quality of data on the capability of the interviewers. These drawbacks could have been circumvented if other methods such as focus groups with selected customers, surveys, and customer selection matrix would have complementarily been used.

Inability to Capture Verbally Inexpressible Needs Data: Eliciting needs data in the surveyed informal metalworking microenterprises entailed: (1) using one-on-one interview technique and stimuli such as pictures, sketches and engineering drawings of existing competitors' products, and/or (2) letting the customer interact with the product with a view to e.g., performing some tasks to understand how it will function or be like. It was, however, difficult to identify needs and requirements that describe sensory experiences of the intended products such as comfort or style. This may be down to over-reliance on the one-on-one interview technique which can hardly capture needs data associated with sensory experiences.

Dependence on Particular Documentation Method: The information generated during interactions with customers were documented in the form of textual notes and hand-sketches on paper in the few informal metalworking microenterprises that document interactions. Most respondents had smartphones equipped with powerful apps and tools which could have also been used to produce audio, video and photographic documentations of the conversations.

Ambiguity of Needs Statements: Apart from customers' verbal statements which were in some instances complimented with sketches and pictures, it is difficult to establish what other kinds of raw needs data were collected, how informal metalworking microenterprises interpreted raw needs data into needs, and if the needs were interpreted as specifically as the raw data. Furthermore, in some microenterprises, needs were not expressed as attributes of the products and the statements were improperly worded. Some of the needs were not expressed in terms of what the product has to do, but on the contrary, in terms of how the product might function.

Hunch-based Needs Prioritization: The processes of organizing and establishing the relative importance of needs are also conducted in an undisciplined manner. In well-established firms, organization of the needs into a hierarchy is conducted in a structured way by following particular steps. For instance, each need statement can be printed on a separate card or a self-stick note, and redundant statements are then eliminated, the cards grouped according to the similarities of the needs they express, and the needs are eventually reviewed and the statements organized. Lastly, the relative importance of the needs has to be established by involving customers in ranking the importance and

criticality of the needs. The surveyed informal metalworking microenterprises indicated that they establish the importance of needs partly by involving customers. Prioritization in these enterprises is done by designers, and is typically hunch-based. Hunch-based prioritization leans heavily on the individual experiences and judgements, and there is therefore vulnerability of emotions or insufficient experience clouding judgements.

Fortuitous Formulation of Requirements and Specifications: It is typically expected that requirements and specifications for the products—with appropriate metrics, units, and particular values—should be formulated after identifying the needs. Ideally, informal metalworking microenterprises are supposed to translate needs into requirement statements that describe how the product will be like and function from a technical standpoint and into the specifications for the product. Tellingly, one of the main observations in this study is that interviewees could not even differentiate amongst needs, requirements and specifications—highlighting severe lack of design knowledge in informal metalworking microenterprises. Vague sets of wishes of the features that customers wanted to be embodied in the product were interchangeably referred to as needs, requirements, or specifications during the interviews.

Unawareness of Design Methods and Tools: The designers in the surveyed informal metalworking microenterprises seem to be unaware of the widely used design methods and tools such as Brainstorming and QFD.

The findings show that the broader socio-economic context in which the microenterprises operate has an influence on the types of products they design and on the ways in which they undertake design activities, including their use of design methods. In summary, it is widely acknowledged that the designers' understanding of the needs and the requirements that describe how the product should be like and how it should function and interact with its environment early on in the design process and the way they generate and select concepts is vital for ensuring quality and for the success of the eventual product in the marketplace (see e.g., [Opiyo, 2016a](#), [Opiyo, 2016b](#), [Opiyo, 2017](#)). Needs elicitation, formulation of requirements and specifications, concept generation and selection, choice of materials and dimensions in the surveyed informal metalworking enterprises are generally undisciplined processes without any particular distinct steps or recognizable sets of activities. Interestingly, all surveyed firms skipped the specification stage. The few specifications for the products enlisted by interviewees popped up either incidentally, by reusing the specification of the existing products or by taking actual measurements at the use environments of the intended products. Overall, the design process in these informal microenterprises is mostly fortuitous. Such a process might work for simple products. The design of complex products demands the use of systematic design methods to ensure that these products satisfactorily perform their desired functions. According to our experience, formal macro-enterprises that produce complex products, tend to adopt systematic methods and hence provide more innovative design solutions. A comparative study between design processes of macro- and micro-enterprises of Tanzania is a future work. As stated earlier, the fortuitous practices, in informal microenterprises, can hardly lead to formulation of accurate and complete set of specification requirements or generation of suitable design concepts. It is imperative to ensure that needs are first interpreted and translated into requirements, which essentially state the objectives of the product and detailed breakdown of what the product should do and achieve. Specifications should then be quantified through the process that entails identifying a list of metrics and measurement units that sufficiently address the needs and requirements and setting ideal and marginally acceptable target values for each metric. Final set of specifications should subsequently be set by developing models to assess technical feasibility and refining the specifications by making trade-offs. It is also imperative to ensure that the designers are aware of the benefits of using design methods and tools and should be trained and equipped with the necessary skills of using them. Some methods to equip them in using design process are: organization of vocational training, crash courses and hackathons, increased access to computers, design software and mock-up facilities, and incentives for innovative solutions.

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