Effect Of Mode Of Training On Product Quality The Case Study Of Arc Welding In Small Scale Metalworking Enterprises In Kenya

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Abstract

The quality of products from the micro and small enterprise sector is affected by both the entrepreneur's and enterprise's attributes. This paper presents and discusses findings of a study that was designed to investigate experimentally the relationship between the quality of arc welding in the Small Scale Metalwork sub-sector and the artisan's mode of training. Four pairs of groups with a total of 36 with secondary education and 36 with primary education consisting of formally and informally trained artisans from urban and rural areas participated in the evaluation. A mild steel product was fabricated by each participating artisan, assessed and scores awarded based on the quality of arc welding. The analysis of variance (ANOVA) was used to show any variation in the quality of arc welding; comparisons of means using the Least Significant Difference (LSD) at the alpha level of 5% were done to determine which pairs of artisans affected quality significantly. The study found out that informally trained artisans with secondary education working in urban areas exhibited the highest quality of arc welding. The informally trained artisans with primary education working in rural areas exhibited the lowest quality of arc welding. Generally formal training does not have a significant effect on urban artisans, but it does improve product quality of arc welding from artisans in rural areas. The findings of the study provide evidence that formal training can improve product quality from artisans working in rural areas, and therefore more resources should be channelled to training of rural artisans.

Key Words: Modes of Training, Product Quality, MSE, Metalworking sub-sector, Arc welding

1. Introduction

The quality of products from the MSE sector is affected by both the entrepreneur's and enterprise's attributes. Many school leavers, retirees and retrenchees as well as those dissatisfied with formal wage employment resort to entrepreneurial activities within this sector as a means of earning a living. However, the MSE sector entrepreneurs suffer various deficiencies in business management. These deficiencies are attributable to their low education levels and training, which in turn adversely affect their ability to produce high quality products among others. The influence of the entrepreneur's attributes such as age, gender, educational level, mode of training, work experienceand membership to business support groups on the productivity and performance of enterprises has been reported. Similarly, enterprise attributes such as its age, location, ownership structure, and formal status and business activity determine production outcomes (Kimuyu, 2001). This paper discusses the findings of a study that was designed to investigate experimentally the relationship between the quality of arc welding in the Small Scale Metalwork sub-sector and the artisan's mode of training. The understanding and validation of this relationship is important for the effective marketing of the MSE products. While it is accepted that higher education and training is necessary for faster individual development, the same may not necessarily be true for product quality. Many people argue that education levels do not affect the quality of products; what matters is the working experience and training and so far there are no experimental data to support this. It is also believed that the MSE/*Jua Kali* products are of poor quality and thus cannot get regional and international markets. There is, therefore, a need to find out how the artisan's mode of training and other attributes influence the quality of products. In their studies Fluitman (1989), K'Aol (1995) and Ferej (1994) found out that training for skills or management for entrepreneurs in the metalworking sub-sector is provided in an uncoordinated manner through on-the-job training or apprenticeships. Apprenticeship has been identified by many studies as appropriate for the informal sector (Fluitman, 1989; K'Aol, 1995; Ferej, 1994).

According to McGrath *etal*., (1994) enterprise-based training provides a package of technical and other skills that the worker will require in the world of work. Kinyanjui (1997) found out that most of the technical training in the MSE sector (particularly in manufacturing and services) was carried out through the traditional apprenticeship system; according to the study 71% of MSE artisans obtain their skills on-the-job training, 19% in formal training, and 7% from friends; formal training are not deemed to be very important by the small producers - most MSE owners indicated that there was no need for formal training for their workers. Haan (2001) reported that a tracer study of theWorld Bank Training Voucher Scheme (MSETTP)hadfound out the mean sales of MSEs who did not participate in the training decreased by 2% while the mean sales of the MSEs who participated in the training voucher scheme more than doubled: from KSh.8,342 to KSh.18,235 per month. The beneficiaries of the scheme performed better than the control group on almost all variables studied such as assets, volume of sales, and diversification of products, business creation, and

employment creation. This is an indication that organized training significantly improves the performance of the MSEs. More survey results suggest a relationship between the possession of vocational training certificates and income, but weaker than in the case of education(Haan, 2001).However, no experimental study has been carried out in Kenya (both in urban and rural areas) to find out whether the enterprise-based training is superior to formal training conducted by technical institutions or other similar organized programs. Most of the previous studies obtained their data through the use of one or more of the following instruments: questionnaires, desk reviews, observations, interviews, focus group discussions, and content analysis. These studies were either qualitative or survey researches, while the present study was mainly experimental research (with a bit of qualitative using observation as far as the use of welding equipment and welding techniques are concerned to find out which groups – secondary/primary or urban/rural - were proficient or understood the welding process).In arc welding processes the most common defects are either surface defects (cracks, distortion, overlaps and rolls, undercuts, excessive spatter, and bad weld surface appearance) or subsurface (hidden) weld defects. These defects come as a result of:

a) Improper selection of process, for example, using a very deep penetrating heat source on a narrow Vee angle so causing cracking in the root run due to large depth-to-width ratio;
b) Applying the welding process incorrectly for the particular application, such as incorrect current setting or excess weld metal deposition;
c) The interaction of the weld metal with prior defects in the base metal, e.g. laminations and impurities like phosphorous, sulphur, and silicate, etc. that cause brittle and weak zones resulting in lamellar tearing;
d) Undesirable metallurgical structure with respect to grain size and hardness as well as undesirable inclusions such as tungsten oxide and slag. Hydrogen is a most undesirable inclusion as it is often the main cause of cold cracking in steels;
e) Undesirable shape and size of weld bead due to overfill and/or poor profile;
f) Incorrect joint preparations and poor fit-up leading to inaccessibility and lack of fusion, cracking, etc.;
g) Stray arcing, tool marks, undercuts, inclusions, poor finish, lack of fusion and penetration, and incorrect weld shape causing a reduction in fatigue life and joint strength;

All these are consequences of the level of training, experience and equipment used. For one to produce a quality product the sequence of welding techniques commonly used (Parmar, 1997), are:

a) The preliminary operations like cleaning, edge preparation, and the fixing of tab-in and tab-out plates are accomplished;
b) Parts are assembled by tack welding or by employing jigs and fixtures;
c) The assembled work piece is presented to the machine or vice versa;
d) Welding is initiated by striking the arc for fusion welding or by bringing electrodes in contact with the work and switching on the current for resistance welding;
e) Relative movement between the welding head and the work to attain the desired welding speed is created;
f) The welding variables like arc voltage, welding current, and wire feed rate is controlled - controlling the welding variables like arc voltage controls the arc length, welding current, and wire feed rate;
g) Welding process is stopped by stopping the relative movement between the welding head and the work;
h) The welding head is shifted to the position the next welding cycle is to be initiated;
i) The completed work is removed.

1.1 Objectives of the Study

The objectives of this study were to compare the product quality in terms of mean scores from formally trained artisans with the artisans that are trained-on-the-job, both with the following attributes:

i) Secondary education working in urban and rural areas;
ii) Primary education working in urban and rural areas.

2 .Material And Methods

2.1 Sampling

The target population of the study consisted of experienced artisans who had completed class eight of the Kenyan primary education and experienced artisans who had completed form four of the Kenyan secondary education. The artisans were selected both from rural and urban areas with two modes of training (on-the-job training and formal technical training). The Kenyan MSE sector engages about 8.33 million operators (Government of Kenya, 2010). Out of this the *Jua Kali* sector (the MSEs that are engaged in technical work) is about 18% according to the National MSE baseline Survey conducted in 1999. The most widely used welding method is arc welding for mild steel products, and according to the survey the number of artisans engaged in welding and fabrication is about 37,485 (Government of Kenya, 1999). About 60% and 40% of this number comprise primary education class eight graduates and secondary education form four graduates respectively (Government of Kenya, 2004). Based on these figures the total population for primary class eight artisans was taken to be 22,491 and for secondary form four was taken to be 14,994. A total of

36 artisans with primary education class eight and a total of 36 artisans with secondary education form four were selected for assessment. The sample size determination was based on the relation:

$n = \frac{Nc^2}{c^2 + (N-1)e^2}$; where n = sample size, N = population size,

c = coefficient of variation (≤ 30%), and e = error margin (≤ 5%).

This formula enabled the researchers to minimize the error and enhance stability of the estimates (Nassiuma, 2000). In this study *c* was taken to be 30% and *e* to be 5% (using the maximum percentage in each case). Table 1 show the number and category of artisans who participated in this study.

Table 1: Number and category of artisans who participated

Education Level	Attributes	Urban Area	Rural Area	Total
Secondary Education	Formally trained	5	14	**19**
	Informally trained	10	7	**17**
	Total	***15***	***21***	***36***
Primary Education	Formally trained	6	10	**16**
	Informally trained	8	12	**20**
	Total	***14***	***22***	***36***
Total		**29**	**43**	**72**

The Directorate of Industrial Training (DIT) testing centers were used for this research. This was meant to minimize the effect on the quality of the fabricated products due to the condition of the welding equipment; (the welding equipments used in all DIT testing centers are more else of the same working condition).

Table 2: DIT Testing centres and number of participating artisans

DIT Centre (Province)	Education Level	Urban		Rural		Total
		F	**I**	**F**	**I**	
1. NIVTC (Nairobi)	Primary	2	2	0	0	4
	Secondary	2	3	0	1	6
2. Ruaraka (Nairobi)	Primary	1	0	0	0	1
	Secondary	1	2	0	0	3
3. Kakamega (Western)	Primary	0	0	1	1	2
	Secondary	0	0	1	0	1
4. Turbo (Western)	Primary	0	0	4	0	4
	Secondary	0	0	11	1	12
5. Kiambu (Central)	Primary	0	0	2	2	4
	Secondary	0	0	0	1	1
6. Machakos (Eastern)	Primary	0	0	3	7	10
	Secondary	0	0	0	2	2
7.Mombasa (Coast)	Primary	0	5	0	0	5
	Secondary	1	2	0	1	4
8. Eldoret (Rift Valley)	Primary	0	0	0	0	0
	Secondary	0	1	0	0	1
9. Nakuru (Rift Valley)	Primary	0	0	0	1	1
	Secondary	1	0	1	0	2
10.Kisumu (Nyanza)	Primary	3	1	0	1	5
	Secondary	0	2	1	1	4
Total		**11**	**18**	**24**	**19**	**72**

F – Formally Trained; I – Informally Trained (i.e. trained-on-the-job)

The selected DIT testing centers were those with high concentrations of welders, and easily accessible by the researchers. A total of ten (10) DIT testing centers were used as shown in Table 2. Work started at the same time in all testing centers. Research assistants (who had been selected from among the DIT trained examiners) were used to supervise the participating artisans. The independent variable of the study was the mode of training, while the dependent variable was the scores awarded to indicate the quality of the product fabricated by the artisan-using arc welding processes. The effect of mode of training was evaluated by comparing the mean scores of the following groups:

a) Formally and informally trained artisans with secondaryeducation in urban areas.
b) Formally and informally trained artisans with secondaryeducation in rural areas.
c) Formally and informally trained artisans with primary education in urban areas.
d) Formally and informally trained artisans with primary education in rural areas.

Besides the above primary groups, the effect of mode of training was also evaluated by comparing the mean scores of the following combined groups of artisans with different other attributes:

e) All formally and informally trained artisans with secondaryeducation.
f) All formally and informally trained artisans with primaryeducation.
g) All formally and informally trained artisans working in urban areas.
h) All formally and informally trained artisans working in rural areas.
i) All formally and informally trained artisans.

2.2 Data Generation Tools

Two instruments were used to collect the required data. These were:
i) Structured questionnaires, and
ii) Assessment of fabricated product.

The questionnaire was used mainly to get information regarding the artisan's attributes and business characteristics. The participating artisans were generally observed to find out how proficient they were in using the welding equipment and methods/techniques as outlined in the introduction.

2.3 Assessment of Product Design

Drawing a mild steel product shown in figures 1 was used in the research. The welding project was marked out 100%. The product was designed in such a way that most of the welding techniques were to be used in fabricating it.

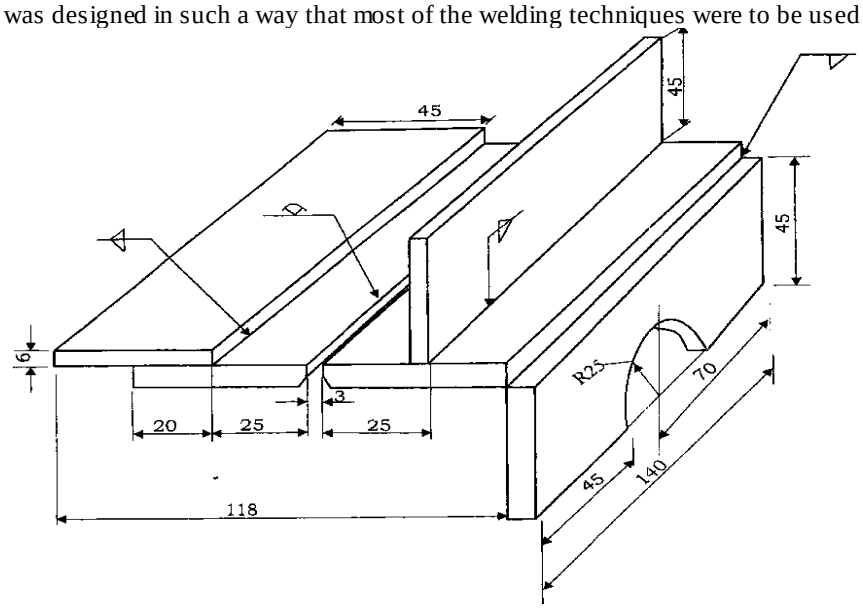

Figure 1: Mild Steel Welding Project

In this study, manual welding was employed; the artisans were given materials in the form of sheets and they were supposed to measure and cut the parts to the sizes shown. The parts were joined together using arc welding processes. The assessment was carried out by checking for the correct part sizes (by using vernier calipers), and examining for the correct part alignment, correct welding and product finish; visual inspection was used to detect surface defects. Careful visual inspection of welds can detect about 80% to 90% of the defects and flaws (Parmar, 1997). The quality of welded joints depends upon the design of the product, the performance of welding equipment, the welding procedures followed, and the skill of the operator. In this study any deficiency in the design and equipment affected all artisans equally. Therefore, the skill of the welder was to determine the scores obtained.

3.Results And Discussion

The data scores collected were analyzed using the Statistical Analysis System (SAS) and excel spreadsheet. The means and standard deviations were generated to describe the quality of arc welding with regard to mode of training. The scores were matched with the artisans' attributes to find their relationships. The analysis of variance (ANOVA) was used to show any variation in the quality of arc welding in each of the eight groups of artisans due to the different treatments, that is, modes of training. Comparisons of all possible pairs of means using the Least Significant

Difference (LSD) method with alpha set at 5% were done to determine which pairs of artisans with quality performances that was significantly different.The eight primary groups could broadly be divided into two: those artisans who were formally trained and those artisans who were trained-on-the-job. A total of 35 participants/artisans who had been formally trained were selected, while a total of 37 participants/artisans who had been trained-on-the-job were selected for this study. The artisans' marks awarded for quality of arc welding provided the data for determining the effects or impact of training on product quality. The objective of the study sought to determine whether there were differences in product quality when using arc welding processes by formally trained artisans and those artisans trained-on-the-job. The specific objective was to find out whether there is any relationship between product quality (quality of arc welding) and mode of training.The analysis of variance was carried out and the results are presented in Tables 3 and 4. Table 3 shows mean scores of product quality for modes of training for primary groups of artisans with the same attributes, and Table 4 showsmean scores of product quality for modes of training from combined groups of artisans with different other attributes.

Table 3: Mean scores of product quality for modes of training for primary groups of artisans with same attributes

Mode of Training	Secondary		Primary		Cumulative Mean Scores
	Urban	Rural	Urban	Rural	
Formal	68.700[a]	69.857[a]	66.583[a]	60.350[b]	**66.41[b]**
Informal	73.450[a]	65.071[a]	70.250[a]	50.875[c]	**63.85[b]**

The means followed by the same letter in the same column are not significantly different at α = 5% using LSD.

Table 3 shows that there are no significant differences in the mean scores of the first three columns. Both formally and informally trained artisans with secondary education perform equally irrespective of their business locations. The same also applies to those artisans with primary education but located in urban areas. However, there is a significant difference in mean scores of the formally trained and informally trained artisans located in the rural areas, with the mean score of product quality from artisans formally trained being higher. The implication from this analysis is that the combined effect of business location and training has very little effect on the performance of artisans with secondary education irrespective of their business locations. In the case of artisans with primary education the combined effect of business location and training has very little effect on the performance of those in urban areas while having a significant effect on those artisans in the rural areas; those informally trained artisans in the rural areas performed poorly. Although the analysis of variance (ANOVA) showed that the combination of education level, mode of training and business location does not have a significant impact on the quality of arc welding, it does affect the informally trained artisans in the rural areas significantly.

Table 4: Mean scores of product quality for modes of training from combined groups of artisans with different other attributes

Modes of Training	Secondary	Primary	Urban	Rural	Overall Mean
Formal	69.55[a]	62.69[b]	67.55[a]	65.90[b]	**66.41[a]**
Informal	70.00[a]	58.63[b]	72.03[a]	56.11[c]	**63.85[a]**

The means followed by the same letter in the same column are not significantly different at α = 5% using LSD.

Table 4 shows that there are no significant differences in the mean scores in all columns except for the rural column. This means that the performance of both formally and informally trained artisans with secondary and primary education, or working in urban areas does not significantly differ. This implies that the mode of training does not have a significant impact on product quality of products from artisans with secondary and primary education, or working in urban areas. However, there is a significant difference in the mean scores in the rural column. This implies that the mode of training has significant impact on product quality of products from artisans working in rural areas. Overall there is no significant difference in mean scores between the formal training and the informal training; however, the formally trained artisans mean score is slightly better than that from artisans with informal training.These results are consistent with the findings of Mullei (2003). In his study on small manufacturing firms Mullei (2003) sought to identify factors that determine firm growth and transformation among small firms in Kenya. The study covered food processing, woodworking, textile and garments, and metal working sub-sectors. The study found out that for an enterprise to graduate from, say micro to small enterprise, the education of the manager/owner and the sector to which the enterprise belonged to, had a significant influence on enterprise graduation. Education was found to have a marginal effect on graduation, probably indicating the importance of vocational training skills (formal training), which are lacking among many small producers. Mullei (2003) also found out that more than half of small producers were

primary school graduates whose ability to assimilate new technologies, innovate and imitate perfectly is limited. The study, therefore, recommends the raising of managerial, vocational and technical skills of small entrepreneurs for long-term industrial development. This shows the importance of higher level of education and formal training.In overall there is no significant difference in mean scores from formally and informally trained artisans, as the last column shows. This further confirms the ANOVA results using SAS which showed that the mode of training has very little impact on product quality from artisans. This also confirms that the combined effect of training and education does not have a significant impact on product quality.

From these analyses it can be concluded that formal training has very little impact on artisans with secondary education or those working in urban areas, but it has a significant impact on artisans with primary education working in rural areas. The formal training improves product quality from artisans with primary education working in the rural areas. Those artisans with secondary education are able to follow the recommended welding techniques better than those artisans with primary education; this was observed during the evaluation exercise. The urban artisans perform better than the rural artisans because they have more exposure and more information, have more work and therefore more experience, more competition, use standard tools similar to those used at DIT centres, better methods of working, more contact with more experienced artisans etc.

Generally artisans formally trained performed better than artisans that trained-on-the-job (or informally trained) in all cases except for those artisans working in urban areas. Artisans that trained-on-the-job working in urban areas performed better than those artisans formally trained irrespective of their education levels. This confirms what Ferej (1994) found out in his study on the entrepreneurial knowledge and skills of apprentices in formal and informal training systems in Kenya, to determine the efficacy of apprenticeships in preparing skilled workers for self employment. He found out that informal sector apprentices were perceived to have acquired significantly higher competency levels than the formally trained apprentices in marketing and technical and operational skills. This study, however, was carried out in Nairobi (urban) through interviews and observations. This could be the reason why it is widely believed in Kenya that enterprise-based training (that is, informal training) is superior to formal training. Most studies on MSEs in Kenya have been carried out in urban areas, where, as this study's results also confirm, the product quality from informally trained artisans is superior to that from formally trained artisans. This study was carried out both in urban and rural areas and went further by categorizing the artisans into eight (8) distinct groups, thus making it more unique in approach.

The study found out that both informally trained artisans with secondary education as well as those with primary education whose businesses are located in urban areas performed better than their counterparts located in the same areas even though they are formally trained. However, it was expected that the formally trained could perform better than those informally trained since they are all working in the same urban areas. From the questionnaires it was found out that more than 60% of the formally trained artisans working in urban areas planned to look for formal employment, while less than 20% of those artisans trained-on-the-job working in urban areas planned to look for formal employment. In the case of those in rural areas the result was different; less than 25% of the formally trained artisans and less than 10% those trained-on-the-job planned to look for formal employment. This means that the formally trained artisans in urban areas are not contented with their self-employment and therefore do not concentrate on their work as much as those without formal training do. This could probably explain why the informally trained artisans in urban areas perform better than the formally trained artisans. The formally trained artisans can easily get formal employment because they hold certificates, while those trained-on-the-jobs find it difficult to be employed in the formal sector without certificates. On the other hand those in the rural areas have very little opportunity for formal employment, which is mostly found in urban areas; hence even those formally trained artisans concentrate on their jobs as much as those without formal training do.

Overall, there is no significant difference in product quality between formally trained artisans and informally trained artisansas evidenced from the last columns of the two tables of mean scores. This implies that training alone does not have a significant impact on product quality.

4.Conclusions And Recommendations

The following are the conclusions of this study:

a) Training alone has very little impact on product quality; however, when combined with business location the impact on product quality is very significant.
b) Formal training can improve the product quality from artisans with lower education working in rural areas.
c) The product quality from informally trained artisans with low education can be improved by either giving them formal training or raising their education level.
d) While formal training improves performance of artisans working in the rural areas, it, however, contributes very little to those artisans working in urban areas.

The following **recommendations** are suggested:

a. More formal training should be given to primary school leavers working in the rural areas so as to raise their product quality to the level of those artisans with secondary education level.
b. Since formal training does not make any significant difference to those working in urban areas, more resources should be channelled to those artisans working in rural areas rather than to those artisans working in urban areas.
c. To further augment the present achievements of this study:

- Research studies should be designed to investigate how other attributes (such as the entrepreneur's age, gender, educational attainment, work experienceand membership in business support groups, and enterprise attributes such as its age, location, ownership structure, and formality status and business activity) affect product quality and/or the performance of the MSE sector;
- Research should be conducted to investigate how the mode of training affect the quality of product quality in other disciplines especially those that are mostly dominated by women, for example tailoring, tie and dye, embroidery, and basketry;
- The study found out that both informally trained artisans with secondary education as well as those with primary education whose businesses are located in urban areas performed better than their counterparts located in the same areas even though they are formally trained. However, it was expected that the formally trained could perform better than those informally trained since they are all working in the same urban areas. It is recommended that further research be conducted to investigate this phenomenon.

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