Keeping Our Markets Open: A Post-Training Evaluation of the Cogni-Constructive Performance on Welding and Fabrication Centrations in the Kenyan Jua Kali Sector Using the Dreyfus Model of Skill Acquisition

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Abstract

COVID-19 mandates and laws after the 2020 outbreak resulted in closure of most public markets in Kenya. The Technical University of Kenya responded to this closure through the "Keep Our Markets Open" initiative which resulted in design of COVID-19 compliant permanent and mobile stall prototypes. The urgency to mass-fabricate these stalls meant integrating NGOKAMKA, an umbrella outfit for Jua Kali artisans into the project, using the "Training on the Job" methodology. The success of this programme encouraged the National Government to mainstream Welding and Fabrication in its flagship projects. This study aimed at establishing the level of competencies of various centrates within the Welding and Fabrication sector and checked if knowledge and skills imparted to the trainees were diffused to their colleagues in their respective workshops. Questionnaires were used to survey fabricators domiciled in government run active construction sites. Levels of competencies for centrates considered core were higher than competencies for centrates considered fringe. This was influenced by factors like repeatability, personal safety, client demand and levels of return. The study recommends measures like improving coherence in training and validation amongst the various bodies, transferring training to the actual workshops and improving collaboration amongst stakeholders.

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Keywords: Jua Kali Sector, Cogni-Constructive Performance, Welding and Fabrication, Centrates, Competencies

Historical Context

When COVID-19 was first confirmed in Kenya on 13th March 2020 (Kairu et al., 2023, p. 2), Kenya adopted drastic protocols to limit the spread of this infection, which included travel restrictions, curfews, prohibition of mass gatherings and social distancing. Workplaces that did not provide essential services were closed and workers instructed to work remotely. These restrictions on movement reduced economic activities across the country which had adverse impact specifically on the lower economic segments of the Kenyan society. Open air markets, having been identified as major's contributor to the spread of COVID-19 due to their congestion, overcrowding and unsanitary conditions, were amongst the first economic activities to be closed down and this had a major adverse effect to the market traders due to their heavy dependence on their daily profits to run their activities and households.

As a response to this challenge, the Technical University of Kenya (TU-K) established a multidisciplinary team drawn from the university administration, academia, technicians, and technologists to provide solutions to these market problems. "Soko Safi" stall designs (TU-K, 2023, p. 1) as part of "Keep Our Market Open (KOMO)" initiative sought to utilise existing market spaces better to resolve the congestion, overcrowding and unsanitary conditions. TU-K engaged other critical stakeholders namely the State Department for Housing and Urban Development and the Nairobi County Government. The team designed and fabricated a responsive market stalls whose capabilities were demonstrated to the National Government. Continuous improvements were done from comments gotten during these presentations and after three demonstrations, two prototypes for permanent stalls (310 units) and one prototype for mobile markets were approved for mass production as shown in figure 1 below.

Type TP.04 – Standard Market Stall

Type TP.01 – Fixed Day Market Stall

Type TM.03 – Mobile Shelf Stall

Figure 1: Three prototypes approved for mass production amongst eleven prototypes registered at the Kenya Copyrights Board.
Source: Author (2024)

TU-K collaborated with the Jua Kali sector in the mass production phase as part of the National Government dual-prong strategy to 1) Mitigate adverse effects of business closure during COVID-19 lockdown and 2) Formally explore the "Training on the Job" concept amongst Jua Kali Artisans. "Jua Kali" refers to the informal sector of traders and small business owners running shops and light industries on the street or in open market spaces in Kenya. NGOKAMKA Group which was appointed to collaborate with TU-K to

fabricate these stalls is a body representing Ngong Road Jua Kali Association, Kamukunji Jua Kali Association and Kariobangi Light Industries Association (Maitei, 2022, p. 41). Since then, Jua Kali Artisans have re-organised and reactivated the Kenya National Federation of Jua Kali Association (KNFJKA) where the NGOKAMKA Group is also a stakeholder. With the continued improvement of Government Policies towards the Jua Kali sector, the federation has been able to secure all Welding and Fabrication works in the flagship Affordable Housing Projects (AHP) that the National Government is currently implementing. The objectives of this research - anchored on these developments –were 1) To establish the level of competencies of various centrates associated with Welding and Fabrication and 2) To establish if the Impact of National Construction Authority (NCA) was being felt amongst the Welding and Fabrication tradespeople.

Practical Training in the Context of Cogni-Constructivism Learning Theory.

Constructivism Theory was pioneered by Giambattista Vico in the 18th century and was clearly developed, mainstreamed and diffused by Jean Piaget in the early 20th century as part of his larger "Theory for Cognitive Development" (Kumar & Gupta, 2009, p. 39). Constructivism Theory states that "Learners do not passively acquire knowledge through direct instructions, but rather they construct their understanding through experiences and social interactions that integrate new relevant information with the existing knowledge" (Barrouillet, 2015, p. 7). Piaget identified four phases of Cognitive Constructivist Development namely:

- Sensorimotor Stage,
- Pre-operational Stage,
- Concrete Operation Stage and
- Formal Operations Stage (Ojose, 2008, p. 3).

The Sensorimotor stage is characterised by 'object permanence' in a person's mind and one would remember how an object, issue, concept or activity looked like even if it was done long ago (Ojose, 2008). In this stage, there are no unitary aspects of self-individuation, but rather, several complex and entangled experiences which influence constructive development (Di Paolo, 2020, p. 5). These experiences include interpersonal interactions, participatory sense making, social interactions, social identification, and social grouping. These experiences are organic, spontaneous and therefore not compelled by rules or formulas. This organic self-individuation is influenced by choices like living standards, clothing standards, education levels, opportunity costs/trade-offs in difficult situations like illnesses, food preferences and overall mode of economic production.

The pre-operational stage is characterised by 'increase in language ability.' This improvement in ability goes on hand in hand with symbolic thoughts, limited logic (Ojose, 2008; Piaget, 1964, p. 2) limited logical cognition (Kanwal et al., 2023, p. 4), memory activation, spatial reasoning, knowledge conservation and imaginative thinking. In this stage, a person is able to comprehend the 'language' through interpreting instructions, images, and actions, thus making it a critical stage since the knowledgeable person is able to impart knowledge and social skills to the trainee making the process unidirectional. When this does not successfully happen, stunting of cognitive constructive growth is normally experienced. To fully master the language, centration – frequency of concentrating to one or small 'language' or concept - is extensively used by the trainee. Continuous centration helps to develop the locus of control where the trainee acquires confidence because they believe that they have mastered their skill and have control over the process.

The Concrete Operational Stage is characterised by explosion of cognitive growth (Ojose, 2008) where the trainee is able to dramatically use the 'language' of instructions, images and actions to fully handle a constructive activity. This stage is characterised by proper use of logic, proper reasoning, problem resolution (Ghazi & Ullah, 2016, p. 4; Tomlinson-Keasey et al., 1979, p. 5) and problem circumvention. Due to this drastic grasping of the 'language,' some form of bi-directional learning takes place where the trainer imparts knowledge and skills to the trainee, who is now confident enough to make queries, and give their alternate opinions which might be right or wrong. Right alternatives are normally adopted in a controlled way, while the wrong alternatives are normally dropped altogether.

The Formal Operation Stage is characterised by the trainee obtaining the highest levels of competitive growth (Tomlinson-Keasey et al., 1979) where the trainee is able to form hypothesis, reason, deduce and infer possible consequences and make concrete decisions, a process broadly known as metacognition (Kuhn, 2008, p. 52). Metacognition include the ability to:

- Clarify - identify and analyse a problem,
- Infer - make deductive and inductive reference,
- Evaluate - use criteria to judge the adequacy of a problem solution and
- Apply - the actual process of solving a real situation. At this stage, there is a high level of bi-directional learning where the cognitive constructive gap between the trainer and trainee is so thin, almost dissolving to a point of the former trainer considering the former trainee to be a peer hence encouraging high levels of peer review, peer feedback, peer interaction, peer engagement and peer critical thinking
- Though they consider one another to be peers, secondary factors like academic levels, professional experience, professional classification, and economic differences play a role in ensuring that the trainer is still at a higher level of the pyramid than the trainee hence some subtle level of control on the extent of bi-directional learning.

While this theory is domiciled on the cognitive development of children, its patterns are consistent with various forms of Cogni-constructive development in apprenticeship training. Apprenticeship training is a practical, vocational form of training where the trainees practically learn non-transferable skills on the job (Daniel et al., 2020, p. 4). This form of training exists in several countries, in various forms and models ranging from structured apprenticeship programmes like VET programmes in South Africa (Mayombe, 2024, p. 132) and NITA programmes in Kenya (Joseph et al., 2023, p. 665) to non-structured, informal apprenticeship programmes which thrive as evidenced by low levels of enrolment in the structured apprenticeship programs after secondary school education (Gewer, 2021, p. 5).

The thriving of informal apprenticeship programmes is caused by factors like informal spontaneous recruitment methods, informal contracting, very flexible training terms, conditions and duration, ability to earn on the job, enterprising nature of the job, the relaxed completion rules and regulations, minimal exposure to statutory bodies that collect fees and taxes. In Kenya, this form of apprenticeship programme is commonly known as "Jua Kali" a loose interpretation of the words "extremely Hot Sun" which ably describes the predominant harsh conditions in which the trainees work in as they acquire the skills. This form of practical training goes through the four stages discussed above but in a mute and quiet way since

documentation through examination does not take place to show successful completion of each stage. This study will highlight these correlations in the context of Welding and Fabrication trade of the Jua Kali sector.

During the Sensorimotor Stage the trainee is regarded as a handyman, called here and there to do various mundane and redundant activities like cleaning the workshop in the evening, collecting metal off cuts, holding onto a piece when they trainer is welding going to the shop to buy items like welding rods, removing the tools, equipment and finished products from the store to the open yard in the morning and returning them in the evening. During this stage, the trainee observes how certain tasks are done but is not even allowed to attempt them. Since the trainee needs to be paid their daily wage, they have to do such redundant tasks that have no direct relation with the training. During the Pre-Operational Stage, the trainee is normally tasked to do fringe, less risky tasks like setting up equipment like welding machines, grinding machines, grinding welded joints under strict supervision and painting undercoats to finished products etc. During this stage, centration takes place in an unplanned manner and trainees with outstanding skills on these fringe tasks are normally recognised and are catalysed to "specialise" in these tasks making them to be ahead of their peers. Once a trainee has been able to prove themself on various centrates / competencies, the trainer gains confidence in the trainee and subconsciously triggers the Concrete Operation Stage.

During the Concrete Operations Stage, the trainee handles complex tasks like reading and interpreting drawings, generating a schedule of materials needed, procuring materials on behalf of the trainer, cutting, bending, and welding metal pieces since the trainer knows that the risks of errors and losses associated with such errors are minimal. The trainer has confidence in the trainee to allow them to do a product from start to finish with minimal supervision. To achieve a win-win situation for both, such trainees are paid on contract terms – the faster you can produce a high-quality product, the more your wage would be - thereby enabling the trainer to minimise micromanagement and spend more time to deal with equally important tasks like customer care, and sourcing for new projects and clients. With this kind of arrangement, the situation seamlessly enters into the ultimate Formal Operation Stage where the trainer fully delegates all Welding and Fabrication activities to the trainee with very minimal or no supervision since the trainee is now as competent as the trainer.

In unique situations the trainer invites the former trainee to be an associate of the outfit and gets rewarded with profits, not wages under predetermined terms and conditions. This forces the new associate to also go out and look for new projects. Where this does not take place and the competent former trainee is retained as a worker just earning a wage, perceptive mistrust sets in. The former trainer starts feeling that the worker is doing their side jobs thereby not concentrating on their work, thereby not giving value for money. On the other hand, the worker, still working under contract, feels that the employer is keeping lots of the profit for themselves, yet the worker perceives that he or she is doing an equally heavier and important task of welding and fabricating the products from start to finish without supervision and therefore starts concentrating on their side projects, not on the employer's products. Persistence in having this working environment of perceptive mistrust results in either the employer sacking the former trainee/new employee or the former trainee leaving this outfit to start an outfit similar to their former employer. Where the employee becomes an employer of a similar but new fabrication outfit, the cycle starts all over again with the new apprentices. Studies have shown that most of these new outfits fail since factors like customer catchment, working capital, experience, loan access etc work against the new outfits.

Centrates Associated with Welding and Fabrication.

Welding and Fabrication as a trade got its footing around 1900. Various inventions associated with metallurgy and the continuous improvement to inventions associated with electricity took place simultaenously (Mutch & Alistair, 2001). With regards to metallurgy, fusion welding - the process of fusing two metals after heating and melting either using gas or electricity was invented during this time. Arc welding using electricity was made possible through invention of the electric arc – process of generating extremely high temperatures – to fuse and melt the two metals (John & Nwaoha, 2018, p. 1). During this period, notable improvements of methodologies to improve electricity penetration and accessibility took place (Meier, 2006, p. 144). Continuous improvement of the inventions on the metallurgy and electricity fronts have made Welding and Fabrication as a trade very accessible, easily trainable, and therefore easily diffusible to any region as long as electricity is readily available and cheap. To become an expert in this trade, the apprentice must – over a period of time - achieve high levels of skills on various critical centrates or competencies. These centrates include:

- Public Health,
- Patents and Copyrighting,
- Time, Quality and Cost Management,
- Specifications and Contract Management,
- Information and Communication Technology (ICT),
- Design and Interpretation of Design,
- Measurements, Calculations and Schedule Generation,
- Competencies on Cutting and Forming,
- Welding and Assembly,
- Polishing and Painting
- Demonstration and Simulation and
- Building Information Management (BIM).

With regards to Public Health centrate, its competencies were critical during the context of the training by TU-K on KOMO. Due to the COVID-19 protocols imposed, trainers and trainees had to take various precautions by enforcing social distancing, using a facemask, frequently washing hands and frequently using sanitisers, sneezing on elbows, vaccination, and on extreme cases of testing positive to COVID-19, going for quarantine (GoK, 2023, p. 1) . With regards to Occupation Safety and Health (OSH), use of Personal Protective Equipments (PPE's) like helmets, overall, gloves, ear muffs, goggles and safety boots (Muema, 2016, p. 39) were critical for trainers and trainees when training on the job. Where training was done using arc welding, safety precautions which include compulsory use of sockets, avoiding naked live wires and minimising instances of electrocution were usually enforced (John & Nwaoha, 2018, p. 3). Where training was done using gas welding, safety precautions like frequently checking for any gas leakage, proper ventilation, and dilution of fumes, welding in open air and properly storing gas cylinders are usually enforced (Golbabaei & Khadem, 2015, p. 53).

With regards to the Patents and Copyrighting centrate, one was considered an expert if they were able to practically handle process of copyrighting and patenting. The Kenyan process of copyrighting was digitised by Kenya Copyrights Board (KECOBO) within their last strategic plan period that ended in the 2022/2023 financial year. This process includes:

- Creating an account as a copyright owner in the portal,
- Launching the application for the proposed copyright clearly stating the shareholding of the copyright
- Uploading supporting documents in the form of write-ups and technical drawings and documents,

- Paying the requisite fees for processing,
- KECOBO reviewing the information you availed

If there is no dispute, a copyright certificate is issued to the copyright holder (KECOBO, 2020, p. 4). The Kenyan process of patenting is still manually handled by Kenya Industrial Property Institute (KIPI). This process includes

- Manually applying for the patent by filling form IP3 – Patent/Utility Model Application Form,
- Availing a detailed description of the invention in a full, clear and exact term which include invention title, technical field of the invention, background information the invention, brief description of the drawings and a detailed description of the invention,
- Placing a claim to precisely claim the novel matter for which protection is sought,
- Providing an abstract that summarises the application,
- Paying the requisite fees,
- KIPI reviewing the information you availed and
- If there is no dispute, a patent certificate is issued to the patent holder which is valid for ten years (KIPI, 2007, p. 5).

With regards to the Time, Quality and Cost Management centrate, Specifications and Contract Management centrates, and Project Planning centrate, one was considered an expert if they were able to effectively balance the iron triangle metrics for any project (Pollack et al., 2018, p. 528). With regards to Time Management, an expert should be able to easily and effectively breakdown a major project into piecemeals that would be easily delegated to colleagues in the organisation, should be able to continuously manage and monitor the broken down works from start to completion ensuring that timelines are adhered to and most critically be able to effectively communicate to all stakeholders should there be a forecast of any time delay.

With regards to quality management, an expert should be able effectively understand and interpret designs before actual implementation, should be able to identify right materials and methodologies to use, practically do high quality cutting, folding, welding, polishing and painting for any project, should be able to come up with customised solutions for unique challenges, should be able to avail proper benching, proper vices and worktop to workers to effectively do their work, should be able to review design documents, understand and interpret specifications to ensure consistency between design and product, should be able to identify the best methodology to execute work, should be able to discern high quality materials from low quality materials and most importantly, should be able to stand their ground where quality is being compromised. With regards to Cost Management, an expert should be able to easily and effectively interpret Bills of Quantities for any size of project, should be able to track expenditures when overseeing the contract to ensure that they are always within margins and no projected escalations would be experienced, at the agreed intervals, should be able to be effectively and transparently lay a claim of work done and should be able to manage the contract from start to finish.

With regards to the ICT and BIM centrates, one is considered an expert if they are able to effectively integrate general digital technologies and specific BIM technologies in effective running of various projects. With regards to ICT, an expert should be able to effectively use word processing tools like MS Word and Google Docs to prepare formal documents for communication to other stakeholders, should be able to effectively use spreadsheet tools like MS Excel and Google sheets to process calculation related

documents like cost monitoring and even do relevant analytics with regards to cost performance, should be able to effectively use presentation tools like MS PowerPoint and Google slides to do relevant presentations, should be able to effectively use graphical design tools like MS Publisher and Photoshop to prepare graphical documents like brochures, pamphlets, letterheads and even branding boards and should also be able to effectively use database management tools like MS Access to manage critical information on Welding and Fabrication over time, information like previous customers, previous workers, previous cost of each material bought and all payments done for all work done. An expert should also be able use emails and easily access internet to do activities currently considered basic like accessing government websites to access job opportunities or access government services and should be able to handle basic coding tools like Python, Scratch, and GitHub. With regards to BIM, an expert should be able to effectively interpret BIM models using tools like BIMx, BIM360 and Sketchup, should be able to generate such models using the same tools, should be able of effectively do CNC machining, laser cutting and 3D printing.

With regards to the Measurements, Calculations and Schedule Generation Centrate, Cutting and Forming Centrate, Welding and Assembly Centrate, Polishing and Painting Centrate, Demonstration and Simulation Centrates, one is considered an expert if they are able to effectively handle the practical aspect of Welding and Fabrication, from start to finish. With regards to measurements, an expert should be able to correctly measure using various tools like tape measure, laser measuring tool, scribe, square and protractors besides being able to seamlessly use the metric system and imperial system of measurement. With regards to calculations, an expert should be able to handle linear, superficial, and volumetric calculations, which form the basis of Quantity Takes Off used to generate schedule of materials and labour that eventually comprise the Bills of Quantities.

With regards to Cutting and Forming, an expert should be able to flawlessly cut any shape, either manually using a vice and hacksaw, or using power tools like angle grinders, should also be able to make many forms ranging from round to sharp bend forms. With regards welding and assembly, an expert should be able to prepare a welding jig board especially for mass fabricating processes, should be able to comfortably use various forms of welding like gas welding (MIG) , arc welding (TIG), stick welding (SAW)and wire wheel welding (FAW) (Golbabaei & Khadem, 2015, p. 53). With regards to polishing and painting, an expert should be able to flawlessly smoothen rough surfaces either manually using sandpaper or using power tools like angle grinders and blasters, should be able to properly paint a metal surface either by using paint brushes or spray-painting machines.

Theoretical framework

Dreyfus (2004) posits that the skill training process goes through five distinct stages namely 1) Novice, 2) Advanced Beginners, 3) Competent, 4) Proficient and 5) Expert stage (Dreyfus, 2004, p. 2). At the “Novice Stage”, the trainee knows nothing, has no experience, and is taught the rules of the trade to guide action of the trainee. At the “Advanced Beginner’s Stage”, the trainee is able to demonstrate marginally acceptable performance to the trade and is able to formulate guidelines on the basis of attributes and aspect of the trade but equally needs help on setting priorities. At the “Competent Stage”, the trainee is able to handle larger scopes of the trade due to increased experience and their supervisor starts having confidence in being given tasks without supervision. At the “Proficient Stage”, due to experience, competent trainee now becomes proficient and is able to cover all scopes of the training with minimal supervision. At the “Expert Stage”,

due to more experience, this person can seamlessly handle all scopes of the training with no supervision (Dreyfus, 2004, p. 2).

Dreyfus Model, though originally used in the context of Adult Skill acquisition, is very adaptable especially to vocational, practical based training which vary from health-based occupations like nursing to vocational based occupations like plumbing, welding and fabrication, masonry etc. This adaptability makes it easy to corelate aspects of this theory to practical stages involved in these forms of training since its emphasis is on skill acquisition as opposed to skill assessment (Field, 2014, p. 121). This model has a lot of similarities with the Cogni-Constructive Theory and is summarised in the theoretical framework shown in figure 2 below.

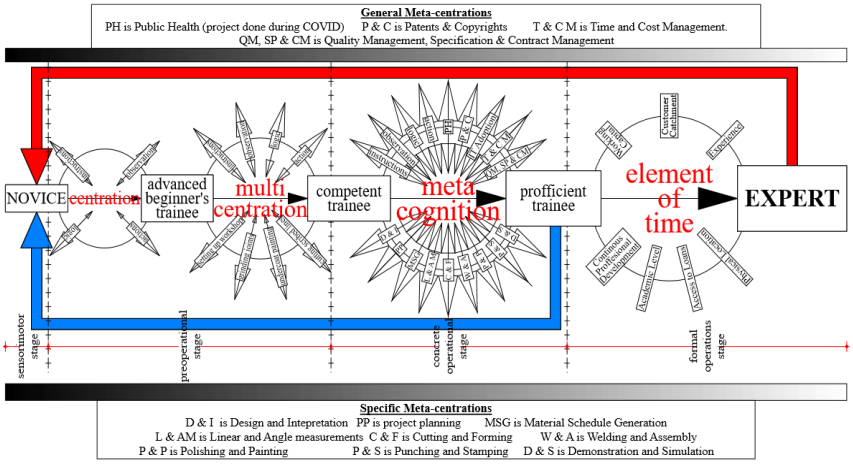

Figure 2: Components of Cogni-constructive Learning

Source: Author (2024)

Research Methodology.

This study used survey method incorporating questionnaires for Welding and Fabrication tradesmen. Purposive sampling was used, and this study limited itself to NGOKAMKA affiliated Welding and Fabrication tradesmen whose population was 3118. For the context of this study, NGOKAMKA had been appointed to collaborate with the Technical University of Kenya (TU-K) to handle the Government of Kenya backed COVID 19 Project named "Keeping our Markets Open" which involved training these tradesmen "on the job" hence the reason why this study limited itself to this population. With the sampling error (e) being at ± 5%, confidence level being at 95% hence (z) is 1.96, variability level being at 50%, the data being collected being predominantly continuous and not categorical (Bartlett et al., 2001, p. 48), the resulting sample size was 116. Questionnaires were manually administered in 2 active construction sites within Nairobi Metropolis – Kibera and Ruiru, where the affordable housing projects are currently being done.

Since this is a real project that happens to be a flagship project for the current government, it was anticipated that the respondents were the *crème de la crème* in this trade in Nairobi since the government could not take the risk of bringing in tradesmen who were not competent in such a project. The respondents were Welding and Fabrication tradesmen who were handling doors, windows and railing fabrications for the

affordable housing being constructed, estimated to be approximately 3,000 housing units. A five-point Likert scale was used to test opinions of these tradesmen on various parameters including their levels of competencies on various centrations. SPSS was used to analyse the data with descriptive method of data analysis predominantly used to give a visual picture of the current situation on competencies of the various centrations. Inferential data analysis was also equally done but limited to Cronbach's alpha.

Data Analysis.

Degree of Responsiveness and Data Reliability

43 out of 116 respondents responded giving a response rate of 37.07%. Based on various research studies (Anseel et al., 2010, p. 346; Rolstad et al., 2011, p. 1104; Rowley, 2014, p. 320), this rate was considered adequate. With regards to reliability, the Cronbach's alpha achieved indicated a high level of data reliability (117 items: $\alpha = 0.945$).

Demographics of Responsive Respondents.

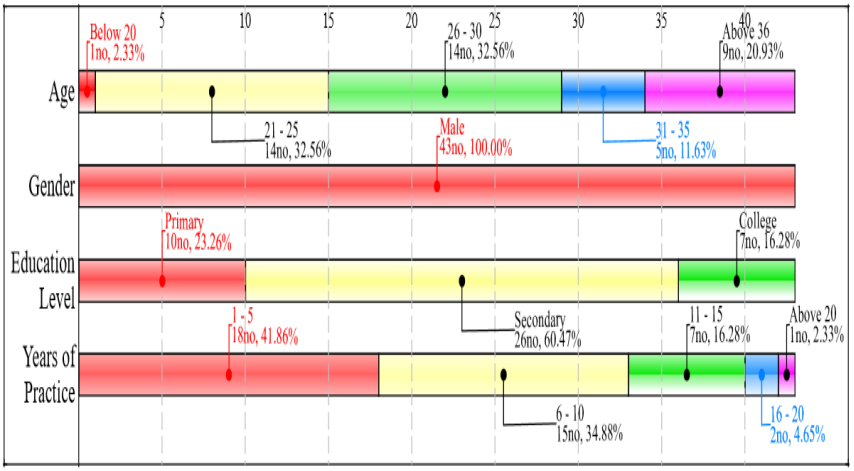

Figure 3: Demographic Profile of Respondents.

Source: Author (2024)

As shown in figure 3 above, respondents were diverse with the predominant age being between 21 to 25 (32.56%) and 26 to 30 (32.56%) with the majority being younger - aged below 30 years representing 67.44% of the respondents. With regards to gender, all respondents were male (100%). With regards to education level, the predominant band was secondary education (60.47%). With regards to practice experience, the predominant band was 1 to 5 years (41.86%) though majority of the tradespeople had experience below 10 years representing 76.74%.

Survey Results

Competencies on Centrates

The study reviewed the competencies of the centrates discussed in chapter 3 by looking at the performance of the various indicators associated with these centrates.

Competencies on Public Health

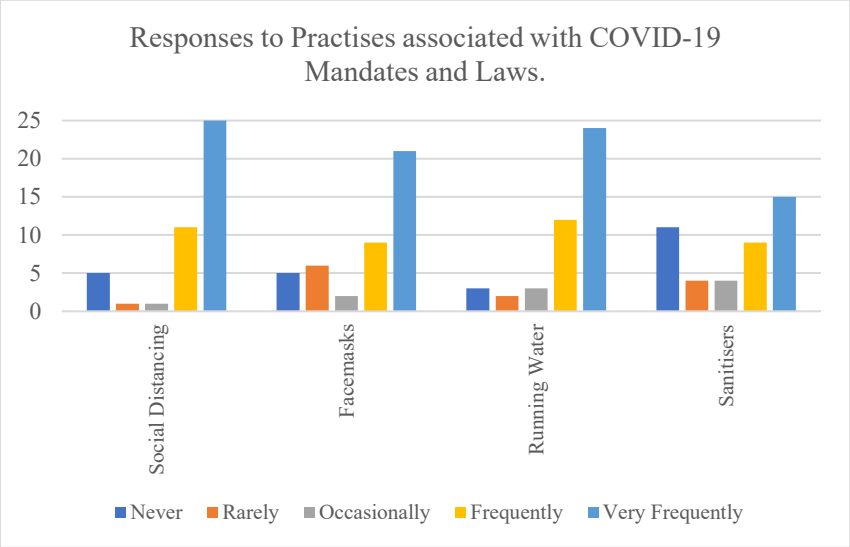

Figure 4: Practices associated with COVID-19 Laws and Mandates

Source: Author (2024)

Keep Our Markets Open" was implemented during COVI-19. While the mandates and laws associated with these periods have been overtaken by time, the respondents seemed to be still practising the mandates and protocols compatible with their own safety practices and incorporated them to their day-to-day activities as shown in figure 4. Social Distancing was still being heavily practiced since it is consistent with the manner in which works of welding and fabrication is done. Most of the times, the fabricators must ensure some distance between two workers to ensure physical safety of these workers. Facemasks replaced handkerchiefs which fabricators used to cover their noses with to minimise effects of fumes. On the same basis, practices that are not compatible with the safety practices of Welding and Fabrication, like use of sanitizers are slowly waning away.

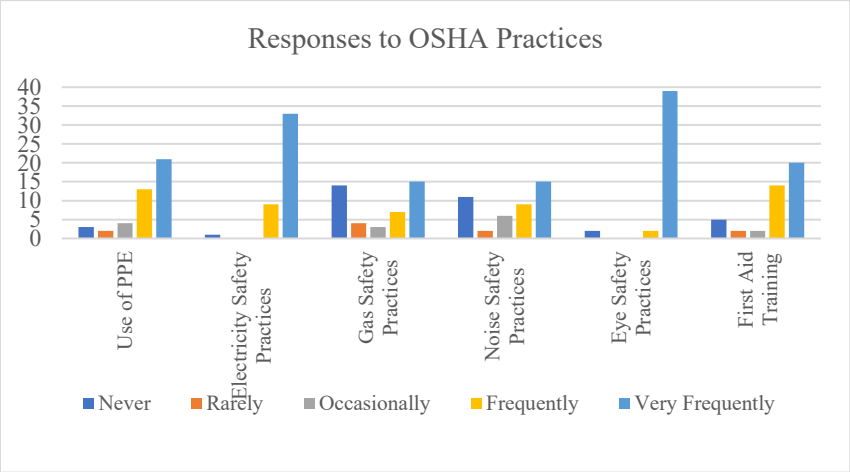

Figure 5 : OSHA Practices

Source: Author (2024)

With regards to Occupation Safety and Health, most fabricators frequently observed these practices as shown in figure 5. Safety practices for eye safety were frequently deployed because this organ is the most critical one with regards to this trade and where they fail, then one would cease to actively practice as a welder and fabricator. Safety practices associated with gas were not frequently deployed because the predominant method of welding in this sector is arc welding, with the ones who have practised inferring that they have also been involved in Welding and Fabrication for vehicle bodies where gas welding is predominantly used. Use of PPE was not very strong amongst the fabricator with the main cause of this being the cost of purchasing these PPE's and the relevant OSHA statutory bodies not enforcing these rules. First Aid training was low, and most tradesmen could not deploy these skills where there was an accident on site.

Overally, competencies on Public Health were high, with most respondents practising most safety practices associated with Welding and Fabrication.

Competencies on Copyrighting and Patents.

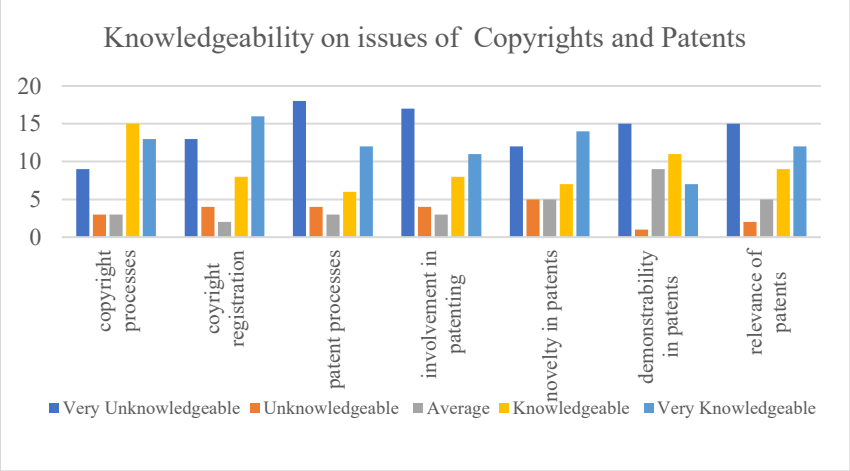

Figure 6: Knowledgeability of Issues of Copyrights and Patents

Source: Author (2024)

Most fabricators displayed higher knowledge levels on copyrighting than patenting as shown in figure 6. Knowledge levels on parameters associated with processes of copyrighting, and specific process of registering a copyright were higher. On the other hand, knowledge levels on parameters associated with processes of patenting were lower though most of them knew of the novel requirement of a patent. Actual demonstration of these competencies was low with most respondents indicating that they have never practically handled either copyright of patent process from start to finish.

Competencies on Quality Management, Specifications and Contract Management and Project Planning

In their self-assessment, respondents indicated a higher level of competencies on these centrates. With regards to Quality Management, most respondents indicated high levels of proficiency on issues relating to parameters associated with this centrate as shown in figure 7.

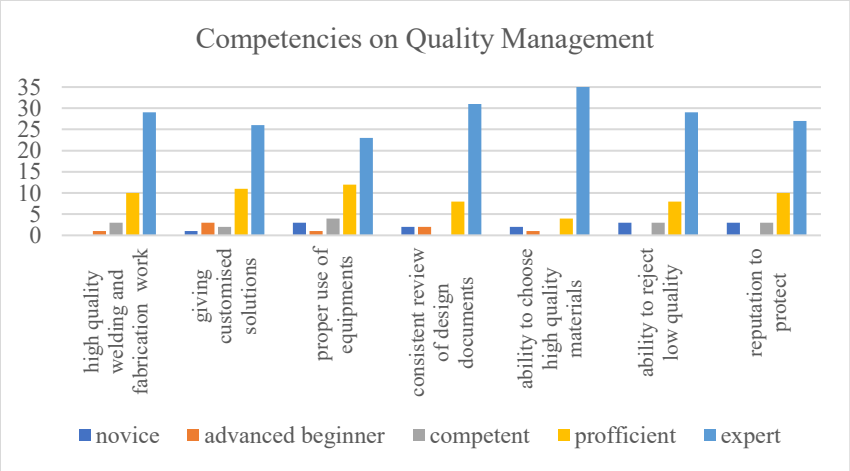

Figure 7: Competencies on Quality Management

Source: Author (2024)

Most of the respondents affirmed their ability to do high quality fabrication work, their ability to choose high quality materials and most importantly their ability to stand their ground when they were forced to use low quality materials since their priority would be to protect their reputation. The main concerns with regards to Quality Management was the unavailability or low availability of proper benches, proper vices, and proper worktops to enable production of high-quality work.

With regards to Specifications and Contract Management, most respondents indicated high levels of proficiency on issues relating to parameters associated with this centrate as shown in figure 8. Most of the respondents affirmed their ability to understand, interpret specifications, and identify the best methodology to respond to a specification. The concerns with regards to Specifications and Contract management was their inability to easily prepare Bills of Quantities, inability to place and claim and most importantly, their inability to effectively track expenditures.

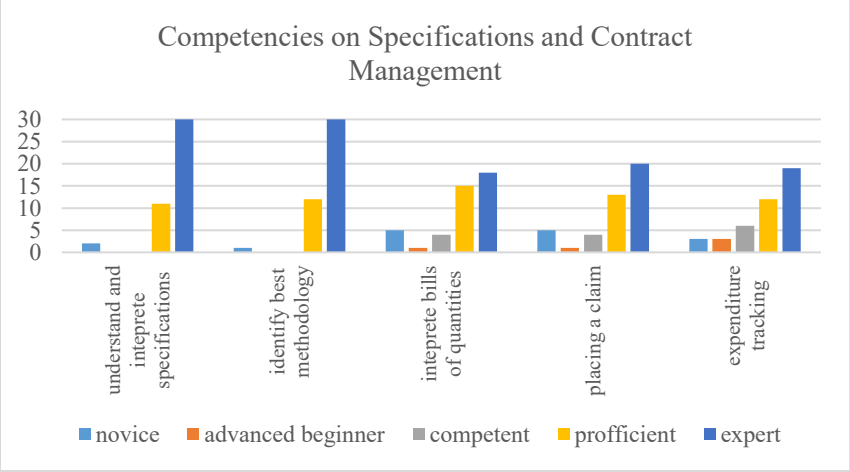

Figure 8: Specifications and Contract Management Competencies

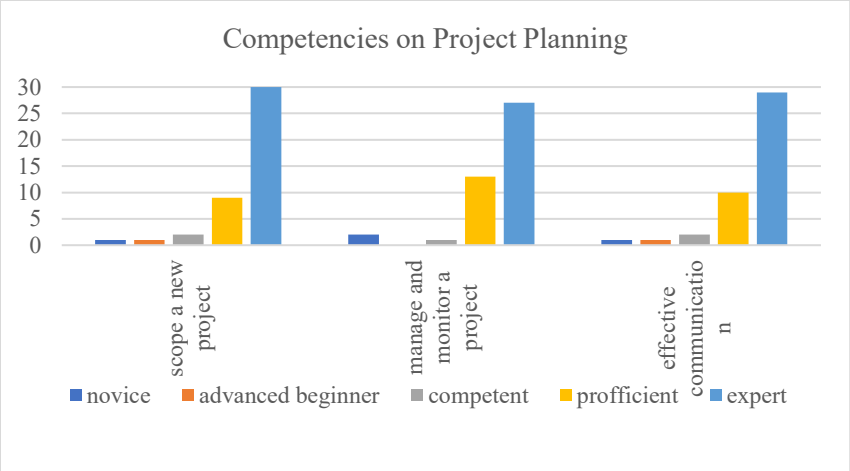

Figure 9: Competencies on Project Planning

With regards to Project Planning, most respondents indicated high levels of proficiency on issues relating to parameters associated with this centrate as shown in figure 9. Most of the respondents affirmed their ability to scope a new project from start to finish, their ability to manage and monitor a project and most importantly their ability to effectively communicate issues, costs, expectations, and timelines to all stakeholders. Overall, competencies on Quality Management, Specifications and Contract Management and Project Planning were high, with most respondents practising high quality, specifications and contract management associated with Welding and Fabrication.

Competencies on ICT and BIM.

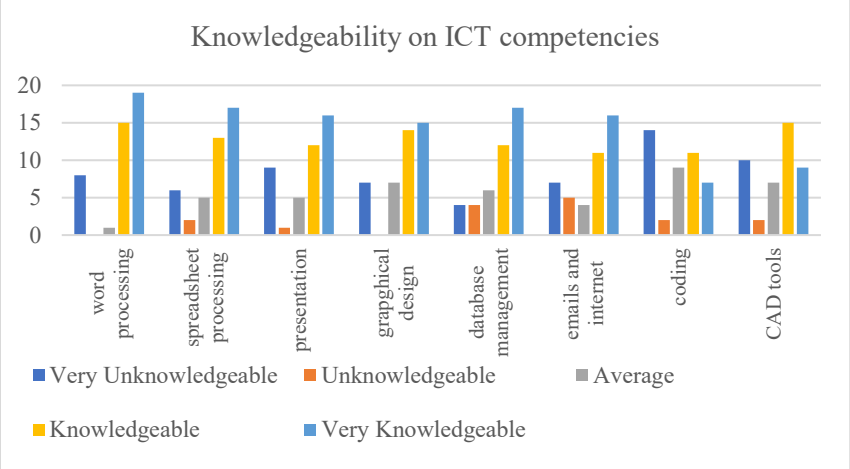

Figure 10: Project Planning Competencies

Source: Author (2024)

In their self-assessment, respondents indicated a higher level of knowledgeability on these centrates. With regards to ICT, as indicated in figure 10, most respondents indicated high levels of knowledgeability on word processing tools which is attributed to ready access of such equivalent tools in smartphones which were readily accessible to them. They were equally knowledgeable on spreadsheet processing tools,

presentation, and graphical design tools. The main concern was low knowledgeability levels on coding and CAD tools which was attributed to unavailability or exposure of respondents to these tools.

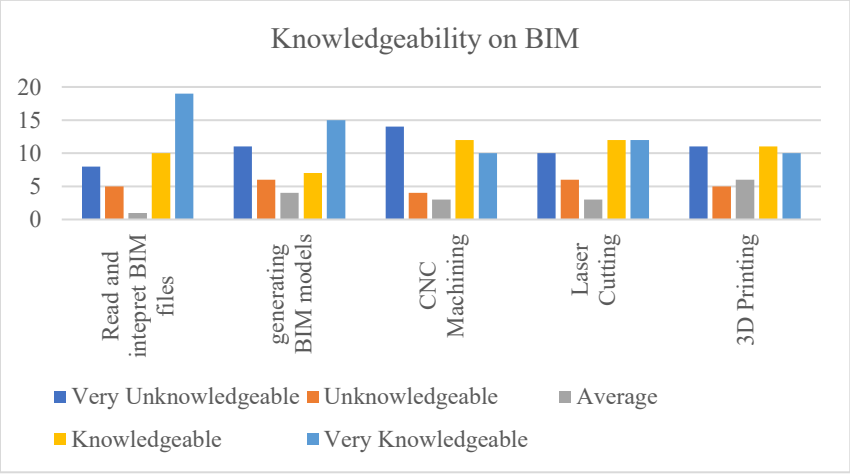

Figure 11: Knowledgeability on BIM

Source: Author (2024)

With regards to BIM, as indicated in figure 11, most respondents indicated low knowledgeability levels with regards to use and manipulation of BIM Tools. Knowledge on CNC machining, Laser Cutting and 3D printing were equally low. These low knowledgeability levels was be attributed to unavailability or low exposure of these respondents to these tools since the demand for such services had not reach the demand threshold. Overall, knowledgeability levels on ICT and BIM were low thereby inferring that the levels of competencies for these centrates were even lower.

Competencies on Measurements, Calculations and Schedule Generation, Cutting and Forming, Welding and Assembly, Polishing and Painting, Demonstration and Simulation.

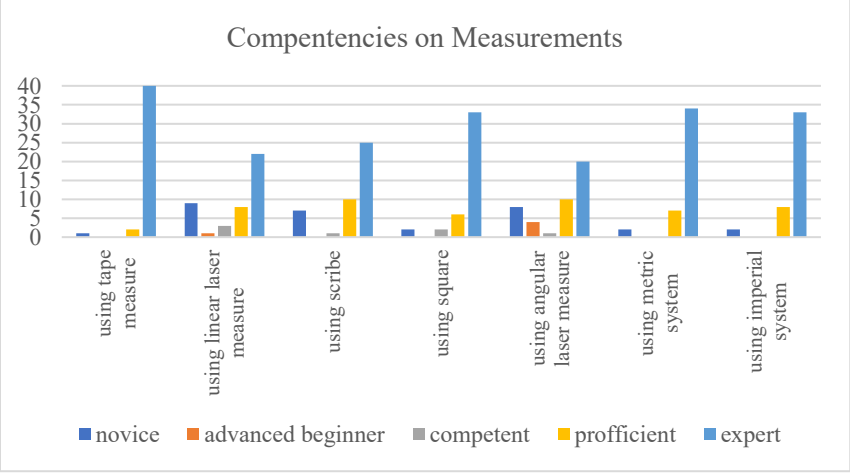

Figure 12 Competencies on Measurements

Source: Author (2024)

In their self-assessment, respondents indicated a higher level of competencies on these centrates. With regards to Measurements, as shown in figure 12, most respondents indicated high levels of competencies on measurement activities. Most of the respondents affirmed their ability to easily use a tape measure and a square, ability to easily use metric and imperial systems. The main concerns with regards to measurement was the low knowledgeability in using new laser technologies for measurements mainly due to their costly nature and their low levels of availability.

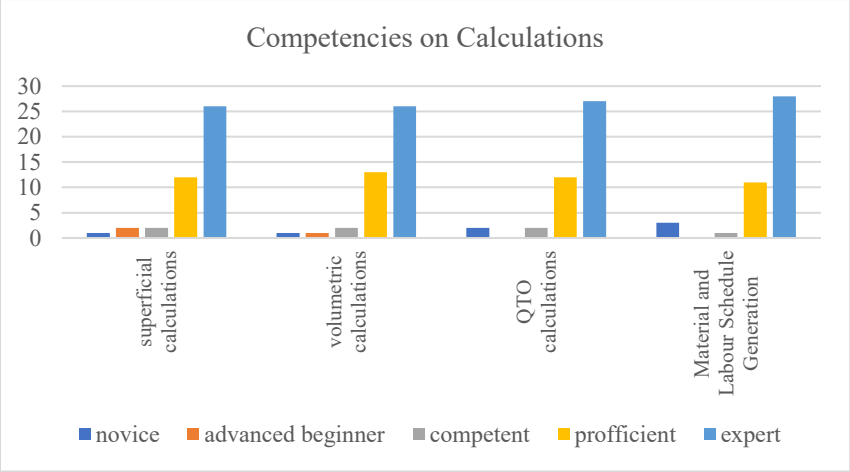

Figure 13: Competencies on Calculations

Source: Author (2024)

With regards to Calculations, as indicated in figure 13, most respondents indicated high levels of competencies on these centrates. Most of the respondents affirmed their ability to easily do superficial and volumetric calculations, ability to easily do Quantity Take Off (QTO) and their ability to generate schedule for materials and labour. These high competency levels were attributed to the repeatability of these activities since before getting any job, they had to do calculations and give figures that were not only competitive, but they were able to get returns from the said job. High-cost figures result into potential clients walking away, lower figures result into the fabricators burning their fingers, not being able to finish their work, messing up their reputation and subsequently losing potential clients due to the messed-up reputation.

With regards to Cutting and Forming, as indicated in figure 14, most respondents indicated high levels of competencies on these centrates. Most of the respondents affirmed their ability to easily cut, whether manually or by power tools, ability to easily smoothen, whether manually or by power tools, ability to easily bend, whether round or sharp. Respondents attributed this to the repetitive nature of this centrate hence the continuousimprovement over time. Cutting and Forming was regarded as a main centrate and where one could not master it fully, irregardless of better performance on other centrates, one would not be considered competent.

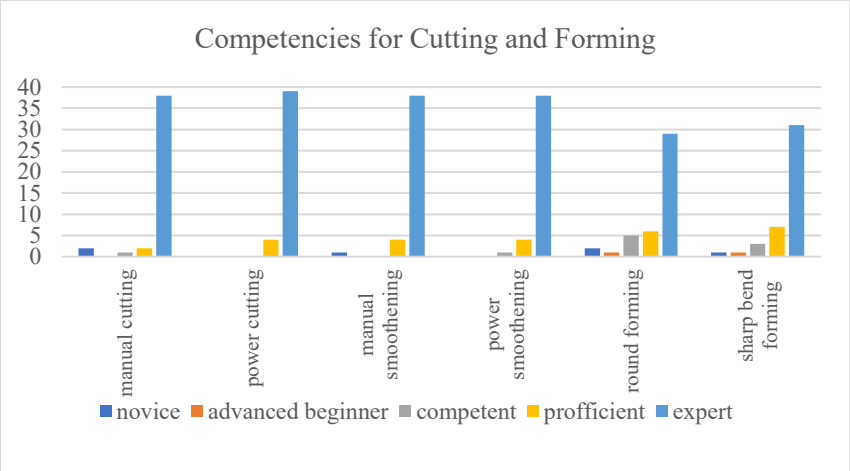

Figure 14: Competencies for Cutting and Forming

Source: Author (2024)

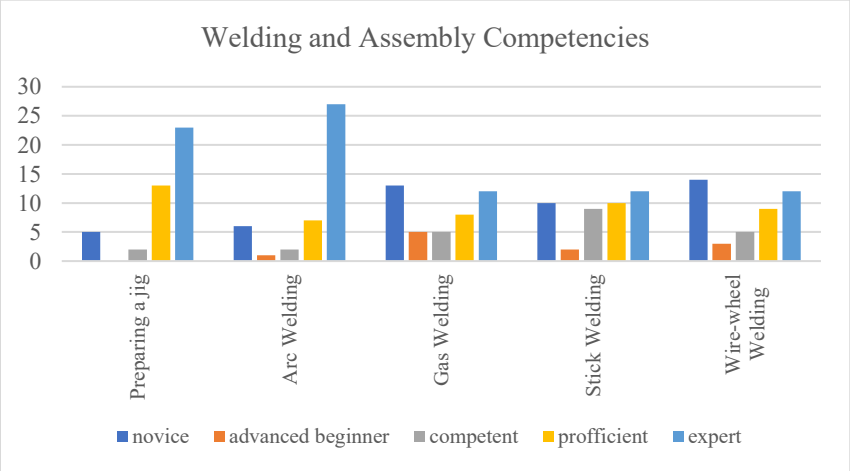

Figure 15: Welding and Assembly Competencies

Source: Author (2024)

With regards to welding and assembly, as indicated in figure 15, most respondents indicated high levels of competencies on these centrates. Most of the respondents affirmed their ability to easily prepare a jig in the case of mass production, and the ability to easily use arc welding. There were concerns about the low level of competencies in using other forms of welding namely gas welding, stick welding and wire-wheel welding.

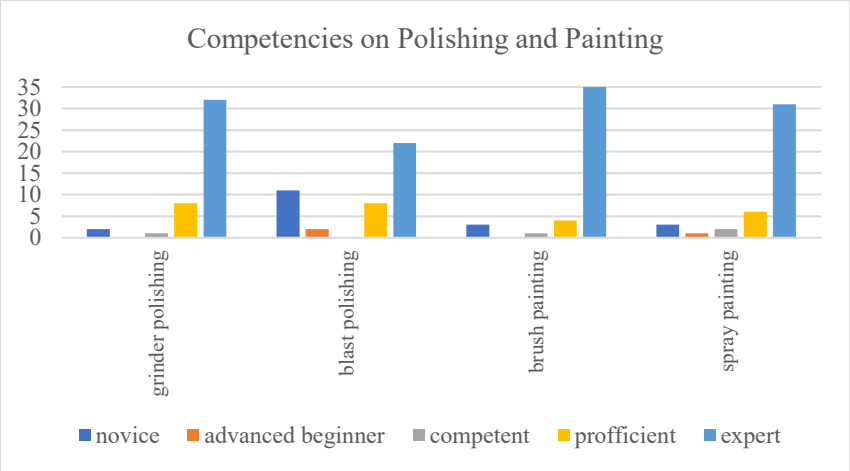

Figure 16: Competencies on Polishing and Painting

Source: Author (2024)

With regards to polishing and painting, as indicated in figure 16, most respondents indicated high levels of competencies on these centrates. Most of the respondents affirmed their ability to fine polish using an angle grinder, ability to easily use brush and spray paint. There were concerns about the low level of competencies with regards to blast polishing.

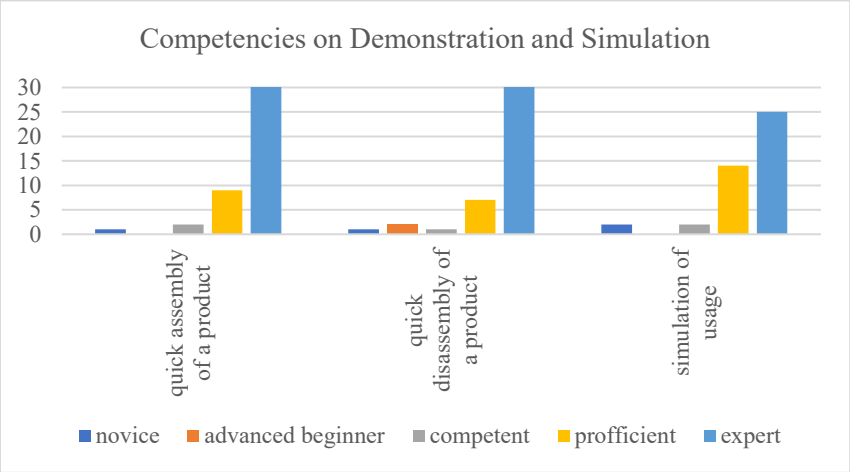

Figure 17: Demonstration & Simulation Competencies

Source: Author (2024)

With regards to demonstration and simulation, as indicated in figure 17, most respondents indicated high levels of competencies on these centrates. Most of the respondents affirmed their ability to easily assemble and disassemble a product, ability to easily simulate use of a fabricated product.

Overally, competencies on Measurements, Calculations and Schedule Generation, Cutting and Forming, Welding and Assembly, Polishing and Painting, Demonstration and Simulation were high, with most respondents easily handling these centrates.

Impact of NCA amongst Welders and Fabricators

The study reviewed the impact of NCA amongst these tradesmen as discussed in chapter 3 by looking at the performance of the various indicators associated with NCA.

Possession Of Updated NCA Card.

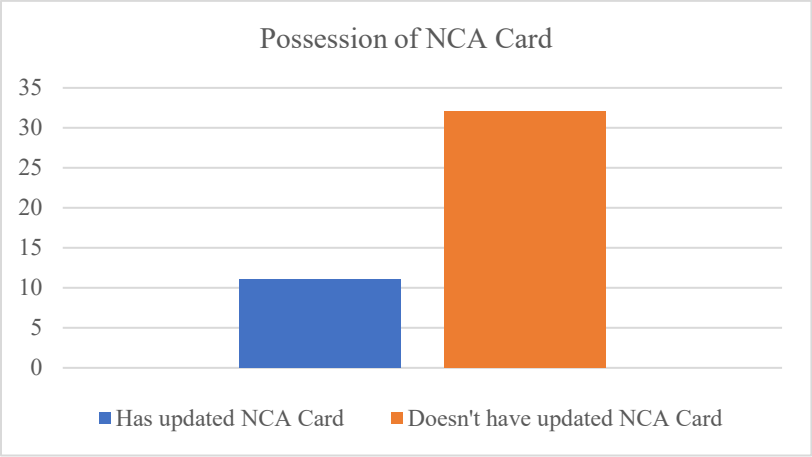

Figure 18: Possession of NCA Card

Source: Author (2024)

In their self-assessment, respondents indicated a low level of possession of updated NCA job cards as shown in figure 18. Respondents attributed this to low levels of enforcement of the NCA mandates and laws on compulsory possession of an NCA approved job card in any construction work. The respondents also highlighted that though they possess the card, they did not know why they needed them, but since they did not want to lose any opportunity coming their way especially from National and County Governments, they just renewed to be compliant.

Continuous Professional Training

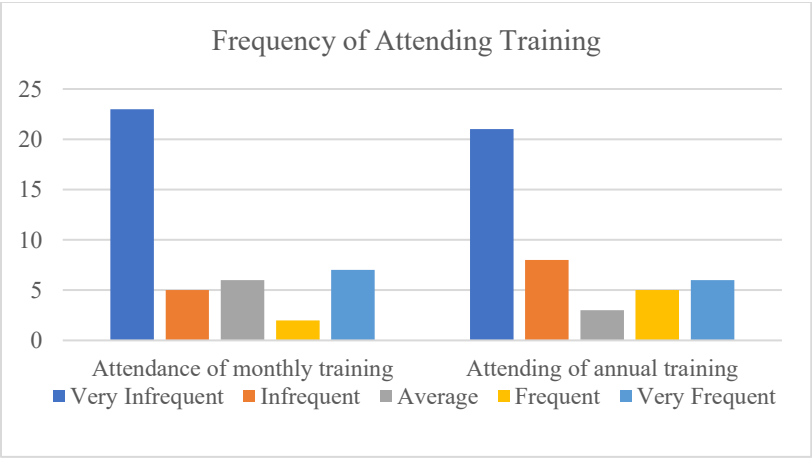

Figure 19: Frequency of Attending Training

Source: Author (2024

In their self-assessment, respondents indicated a low frequency of attending NCA organised training as indicated in figure 19. Residents attributed this mainly to the "earn as you work'' model of compensating them whether daily, weekly or via contract. The impact of this model is that the fabricators must achieve certain milestones for them to be paid. As such, when no work is going on when they go for the training, they suffer losses.

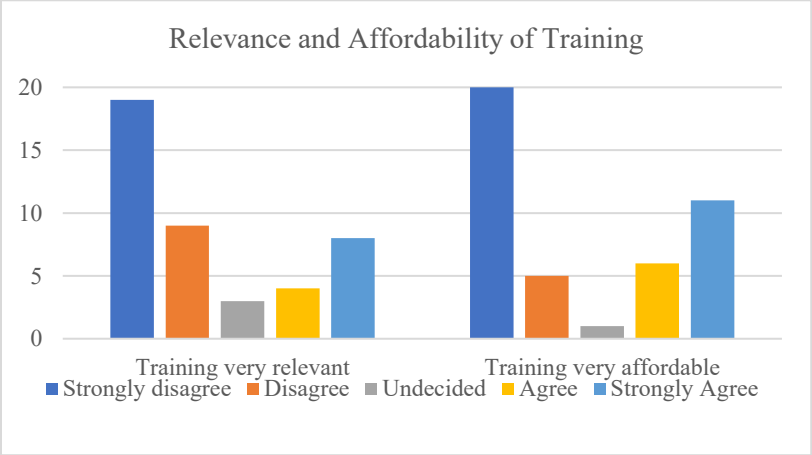

Figure 20: Relevance and Affordability of Training

Source: Author (2024)

With regards to relevance and affordability of these training, as indicated in figure 20, most respondents indicated low levels of relevance and low levels of affordability. Low relevance was attributed to the general nature of the trainings, which most of the respondents felt that were not relevant to them. Respondents also felt the training costs were not affordable since the do not get value for money when they go for these trainings.

Overally, the impact of NCA amongst welders and fabricators was low.

Status of Welding and Fabrication in Kenya

Levels of competencies on centrates considered core were noted to be high. This was attributed to factors including 1) Repeatability, 2) Personal Safety and 3) Dynamics of clients. With regards to repeatability, centrates that were frequently repeated for example quality management, measurements, calculations, schedule generation, cutting, forming, welding, assembly polishing, painting, demonstration, and simulation had higher levels of competencies since the fabricators had to repeat them every now and then in any new fabrication works. With regards to Personal Safety most attributes associated with Occupational Safety and health were frequently deployed by the fabricators for their own safety while the ones that had no direct relationship with their personal safety were normally ignored. With regards to Client Demand centrates that were client sensitive for example cost time quality had higher competencies since most fabricators aligned their performance to the client tastes, preferences, and failure to do this would result in loss of earning and livelihood.

Levels of competencies on centrates considered fringe were noted to be low. Again, this was attributed to 1) Lack of repeatability, 2) Low Client Demand and 3) Low or no return value. With regards to Lack of

repeatability, centrates that were rarely used for example patenting, copyrighting,ICT and BIM management had lower levels of competencies. With regards to Low Client Demand, centrates that did not directly contribute to good quality work resulted into the client not appreciating the costs associated with them. Where a fabricator adopts use of BIM to showcase proposed designs, the client would appreciate it as long it did not increase the cost of overall work. Should it increase this cost, the client would explore getting an alternative fabricator making the initial potential fabricator lose on this opportunity due to the attempt to do value addition. With regards to Low or no return value, fabricators are rational beings and engage in this trade to get benefits in terms of wages or profits. Clients are equally rational and would go for the lowest possible cost as long as the quality is not compromised. With these two actions guiding the price ceiling dynamics of a product, the fabricator - since he or she needs these jobs to get going - would do it but in the process, eliminate centrates that have no direct return for value to try reducing on his or her costs.

Training activities within the Welding and Fabrication sector is not coherent. There exist many players for example educators like the Technical Institutions, Statutory Training Authorities like NITA and Statutory Quality Validating Authorities like NCA. All these players act independently and "in silos". As a result, the training activities in the country are disjointed, are overlapping and elements of "ring fencing" amongst training stakeholders were noticeable. While most fabricators have competencies on certain centrates, their lack of certification normally disadvantage them.

Recommendations

This study recommends actions to help continuous improvement on Welding and Fabrication centrates and limits it to

- Coherence in training,
- Supervision and validation on the job and
- Collaboration amongst the various stakeholders and
- Mainstreaming of gender balance in the welding and fabrication sector.

With regards to coherence in training there is need for all stakeholders in the training and validation of welders and fabricators act synchronously and coherently. These key actors need to come up with a consistent way of handling their processes, establishing systems of cross-party recognition for example, a certificate issued by NITA should be as good as a certificate issued by TU-K, which should be a good a certificate issued by NCA. There is need for Recognition of Prior Learning (RPL) to be formalised and mainstreamed, a process that would activate the alternate career progression pathway as envisaged by Kenya National Qualification Authority (KNQA).

With regards to supervision, validation and continuous training on the job, there is need for Statutory Quality Validating Authorities like (NCA) to consider supervising fabricators where they are physically working in their respective workplaces as opposed to the fabricators coming to NCA seminar for training. When NCA does training on the various workplaces of these fabricators, it becomes easy for them to acquaint themselves firsthand with the challenges these fabricators face, and this experience enables them to provide training that is tailor-made to their conditions. This approach passively helps in ensuring that basic mandates and laws like OSHA, NCA registration, compliance to government requirements e.g. tax compliance etc are regularly adhered to.

With regards to collaboration, there is need for all stakeholders to regard each other as equals, no institution is above the other and that each stakeholder complements the other. The recent change of Government Policies and Attitudes towards the Welding and Fabrication sector has resulted into the Kenya National Federation of Jua Kali Association (KNFJKA) negotiating and ringfencing most Welding and Fabrication works in government projects (like the Affordable Housing Project) that are valued in billions of Kenyan Shillings. As such, empowering KNFJKA and being seen as an equal stakeholder can assist in deploying policies that would catalyse the growth of competencies in the sector. These policies include 1)Domiciling KNFJKA training activities within a training institution which would assist in professionalising and formalising the way KNFJKA and by extension fabricators interact with the other stakeholders; 2) Setting aside a portion of their contract sums in their various contracts to training which would also help in ensuring that competencies are consistently trained and upgraded amongst these fabricators, and 3) Coming up with a structured method of training trainers (ToT) who would eventually diffuse these competencies and knowledge all over the country in collaboration with the various Technical Training Institutions throughout the country.

With regards to gender mainstreaming there is need for deliberate effort to be laid in ensuring that gender balance is achieved in this sector. There is need to slowly enforce change of perception amongst the females' gender towards Welding and Fabrication which they consider to be a difficult trade, yet it has considerably improved over time. Developments like accessibility to power tools, light welding machines etc have made welding and fabrication easier. Besides, there are also many centrates in this sector that do not involve physical engagement for example patenting, copyrighting, ICT and BIM activities which are equally important to make this trade formal.

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