



## UWS Academic Portal

### DigiCAP

Marzano, Adelaide; Viza, Evdoxia; Cano, Michele

*Published in:*  
Procedia CIRP

*DOI:*  
[10.1016/j.procir.2020.05.032](https://doi.org/10.1016/j.procir.2020.05.032)

Published: 13/06/2020

*Document Version*  
Peer reviewed version

[Link to publication on the UWS Academic Portal](#)

*Citation for published version (APA):*

Marzano, A., Viza, E., & Cano, M. (2020). DigiCAP: towards digitalization for empowerment and capacity building of handcraft developments in Sub-Saharan Africa. *Procedia CIRP*, 88, 179-184.  
<https://doi.org/10.1016/j.procir.2020.05.032>

#### General rights

Copyright and moral rights for the publications made accessible in the UWS Academic Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

#### Take down policy

If you believe that this document breaches copyright please contact [pure@uws.ac.uk](mailto:pure@uws.ac.uk) providing details, and we will remove access to the work immediately and investigate your claim.

13th CIRP Conference on Intelligent Computation in Manufacturing Engineering, Gulf of Naples, Italy

# DigiCAP: Towards digitalization for empowerment and capacity building of handcraft developments in Sub-Saharan Africa.

Adelaide Marzano <sup>a\*</sup>, Evdoxia Viza, Michele Cano

<sup>a</sup> School of Computing, Engineering, and Physical Science, University of the West of Scotland, Paisley, PA1 2BE, UK

\* Corresponding author. Tel.: +4401418498292; fax: +4401418483000. E-mail address: [adelaide.marzano@uws.ac.uk](mailto:adelaide.marzano@uws.ac.uk)

## Abstract

This work presents a digital toolkit, which brings together multidisciplinary expertise in manufacturing, human factors and female entrepreneurship, to develop new methods to capture, predict and enable capacity building by digitalising local craft knowledge in Sub-Saharan Africa. The overall goal of DigiCAP is to produce a toolkit, derived from new fundamental capability engineering research that will enable women craft to increase productivity, support Digital skills adoption and de-risk the implementation of future digital skills through the consideration of human requirements and capabilities.

© 2019 The Authors. Published by Elsevier B.V.

Peer-review under responsibility of the scientific committee of the 13th CIRP Conference on Intelligent Computation in Manufacturing Engineering.

*Keywords:* Digitalization; Manufacturing; Human factors

## 1. Introduction

The objective of this work is to strengthen the design, marketing and operation management skills of Sub-Saharan craft workers in order to improve the production and quality of their products for economic empowerment and sustainable development. It aims to identify, promote and safeguard traditional know how in crafts making in the diverse cultural expressions, build the capacity of crafts workers in design, operation management and marketing skills in order to improve their business acumen and profits through the crafts industry.

With the use of digital tools to promote intercultural dialogue and diversity of cultural expressions, respect for aesthetics and traditions and create awareness about the importance and role of the crafts industry in the economic development of the country.

The objective of this paper is to analyse relevant theories and best practices in manufacturing processes and to propose an approach to elicit, analyze, specify and manage the requirements for capabilities and their patterns within the life cycle of an entire development methodology. A requirement in this context refers to a documented business functional need

that the subsequent capability design must be able to support through executable processes and services. To ensure a cross-industry applicability of the digitalization, we have followed action research methodology, by introducing requirements engineering process for capability modeling in handcrafts. The rest of the paper is organised as follows. Section 2 describes the handcraft and development in Sub-Saharan Africa, as well as the capability model and barriers of the society. Section 3 defines DigiCAP toolkit, the methodology process for capability and capability patters, which is illustrated with a case study of Ugandan women handcraft. Section 4 presents a brief discussion, conclusions and future work.

The objectives of the project and research question are to identify the critical factors that foster innovation, female entrepreneurship and encourage capacity building for handcraft women in Kenya. Furthermore, we defined a toolkit intended to strengthen capacity for craft women and easy available on mobile devices.

We consulted with craft women, educators and policy makers in Kenya and Scotland to identify skill gap and how to build capacity.

The objectives are to:

- Foster women's entrepreneurial skills in manufacturing

- Encourage training and education in a practical hands on way and digital platform
  - Facilitate local innovation and sustainability
  - Facilitate local economic development by sourcing materials locally and keeping production locally
  - Develop role models for the next generations particularly in male dominated sectors such as engineering.
- The toolkit provides:
- Methods based on manufacturing capabilities and analytical tasks analyses for hand craft women
  - Analyse labour tasks taking into consideration ergonomics issues, safety assessment and competence management tools.
  - Provide best practice on hand craft manufacturing processes.
  - Explore alternative business models for craft women to commercialise their products and skills

## 2. Handcraft and development in Sub-Saharan Africa

Being located in Uganda, the case study is situated within a context, which is essentially different from any study of digitalization use in a developed context. Poverty, gender inequality, HIV/aids, and lack of access to even basic resources such as electricity are just some of the backdrops of the study. The study shows that the creative use of digital tools and facilitation of existing structures and resources have improved the involved women means of communication, with positive effect on their livelihood as well as their participation in public life. However, the majorities of women in Uganda remain without access to means of communication and entangled in structures of inequality, [1]. Lack of adequate skills are other constraints faced by female entrepreneurs, [2]. Training for women often focuses on “traditional female skills” in tie and dye, basket making etc. for which the market is saturated. Women’s high illiteracy rate also limits the types of vocational and skills training they can be offered, [3]. Various factors limit women’s income generating activities access to markets. As noted earlier, women disproportionately experience limited mobility due to various factors linked to either their family responsibility or cultural practices. Those who can travel lack the market information on products and inputs, thus become dependent on the middle traders who buy their products at relatively lower than the market price, [4]. Because women often produce small amounts, they are limited to the local village markets, where the market for their products and services are already saturated. Some projects, which organized women producers in handcrafts and other goods, have shown some good practices where women producers were linked to international markets. Such projects invest extensively into training and coaching to ensure the products match the international quality standards and improve competitiveness, [5]. Other factors such as improved technology for preserving and storage facilities close to market areas are some of the constraints related to marketing of goods. A study on women cross-border traders in West Africa reported that lack of technology and cool storage close to markets affect women who trade in processed food such as fish in the region, [6]. In addition, limited access to input

markets, due to shortage of raw materials and high price of imported inputs such as chemicals for batik work and tie and dye can constrain their productivity, [7].

### 2.1. Limited enabling environment

Governments in many part of Africa recognise the role micro and small enterprises can play for employment generation and poverty reduction. However, creating a more enabling environment for promoting micro and small businesses and transforming the 16 informal economy into a dynamic economic sector has been a challenge. The absence of statistical data to determine the size characteristics of the informal sector operators and the capacity of the institutions with which they interact limits the ability of governments to make informed policy measures. Operating informally denies these incomes generating activities access to securing markets and other facilities necessary for their business operations.

Weak Infrastructure the low development of roads and lack of transport affects both male and female entrepreneurs. But, a closer examination at the gender differentiated impact of weak infrastructure on women and men and their respective income generating activities tells a different story, [7]. As indicated earlier, women’s ability to be more actively engage themselves in their economic activities is partly affected by the heavy labour burden and time poverty associated with their family responsibilities, [8]. Women who live in communities with low infrastructure, (transport, water and sanitation and energy) are worse affected. Studies have shown how women’s time burden is affected by inadequate transport systems, [9]. A World Bank study, [3] reported that 87 percent of trips in rural Africa take place on foot. Of this, the time women spent accounts for more than 65 percent of the household’s time and effort put on transport. The study also found that the average daily load of women carried was 20 kilograms for 1.4-5.3 kilometers). Some studies suggest that access to roads can improve women’s income – in Cameroon women in a village on a main road earned more than those located 90 minutes away from the road, [10]. Collecting fuel-wood is a predominately female responsibility in most of African countries. A study conducted in three countries reported that women spend up to 300 hours a year in Ghana and Tanzania and 800 hours a year in Zambia collecting fuel wood, [6]. In northern Ghana, it was reported that the productivity of shea butter production was affected due to shortage of fuel-wood and lack of alternative energy. A total of 20 hours of arduous work (women’s labour) is needed to produce one kilogram shea butter, [6]. Use of adequate energy and improved technology can dramatically reduce the amount of time and drudgery of labour need and increase productivity and income. Women and girls spend more time fetching water compared to men and boys, [5].

### 2.2. Limited enabling technology

Some key issues regarding technological capabilities in manufacturing in sub-Saharan Africa influenced the women entrepreneurship. They looked at what these capabilities are and how they can contribute to competitiveness and

development. Sub-Saharan Africa's recent industrial and technological performance has been disappointing. Despite many years of economic liberalisation, the manufacturing sector in most countries is tiny. Firms are smaller, less efficient and less innovative than in other developing countries, [11].

In addition to political and governance problems, the region's industry suffers from structural constraints. The supply of modern skills and physical infrastructure, for example, is weak and inadequate. Most importantly, African company' technological capabilities and the underlying technology system are poor, [12].

Technological capabilities are the skills technical, managerial or organisational that enable firms to efficiently use equipment and information, and improve technology.

Firms can be induced to develop technological capabilities and exert appropriate efforts through international trade and domestic competition policies. However, they must still rely on existing capabilities, such as skills, technology, finance and infrastructure. Being able to compete with imported goods, for example, depends on local skills and a firm's own technological efforts, [13].

We can categorise technological capabilities by their complexity. Less complex capabilities are 'routine' or 'adaptive and replicative', while more complex ones are 'innovative and risky', [14]. Capabilities can also be categorised by their function. Investment capabilities, for example, include assessing the feasibility and profitability of a project, defining it, sourcing the most appropriate technologies, negotiating their purchase, building equipment, and recruiting and training skilled personnel.

Production capabilities allow a given technology to be efficiently operated and improved. Specific skills include trouble-shooting, quality control, equipment stretching, scheduling workflows, inventory control, monitoring productivity and innovation following basic research.

Linkage capabilities include establishing links among enterprises and with service suppliers or science and technology institutes like universities or standards bureaus.

The level and depth of a country's technological capabilities affect its industrial performance, [15].

Although formal research and development as a share of national income can be used to measure a country's technological activity, to be relevant to production and manufacturing it is better to look at the level of research and development that is financed by productive firms. Even this measure, however, does not account for all the informal and incremental activities that build and improve technological capabilities. The few available data for sub-Saharan Africa suggest that the continent lags behind other developing regions. Many firms are technologically isolated, working in an information-poor environment where interactions with other firms and organisations are often restricted and collective support systems are largely non-existent or poorly delivered, [16]. African firms are forced to rely almost exclusively on their own learning to build technological capabilities, [17]. Such efforts are often limited, and lack continuity due to poor financing and insufficient awareness of their usefulness.

Data from Ghana and Zimbabwe suggest that production and investment capabilities can significantly improve firms' relative technical efficiency in manufacturing. In Kenya, Tanzania and Zimbabwe, firms that are larger, with longer production experience and more internal training, have also proved locally competitive, [18]. However, even in the best African firms, technological activity is still lower than in other developing countries in Asia or Latin America, [15].

### 3. DigiCAP toolkit: craft Ugandan women case study

In order to build capability and significantly improve craft women business a unique digital toolkit is presented which satisfies the requirements for design and ergonomic, manufacturing operations and quality management through the conception of an original virtual toolkit, DigiCap, Fig 1. This framework is used in a case study to demonstrate the capability of the toolkit to applications of craft Ugandan women.



Fig. 1. DigiCap toolkit

#### 3.1. Methodology

An exploratory qualitative research approach in the form of a case study design is adopted for the purpose of this study. The researchers focused on observation and conversation with entrepreneurs in their territories. A data collection instrument in the form of an interview guide was prepared based on the literature review presented above. The interview guide served to steer discussions to focus on common themes. It was kept flexible, allowing the interviewer to decide on the sequence and wording of questions in the course of the interviews. For concise analysis and interpretation, a total of 10 women entrepreneurs were asked to list, in descending order, the most significant barriers they faced in their entrepreneurial development, as shown in Table 1. The questions of interest specific to this study were: What are the barriers that you face as a woman in your determination and ambition? How do they hinder your success as a woman entrepreneur? What are the key suggestions that could be helpful in lobbying for legislation? Finally, what mechanisms would you recommend for women entrepreneurs to start, manage, and grow their businesses?

Table 1. Main Barriers to Women entrepreneurship in Sub Saharan Africa

Barriers	
1	Gender-related stereotype still prevent some women from owning a NIC. In a country that has the third highest rate of female entrepreneurs in the world
2	Under capitalization, (credit discrimination, high interest rate, etc.)
3	Multiple responsibilities (business, family, childcare, social life)
4	Dealing with authorities (corruptions, procedures, policies)
5	Political instability and economic stagnation
6	Lack of timely business information (business knowledge and market information)
7	Tax policies and regulations ,financial inclusion and business registration

As illustrated in Table 2, the interviewees were drawn from a range of age groups (i.e., 20 years old to 67 years old) and different business (e.g., beadwork, basketry, textile, carpet weaving, etc.), thus they bring a variety of vantage points and perspectives. Seven were married, and one each was divorced, widowed, and engaged, respectively. All had children and caregiver responsibilities. Most of the women entrepreneurs in the sample also have varied academic qualifications (bachelor degrees, master degree, one diploma, one advanced level certificate, while one had no formal qualification).

Table 2. Sample women handcraft profile.

Cases	Business	Level of education	Year of experience	Marital status +children
1	Beadwork	No formal education	Over 20	Married+3
2	Textile including carpet weaving	No formal education But read and writing	10-12	Married +2
3	Basketry	A level	5	Married+2
4	Pottery	Bachelor	10	Widow
5	Shoes	Bachelor	10	Single
6	Skin work	A level	10	Married +3
7	Leatherwork	Diploma	20	Married +6
8	Carving	A level	20	Widow +5
9	Jewellery	No formal education	20	Married+6
10	Miscellaneous crafts	No formal education	15	Married+3

Only half had relevant prior work experience. All interviews were conducted in English, as the interviewees seemed to all have a good command of the language. While there was the option of using a native language, respondents often chose to use English, sometimes together with Luganda, the local language commonly used in Kampala, central Uganda, and a few other parts of the country. The interviews lasted on average two hours, and were tape recorded.

The researchers visited 2 villages and observed the craft women making beadworks, basketry and textile including carpet weaving, we carried out 2 training workshops for 2 groups of craft women each group consisted of 12. The aim of the workshop was to train the groups on the design and ergonomics, manufacturing operations (value stream mapping, lean manufacturing) and quality management (branding) and capture the requirements to develop an e-learning toolkit, DigiCap,

### 3.2. Design and Ergonomics

The DigiCap aimed to be a practical toolkit for the handcraft women to use as part of their processes but incorporate some of the concepts we covered during the workshops.

The images below represent the first prototype that we took for consultation during our second visit to Kampala. Based on the feedback received, it was decided to have two options. One would be the apron shown below with pockets to sort their craft tools (incorporating 5S part of Lean Management, place for torch for areas/times that electricity or natural light is not available and gloves to avoid contact with hazardous materials). An extra option was incorporated, and this was fed back to the graphic designers: a fold out toolkit that it would be of rectangular shape when unfolded with customised pockets to adjust to the needs of the different crafts, and able to fold back to a cloth bag when not is use and for ease of transport (mobile workstation). Local colours and culture where taken into consideration for the design.

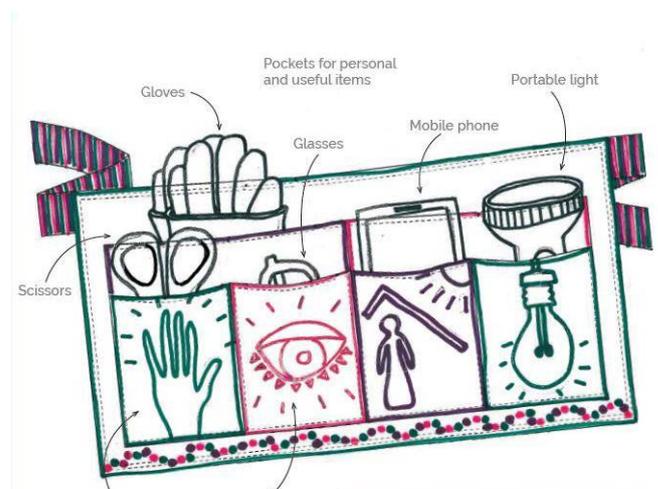


Fig. 2. Concept drawing for craft women Apron.



Fig. 3 .Prototype Work Mat for craft women.

### 3.3. Digital learning experience

In the Kampala study, internet usage play a more dominant role, since many of the people and organizations spoken to have internet access and use it on a regular basis, [15]. Internet is primarily used to collect, present and communicate information, including experiences and best practices, in written or oral (podcast) form. Another role played by the internet is to provide visibility for smaller organizations/enterprises, and to facilitate public debate via thematic mailing lists, [19]. As with this project, the internet is used in combination with other media, such as notice boards, radio, and mobile phones, which are accessible to a broader audience. Linking back to the concept of media diffusion, the case illustrates how old and new media platforms are used as a tool for empowerment in Uganda, [14],[1]. The study thus points to the multiple ways in which various platforms may be combined, even within a context of relatively limited ICT access. Regarding the analytical framework, and its categories of access, freedoms and resources (capacity building), this provided a useful but also somewhat abstract reference for the analysis. The notions of access and resources to communicate seemed relevant when discussing ICT usage from a public sphere perspective, thus emphasizing the potential empowering role of technology with regard to communication, decision making and participation in public life, [20]. The current project will verify findings and give the opportunity to scale up the learning model to additional countries across Africa. Furthermore, the digital toolkit will capture intangible data of craft making and create a database for further training and development. The off line content of the digital element will also facilitate learning on mobile devices addressing issues of remoteness and challenged of mobility. The knowledge gained from the project will create a strong case to apply for a larger fund based on a advantage of evidence based/data driven proposal and also to the links and partnerships developed from both projects and lessons learned with inter-cultural work.

### 4. Conclusion and future work

The projects succeeded in establishing technology as a sociocultural enterprise that is interdependent with society.

Success of women centered projects in general hinges on the ability to ensure that the technology is adapted to suit the women's reality. The women's digital baskets project in Rwanda used a craft practiced primarily by women, basket weaving as the entry point through which rural women in Uganda were introduced to the digital world. The different ICT platforms provided women with the tools and abilities to address their situations. Prior to their experiences with ICT the women lacked access to information that perpetuated their positions of dependency. However, it is not the ICT but the courage of the women that enabled them to take the stride outside of their confinement. It is important to be aware of the continued challenges that many of these women will face in the future. For many developing regions, assertive women run the risk of being ostracized as this challenges the structures of male dominance. For the future work, we plan to define a process for managing the requirements for capability patterns. A composite structure of the patterns requires specific guidelines and a language for their specification, storing, search, combining, etc. Another challenge to address concerns the elicitation of capabilities in the situations where a supporting base of software services has been previously developed, and capability requirements need therefore to consider these services as existing "IT capabilities".

### Acknowledgements

Research results presented in this paper are based on the activities carried out in the framework of the project "Critical factors for facilitating capacity building for the handcraft women in Uganda", funding by Royal Academy of Engineering, Frontiers of Engineering - Seed fund round 3 (FoESF1718\3\9). Authors would like to acknowledge all the women in handcraft who have participated to this project.

### References

- [1] Jørgensen RF. ICT as a tool for empowerment in Uganda Center for Internetforskning. n.d.
- [2] Amine LS, Staub KM. Women entrepreneurs in sub-Saharan Africa: An institutional theory analysis from a social marketing point of view. *Entrep Reg Dev* 2009;21:183–211. doi:10.1080/08985620802182144.
- [3] Dejene Y. PROMOTING WOMEN'S ECONOMIC EMPOWERMENT IN AFRICA. n.d.
- [4] Pandarum R, Harlocka SC, Hunter L. an Empirical Study Exploring Body Perception and Apparel Fit Preferences for South African Women. *J Consum Sci Spec Eddition Divers Cloth Res South Africa* 2017;2:40–54.
- [5] Spring A. African Women in the Entrepreneurial Landscape: Reconsidering the Formal and Informal Sectors. *J African Bus* 2009;10:11–30. doi:10.1080/15228910802701296.
- [6] Kuada J. Gender, Social Networks, and Entrepreneurship in Ghana. *J African Bus* 2009;10:85–103. doi:10.1080/15228910802701445.
- [7] Brush CG, Cooper SY. Female entrepreneurship and economic development: An international perspective. *Entrep Reg Dev* 2012;24:1–6. doi:10.1080/08985626.2012.637340.
- [8] Jennings JE, Brush CG. Research on Women Entrepreneurs: Challenges to (and from) the Broader Entrepreneurship Literature? *Acad Manag Ann* 2013;7:663–715. doi:10.1080/19416520.2013.782190.

- [9] Kumari R. Economic growth, disparity, and determinants of female labor force participation. *World J Entrep Manag Sustain Dev* 2018;14:138–52. doi:10.1108/WJEMSD-03-2017-0009.
- [10] Lakwo A. Microfinance, rural livelihoods, and women's empowerment in Uganda n.d.
- [11] Sriram V, Mersha T. Stimulating entrepreneurship in Africa. *World J Entrep Manag Sustain Dev* 2010;6:257–72. doi:10.1108/20425961201000020.
- [12] Raimi L, Patel A, Adelopo I. Corporate social responsibility, Waqf system and Zakat system as faith-based model for poverty reduction. *World J Entrep Manag Sustain Dev* 2014;10:228–42. doi:10.1108/WJEMSD-09-2013-0052.
- [13] Murthy VP. Integrating corporate sustainability and strategy for business performance. *World J Entrep Manag Sustain Dev* 2012;8:5–17. doi:10.1108/20425961211221598.
- [14] Books SL-, 2001 undefined. Competitiveness, technology and skills. IdeasRepecOrg n.d.
- [15] Fostering technological capabilities in sub-Saharan Africa n.d.
- <https://www.scidev.net/global/r-d/policy-brief/fostering-technological-capabilities-in-sub-sahara.html> (accessed October 30, 2019).
- [16] An Assessment of Technological Capability Building in the Informal Nigerian Automobile Sector An Assessment of Technological Capability Building in the Informal Nigerian Automobile Sector 2015. doi:10.12691/jbms-1-4-3.
- [17] Dejene Y. PROMOTING WOMEN'S ECONOMIC EMPOWERMENT IN AFRICA. n.d.
- [18] Loxley J. Structural Adjustment in Africa: Reflections on Ghana and Zambia. *Rev Afr Polit Econ* 1990;17:8–27. doi:10.1080/03056249008703845.
- [19] Digital Identity Country Profile: Uganda. 2019.
- [20] Wamala C, SPIDER. Empowering women through ICT. SPIDER; 2012.