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# Design Science Research Strengthened: Integrating Co-creation and Co-design

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**Abstract.** Design science research (DSR) is a well-known methodology that uses design as a tool for the development of both practical research resulting in an artefact solution, and theoretical scientific knowledge resulting in improved design processes. In this paper, we advocate strengthening the DSR methodology by including elements of co-creation and co-design in order to produce meaningfully contextualised solutions and to foster a stronger sense of ownership and social acceptance of a developed technological artefact solution within ICT4D. In our work, the inclusion of co-creation and co-design within DSR takes place in all of the stages of the design cycle, influencing also the relevance and rigour cycles as well as the impact of the artefact in the broader socio-technical context. Here we illustrate the practical implementation of these ideas through the involvement of women entrepreneurs from rural Tanzania in the development of a mobile application. This paper contributes to the body of research on the meaningful application of DSR processes to ICT4D.

**Keywords:** design science research in ICT4D, co-creation, co-design

## 1 Introduction

Design science research (DSR) has guided the development of numerous ICT-based solutions in emerging economies within the ICT4D field [ CITATION Smiay \l 1035 ]. As a multi-paradigmatic research arena, DSR fits well with the interdisciplinary nature of ICT4D. Thus, from this fusion, several richly developed research endeavours have been reported. For instance, Van Biljon and Marais [CITATION Van17 \l 1035 ] employed DSR to the creation of an open knowledge repository for research collaboration in South Africa; Smith and Turpin [ CITATION Smiay \l 1035 ], complemented DSR with activity theory to highlight uncovered social and political issues during the creation and deployment of an ICT platform in a rural community; and Islam and Grönlund [ CITATION Isler \l 1035 ] described the general use of DSR in ICT4D research, putting forward the realisation of a mobile information service. These examples reveal the applicability of the DSR framework to the ICT4D research field. However, as Islam and Grönlund [ CITATION Isler \l 1035 ] pointed out, DSR within ICT4D “needs an integrated research approach with well-coordinated activities throughout the development process”. We take these considerations a step further and look into strengthening and enhancing the DSR methodology through the inclusion of a coordinated participatory design approach. That is, co-creation and co-design activities used as anchors that facilitate the application of DSR to the ICT4D realm.

The direct involvement of end-users as active partners through participatory design during the development and deployment of DSR in ICT4D has been briefly mentioned previously, albeit it is a rare practice. For instance, Grobler and De Villiers [ CITATION Gro17 \l 1035 ] reported using human-centred design thinking with DSR as a way to enhance and boost the DSR to create an artefact, the community shaping solutions framework, CSSF. It is well accepted in the ICT4D community that when developing technological solutions to real-world contextualised problems, a human-centred design approach is useful. It is fundamental to look at what people actually want to have and/or use instead of what is technologically feasible to create [ CITATION Gro17 \l 1035 ]. Therefore, Grobler and De Villiers in their work used a design thinking iterative process, where the community was directly involved to “co-create frameworks, solutions, opportunities and prototypes” [ CITATION Gro17 \l 1035 ]. This, in fact, seems to fall beyond the user-centred approach to the premises of viewing ‘users as partners’ with direct participation in the research practice and development [ CITATION San08 \l 1035 ].

The participatory design approach to developing technological solutions pioneered in Scandinavia, starting in the 70’s and has steadily being established widely, in the information systems (IS) community and elsewhere, as the preferred and more sustainable approach to achieve meaningful creations and solutions [ CITATION Sch93 \l 1035 ], [ CITATION Mul93 \l 1035 ] [ CITATION Pih17 \l 1035 ]. With participatory design, *co-creation* and *co-design* come to life. According to Sanders and Stappers [ CITATION San08 \l 1035 ], co-creation refers to collective creativity produced for instance by researchers, expert designers and end-users working together. Co-design refers then to that collective creativity applied to the entire design process. It is important to notice that co-creation and co-design go beyond the user-centred design approach in that the former approach sees end-users as *active partners* (e.g., having the users participate and voice their ideas and concerns to guide the design process) whereas the latter approach sees users

as passive participant in the study (e.g., observing users doing tasks, collecting questionnaires, etc.). In our work, we embrace these concepts to put forward a stronger DSR framework that reflects aspects of co-creation, and co-design in order to achieve contextually meaningful interventions. Although few reported research indicates the use of co-creation activities alongside a DSR methodology (see for instance [ CITATION Mra16 \ 1035 ]), a concrete framework is yet to be established.

Addressing this research gap, here we present our strengthened DSR framework and its preliminary implementation as part of our ongoing research work. This work has been realised in partnership with women entrepreneurs in rural Tanzania, striving to achieve the meaningful creation of a technological artefact suitable for supporting their business development through an online market platform accessible with mobile devices. Our contribution highlights the benefit of using participatory design concepts within DSR to go a step beyond the human-centred approach, where end-users are seen as passive elements for observation, towards making end-users active partners in the development of appropriate and contextualised solutions. Furthermore, we invite open discussion from the ICT4D community on issues related to the practical use, refinement and deployment of our framework strengthening DSR.

## 2 Background

### 2.1 Concept of Design Science Research

Design science research (DSR) is a research methodology that invents or builds new, innovative artefacts (new reality) for solving problems or achieving improvements, i.e. DSR creates new means (knowledge) for achieving some general goal as its major research contributions[CITATION Liv09 \ 1035 ]. The contributions of DSR are observable in the combined novelty and utility of constructed artefacts. The essential principle of DSR is that knowledge and understanding of a design problem and its solution are required in the building, application and deployment of an artefact. In DSR, new knowledge is created through rigorous evaluation[ CITATION Hev10 \ 1033 ]. The outcome of a DSR project could be then highlighted through its contribution towards designing and creating new technological artefacts, theories or processes as well as through the impact of the project [ CITATION Bas18 \ 1035 ]. In practical terms, DSR is viewed as a methodology that seeks to reduce the gap between theory and practice but maintains the necessary amount of rigour to ensure the reliability of results[ CITATION Lac15 \ 1033 ]. According to Gregor and Hevner [ CITATION Gre13 \ 1033 ], DSR aims at generating solutions that are more efficient, leading to more effective products, procedures, services, technologies, or thoughts.

The activities within the DSR methodology are embodied into several closely linked cycles that iterate between the core activities of building and evaluating the designed artefact. According to Hevner [ CITATION Hev07 \ 1033 ], these cycles include the *relevance cycle*, the *design cycle* and the *rigour cycle*. Drechsler and Hevner [ CITATION Dre16 \ 1035 ] also propose a fourth cycle of DSR, *change and impact*, to capture the impact in time of the artefact in the wider socio-technical system context where it is utilised. The design cycle is the central part of the DSR methodology, which improves the environment (relevance cycle) through the building and introduction of new and innovative artefacts thus generating new knowledge (rigour cycle), adapting to contextual changes and evolving with time (change and impact cycle). The design cycle iterates rapidly within itself, between creating an artefact, its evaluation and its subsequent feedback to refine the design further. In our work, we consider strengthening the design cycle to accommodate elements of co-creation and co-design in order to achieve meaningfully contextualised artefacts. During a practical implementation of these ideas, we developed a mobile phone application (artefact) contextualised to women entrepreneurs (WEs) for selling and marketing their products, fully involving them in all stages of the design process in order to foster a strong feeling of ownership and to facilitate the social acceptance of the solution for use in real-life settings.

### 2.2 System-centred, Human-centred and Participatory Design

The system-centred design (SCD) focuses on technology models that regard the artefact or system as primary, having the notion that developers and inventors of the technology know what is best for its design, dissemination and intended use [CITATION Joh98 \ 1035 ]. Overall, “system-centered view holds that the technology, the humans, and the context within which they reside are perceived as constituting one system that operate in a rational manner toward the achievement of predetermine goals” [CITATION Joh98 \ 1035 ]. In the system-centred technology, there is no need for the end-users to be involved with the system or artefact during its development. This perspective streams from the standing point that because the system is too complex it should be designed and developed by experts who know what is most appropriate in the system design. The system is created through the process of prototyping and iteration redesign that is primarily controlled by the designers[CITATION Joh98 \ 1035 ]. This approach has been successfully implemented to put forward large technological developments that go beyond the needs of contextual end-users, for example increasing information processing speed of machines with more powerful processing cores or pushing forward the development of massive memory storage capabilities in the computing domain.

The SCD approach might not be, however, successful when it comes to contextualising solutions based on the particular needs of the end-users. Thus, system-centred design shifted to user-centred design (UCD) of technology. UCD involves end-users in the product or artefact development through observations and interviews within the

environment in which they would use the product or artefact being designed [ CITATION Abr04 \l 1035 ]. The aim is to make intuitive artefacts that require minimum effort from the user to learn how to use them – designing *for* users [ CITATION San03 \l 1035 ]. Moving a step further, participatory design (PD) advocates the collective, joint value creation, and collaborative process between researchers, designers, developers and end-users – designing *with* users [ CITATION San03 \l 1035 ] [ CITATION Cov09 \l 1035 ]. This brings with it a shift from UCD merely observing end-users as passive actors towards end-users becoming interactive partners in the design process.

In our work, participatory design is deployed as an end-user-centric tactic putting women entrepreneurs (end-users) first and recognising them the starting point of the experience from problem explication and user requirements definition through artefact design and development, to the evaluation of an artefact for enhancing their business performance (see examples of similar practices in [ CITATION Neu16 \l 1035 ]). Furthermore, since PD is value-based and focused on relationships and distribution of responsibilities between researchers, designers and WEs during the DSR process, it thus improves synergies for co-creation. Our work strengthens the DSR methodology by acquiring the value of co-creation and co-design for sustainable innovation.

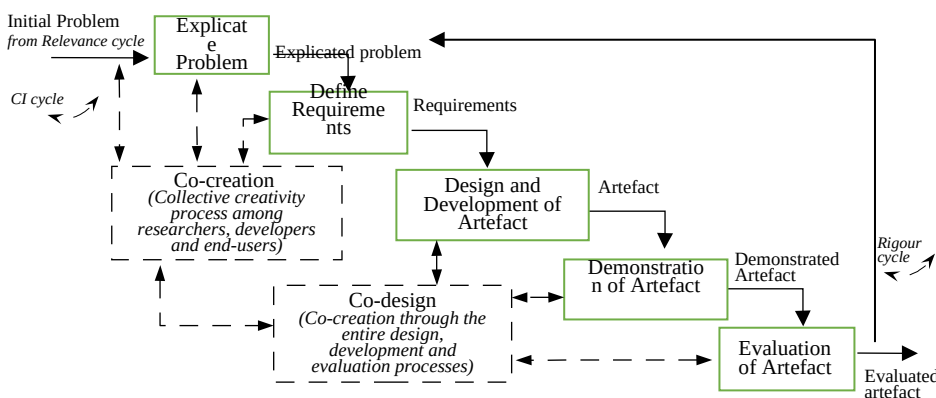
### 2.3 Co-design and Co-creation in Design Science Research

Participatory design through co-creation and co-design offer a significant contribution towards facilitating and improving DSR processes in ICT4D. According to Sanders and Stappers [ CITATION San08 \l 1033 ], co-creation refers to any act of collective creativity, shared by two or more people, for instance researchers and end-users. Co-design refers to the application of the collective creativity (co-creation) across the entire a design process. Co-creation is akin to a customer-centric approach based on the principles of putting customers first and recognising them as the starting point of the value creation experience (see, for instance, Ramaswamy and Ozcan’s *value-in-interactional creation* concept, which poses value creation as a co-creation, with interactions across systems as locus [ CITATION Ram18 \l 1035 ]). A co-design and co-creation approach involves collaboration between researchers and end-users from the beginning, in problem framing and research design and delivery, which influences the research process and implementation strategy from conception (e.g., see [ CITATION Goo15 \l 1033 ]).

We argue that the integration of co-creation and co-design in DSR methodology for ICT4D is of vital importance as it highlights end-users’ participation in the solution-making activities, which could result in a more sustainable sense of ownership and acceptance of the created artefact. Furthermore, since the process of co-design and co-creation tend to yield unexpected benefits, the research results may change the implicit assumptions of researchers by gaining new ideas from the participants in DSR process [ CITATION Ste11 \l 1033 ]. Drawing from the experiences of business ventures, co-creation and co-design enhance customer’s commitments, create offerings that are more competitive, foster faster time to market, and build brand awareness [ CITATION Fro15 \l 1033 ]. Similar results could be expected from the perspective of users’ sense of ownership and acceptance of artefacts created through DSR within ICT4D, having the end-users as partners in development. Thus, in our work we view co-design and co-creation as integral parts in all DSR design cycle activities. Therefore, end-users are involved in the entire design process from the iterative problem explication and definition of requirements, to the design and development of the artefact and to its demonstration and evaluation, until a satisfactory outcome is reached between researchers, designers and the end-users (see Fig. 1).

## 3 Strengthening DSR

Fig. 1 highlights our ideas regarding strengthening the DSR framework (design cycle) through accommodating co-creation and co-design. We build upon the DSR framework proposed by Johannesson and Perjons [ CITATION Joh14 \l 1035 ].



**Fig. 1.** Our framework for strengthening DSR with elements of co-creation and co-design (adapted from Johannesson and Perjons [ CITATION Joh14 \l 1035 ], p. 77)

From the starting point of identification of the initial problem, co-creation and co-design play a prominent role in leading the design process. During the problem explication, end-users and researchers through exploratory group discussions elucidate the challenges encountered to which they would like to find a solution (practically, this is discussed within the scope of the specific goal of the project). In our case, in doing business effectively, for instance, lack of capital, lack of skills, and unreliable market were identified as hindrances. The identified challenges are then assessed through brainstorming technological solutions to improve the situation from the perspective of the end-users. Following this, through the process of co-creation, user requirements of the practical implementation of the technological solutions are brought forward. The aim is to clearly identify what solution would provide a meaningfully contextualised artefact to tackle the problem under analysis. The end-users requirements are the cornerstone for the design and development of artefact. During the design and development of the solution artefact, there is a continuous iterative interaction with end-users through co-design workshops in order to pool together the collective creativity and to redefine the original problem and user requirements to fit the needs to satisfactory level. During the demonstration and evaluation, end-users use and give their feedback on the implemented artefact. This feedback is used for improvements or changes in the solution in order to meet the users' needs and to realise its full potential of intended usage.

Although several applications and adaptations of the DSR methodology have been proposed in the information systems research arena (see for instance [ CITATION Pef07 \l 1035 ] and [ CITATION Vai15 \l 1035 ]), our framework is intended to facilitate the successful implementation of the DSR methodology in the ICT4D realm, through the integration of co-creation and co-design to foster the meaningful contextualisation solutions.

## **4 Strengthened DSR Framework in Action**

In the implementation of DSR, the elements of co-creation and co-design are employed in order to put forward a meaningful intervention and to create acceptance of the design artefact by the end-users (i.e., women entrepreneurs, WEs, in rural Tanzania). Through this, we aim at increasing the potential value chain activities and efficiencies of the DSR methodology [ CITATION Fro15 \l 1033 ]. The processes of co-creation and co-design as described in Fig. 1 were implemented alongside WEs in the food processing business in rural Tanzania. One hundred and eighteen WEs and five customers participated in the study, distributed in the different stages of the DSR design cycle process.

### **4.1 Explicate Problem**

The problems that affects women entrepreneurs (WEs) in doing business were investigated and analysed through a co-creation strategy between the researchers, designer and WEs in order to ascribe a specific social problem. During this stage, 80 WEs participated, data were gathered through face-to-face informal interviews, focus group discussions and researchers' participation on the daily activities of the end-users in order to gain insights of the socio-cultural challenges and other issues that the WEs deal with in rural Tanzania. The co-creation activities involved participation of the end-users to elucidate their inner challenges in doing business. During these activities, several challenges that hinder business performance and expansion were highlighted, including lack of market information and lack of capital. As the use of mobile devices is becoming widespread even in rural areas, this pointed towards the need for a mobile technology application for empowering the WEs during their business development.

### **4.2 Define Requirements**

Understanding end-users requirements is fundamental for devising solutions to the explicated problem in the form of an artefact. It involves transformation of the problem into an artefact with functions, structure and operating environment. During the fieldwork, 33 WEs participated and focused on problem clarifications and requirements definitions together with researchers in order to identify and represent opportunities and potential technological solution. During the co-creation process, data was collected through semi-structured interviews and exploratory focus group discussion using mockups and drawings to aid in defining the problem, the user requirements and a viable solution precisely. This process was continuous and iterative in order to refine ideas, until a consensus between researchers, developers and WEs was reached. The involvement of the end-users in requirements definition in this manner enabled to sketch a possible artefact that could address the problem of accessing market information, and boosted the artefact's acceptance from the onset.

### **4.3 Artefact Design and Development**

The artefact was designed and developed fulfilling the end-users requirements that addressed the explicated problem (33 WEs were involved). The participants agreed that the most suitable artefact would be a mobile application that enable them to market their products (e.g., a virtual market). The users were invited to create suitable design interfaces for the application together with the researchers and developers. The main purpose of these activities was to produce prescriptive knowledge by designing and creating the artefact together. During the process of design and development, researchers, developers and WEs were fully involved in describing the artefact functionalities and structure; justifying

the artefact components that address the identified requirements; and illustrating how the artefact and its components were to be used in its intended context of accessing or sharing market information (e.g., through storytelling the WEs described everyday scenarios where they could use the artefact at home while attending other tasks). The co-creation and co-design process enabled the sharing of swift feedback about the functionalities of the artefact through visualising its contextualisation in WEs everyday life environments and activities. In turn, this facilitated a continuous process of re-defining important user requirements and design corrections until reaching a satisfactory outcome taking into consideration a suitable balance between the available resources and the end-users' needs. With this, features such as audio descriptions and voice recording through the interface to make it accessible for less literate end-users were implemented.

#### **4.4 Artefact Demonstration**

The use of the artefact, the mobile application, was demonstrated to show its practical deployment in a real-life scenario with end-users. During the demonstration, a training workshop was arranged with five WEs and five of their customers to establish the mobile application usefulness. During the workshop, the participants learnt to open their mobile devices and browse; download the application; understand the functions of different icons; operate the application by posting new products and viewing existing products within the virtual market. Participants were given two days to familiarise with the mobile application by themselves in their real-life settings to ascertain whether they understood how to use the application as well as its suitability to address the problem of accessing and sharing market information. The end-users had the opportunity to voice their concerns and questions regarding the application as part of the co-design process.

#### **4.5 Artefact Evaluation**

The mobile application was qualitatively evaluated through co-design group discussions in order to determine how well the application facilitated the access to market information and whether it fulfilled the requirements after a 21-day in-the-wild testing with five WEs and their 5 customers. The WEs reported that the mobile application performed well, allowing access to market information by fostering and facilitating the interaction between them and their customers. The application also helped them save resources in terms of time and costs of travelling to market, allowed easy access of data from all devices that connect to internet, linked them to customers, and helped them increase their market size through sharing the app within their network. However, WEs pointed out the challenge of airtime costs (bandwidth) as a hindrance to the use of the application, since many could not afford to have their phone consuming bandwidth at all times. The 2018 GSMA report for sub-Saharan Africa [ CITATION Glo18 \l 1035 ] shows insights on the current connectivity challenges of the region. Nevertheless, the report also indicates that future growth opportunities will be concentrated in rural areas. Moreover, since the number of mobile subscribers and service providers is increasing, the costs of airtime and handsets are expected to decline rapidly as to keep a competitive advantage in the free market economy. This could facilitate the wide intake and use of the proposed co-created solution.

## **5 Reflections and Future Work**

Integrating participatory design (PD) into a DSR framework for ICT4D is not trivial and does not come without its challenges. As reported in the literature, there are many reasons why PD faces opposition in research work, chiefly related to the costs and risks associated with PD implementation [23] – it is a resource-intensive, delicate process to bring in researchers, designers/developers and end-users together to develop innovative solutions to problems. In our work, we observed that the reluctance of participants to engage in group discussions, especially when they do not see an immediate incentive for their personal use, was challenging. In addition, if the participants or their communities have taken part in research projects before but they did not see how their voices were heard, how they influenced the process or how they made an impact, they could be discouraged to engage into a mutual solution-seeking endeavour like the one presented here. Although we encountered these challenges, through community leaders who are working at the grassroots level, e.g., church leaders, we could recruit WEs to participate in the study and build trust, a fundamental step in order to uncap the benefits of participatory design and foster the social acceptance of the solution. Through this trust, WEs were in a position to voice their grievances in doing business and felt empowered as they could see that their input made a difference throughout the co-creation and co-design of a solution. The future work will explore the mid-term benefits of this approach through verifying the sense of ownership and acceptance of the co-created artefact.

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