Rapid and Collaborative Development of Socially Relevant Computing Solutions for Developing Communities

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Abstract

Information and communication technologies (ICTs) have an immense potential as a tool for development. It is now common knowledge that advances in the use of technology can improve economic opportunities for the poor, improve service delivery to the underserved, provide employment opportunities, and benefit social change. ICT4D projects as agents driving developmental objectives using ICTs have made some significant strides in our local communities, especially with the uptake mobile telephony in developing countries. However, many ICT4D projects still fail to meet their objectives and intended impact. At the same time other initiatives such as the hackathons, as short software development events, that foster collaborations amongst different stakeholders, including communities to work on common social challenges over a short period of time are emerging to address the technological gaps in ICT4D projects. This research expands on the extensive work that has been done over the years in ICT4D projects to propose a hackathon model that focuses on the rapid development of socially relevant technological interventions that could be implemented in communities within a shorter period of time. The approach was conceived based on an exploratory case study using a community engagement project at one of the universities in South Africa. The model centres around four key elements that could expedite the development of technological artefacts together with the community, stakeholders, and digital volunteers in ICT4D projects.

Keywords
ICT4D, social development, rapid software development, hackathons, socially relevant computing, collaborations, human capital development, crowdsourcing

Steyn, J., Van Greunen, D. (Eds). (2014). ICTs for inclusive communities in developing societies. Proceedings of the 8th International Development Informatics Association Conference, held in Port Elizabeth, South Africa.
ISBN: 978-0-620-63498-4 Pages 337-348

1. Introduction

Information and Communication Technologies (ICTs) have patently changed the technological landscape in developed, developing and underserved nations over the past few years. Today, the underserved communities almost enjoy the "same" access to information as those in developed communities, albeit still plagued with a number of infrastructural challenges and limited broadband connectivity. A steep increase in the research and deployment of Information and Communication Technology for Development (ICT4D) projects in developing communities has also been observed over the previous years.

However, most ICT4D projects partially meet or completely miss their set developmental objectives. In addition, most of the projects do not enjoy wide adoption and expected developmental impact (Renken & Heeks, 2013; Walton & Heeks, 2011); despite their positive intentions. For instance, the World Bank evaluator report (Lakshman, 2011) laments that their funded ICT4D projects had a failure rate of over 70% between 2003-2010. Of course, there are diverse attributions to such failures, including limited budgets, developmental divide between those implementing the projects and the communities, cultural differences (Krauss & Turpin, 2010), infrastructural inadequacies and lack of approaches for unifying software development tasks, including replicating successful ICT4D projects in different use case scenarios (Doerflinger & Gross, 2011).

In addressing the high failure rate of ICT developmental projects, academic researchers continue to propose alternative interventions. These include, to name but a few; a process approach proposed by Walton and Heeks (2011); ICT4D project champions (Renken & Heeks, 2013); bottom-up and community-centric projects (Dodson, Sterling, & Bennett, 2012), and "paying more attention to human beings", who are envisaged to be users of the technologies emanating from the ICT4D projects (Toyama, 2010).

In this paper, the main contribution is the expansion on some of these initiatives by proposing a collaborative approach through a case study, referred to as the *hackathon* model. The approach focuses on the rapid and collaborative development of socially relevant technological interventions that could be implemented and deployed in communities within a shorter period of time. This could be done in order to evaluate from onset the viability of ICT4D project prior to long term commitment and implementation in communities. The approach is conceived based on the successes and collaborative nature of hackathons in delivering functional prototypes within a short period of time, designed and developed by digital volunteers with subject matter experts, and mostly initiated by those affected by the challenges.

The remaining sections of this paper cover the following: Background details with regard to the concept of hackathons and ICT4D projects are presented briefly in Section 2. Section 3 details the research methodology employed for this paper. Section 4 presents a brief case study that informed this research and details the community engagement project under which this study was conducted. Preliminary results from the case study are highlighted in Section 5 with the main focus on the themes that inspired the hackathon model. The proposed model that purports to promote rapid and collaborative development

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of socially relevant computing solutions is illustrated and discussed in Section 6. The paper is concluded in Section 7 by highlighting possible future research work.

2. Background

Information and Communication Technologies (ICTs) continue to be touted as having a potential in stimulating socio-economic development, particularly in developing and under developed nations. The South African National Development Plan 2030 (NDP, 2011) also envisages ICTs as being central to addressing social challenges, such unemployment, education, health, water, and economic growth. Parallel to such plans and hopes, ICT4D (also referred to as ICTD or IT4D) initiatives continue to sprout all over Africa, Asia, Latin America, North America, and Europe. The following subsections provide a brief background on the concepts that define ICT4D projects and hackathons.

2.1. ICT4D Projects

The term Information and Communication Technologies for Development (*ICT4D)* can be broadly defined as an approach of using ICTs for affecting socio-economic development, stemming from a premise that ICTs have the potential to contribute towards the practical development of societies (Heeks, 2008; Sutinen & Tedre, 2010). Thus, the central objective of ICT4D projects is to exploit suitable ICTs, such as low-cost personal computers, mobile phones, and the Internet to address disparate community challenges. It worth noting that ICTs could be either directly implemented in societies to address specific needs or indirectly where they are deployed in government, non-governmental organizations or businesses to solve socio-economic challenges affecting communities at large.

ICT4D projects generally sprout from the eagerness and interest by research practitioners, philanthropists, and members of societies to tap into existing technologies or develop new socially relevant technologies in order to address pertinent socio-economic issues in different spheres of life (Toyama, 2010). Technically, ICT4D projects are not only about the poor or Africa, but are meant for all the underdeveloped communities, whether they are in developed, developing or underdeveloped regions.

Some projects, such as M-PESA (Ngugi, Pelowski, & Ogembo, 2010) have made great impact in Africa. However, other developmental projects have barely met their development objectives or made noticeable impact (Dodson et al., 2012). A number of studies attest to a very high failure rate of ICT4D projects (Dodson et al., 2012; Renken & Heeks, 2013). Some of the pertinent challenges that are attributed to the high failure rate of ICT4D projects are the “developmental divide” (Krauss & Turpin, 2010) , technology-centric and top-down approaches that scantly involve communities in the conceptualization and implementation of these projects (Dodson et al., 2012; Walton & Heeks, 2011). Other reasons for failure include “incomplete assessment of the problems being tackled” by researchers (Tongia & Subrahmanian, 2006), and incompatibilities between provided solutions and resources owned by the users in the communities (Dodson et al., 2012).

Notably, different ICT4D projects also fail at different levels, viz.: inception, design,

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development, implementation, or impact assessment level. It is also important to note that some of the failures are caused by circumstances beyond the control of research practitioners, such as under-developed environments, infrastructural deficiencies, or political influences. In addition, ICT4D projects tend to take longer to reach the technical implementation phase, chiefly because many of the ICT4D projects are developed and implemented by a small group of researchers with limited collaborations. However, collaborations should be central in ICT4D projects, especially since there is also a shortage of software development skills within the projects and communities. In addition, most of these projects are also not sustainable beyond the research stages, because communities, generally, lack the skills required to maintain technical ICT4D projects, thus human capital development and multi-stakeholder collaborations are key and should not be ignored in developmental projects.

2.2. Emergence of Hackathons

Hackathons, as ICTs prototyping events that foster collaborations amongst different stakeholders to work on common challenges over a short period of time, are gaining considerable momentum across the globe (Chowdhury, 2012; Coetzee, 2010; Leckart, 2012; Popyack, 2014). These events are also referred to as code sprints, hackdays, civic days or code festivals. Today, hackathons are hosted in large organisations such as Facebook, Yahoo, Google, and Microsoft to crowd source innovative solutions, empower a community of developers, entice developers to embrace their latest technologies, and recruit bright software developers into these organisations. Furthermore, hackathons have found their way into universities and government institutions. These events attract over 5000 digital volunteers globally, and continue to grow even in developing countries, such as South Africa and Kenya (NASA, 2010; RHoK, 2012).

The general focus of hackathons is on “rapid and iterative software development” that seeks to address societal challenge, build or promote new technologies, build human capital development, or in some instances stimulate the entrepreneurial spirit in young people. These technical sprint events are regularly in different parts of the world, normally lasting for 2-3 days, and in limited instances a week. According to Leckart (2012), in one year (i.e. 2011), over 200 hackathons were hosted in different cities in the United States and other parts of the world, tackling issues around education, disaster responses, corruption, health, water, climate change, government elections, politics, food security, transport, and mobility. Most of the events are hosted on-site, with a few being hosted virtually, attracting participation from volunteers all over the globe.

The evident growth of hackathons over the past few years is still difficult to scientifically quantify due to lack of documentation and research in this field. However, their potential impact is self-evident, especially in enabling an environment for communities to initiate and pitch their central challenges that could be addressed speedily by technologies designed and developed by digital volunteers and relevant stakeholders. Hackathons also have the potential to up skill emerging software developers, especially graduates and students from the ICT discipline (Mtsweni & Abdullah, 2013). This is so because during hackathons participants interact and collaborate with experienced developers, subject-matter experts, and communities. In the same breadth, hackathons have also proven to be quite effective

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in bringing forth solutions that are able to address immediate challenges emanating from natural disasters. Tweak the Tweet (Starbird & Palen, 2011), an idea that has since been further developed by the Project EPIC team, originated from a hackathon. This project has been used in disaster situations in Haiti, Japan, and United States. Features such as the "Timeline" and the "Like" button used in the Facebook application were initiated during hackathons (Keyani, 2012). Projects such as Ushahidi also continue to be developed and enhanced during hackathons.

Noticeably, hackathons do not necessarily deliver complete ICT solutions within 2-3 days, but they deliver mobile, web, desktop, and back-end solutions that could be deployed and tested in the field within a short space of time, making it possible for researchers, communities, and developers to timely ascertain and evaluate if the envisaged ICT4D solution is appropriate for addressing an identified challenge, especially since "*not all social challenges necessarily need to be addressed with a technology*" (Watters, 2012).

3. Research Methodology

An exploratory case study approach (Yin, 2009), supported by document analysis, direct and participant observations, expert evaluations, and open-ended interviews with selected participants, was used for this research. The case study method was chosen and preferred as it provides opportunities to collect data using multiple sources of data (Tellis, 1997; Yin, 2009). The single case study (as described in Section 4) was designed within an existing community engagement project, called Computing Pro Bono (as discussed in Section 4). The case study was conducted and administered over a period of 18 months, spanning three (3) hackathon events. The major component of the case study focused on observations and expert evaluations of the prototypical solutions.

The participants who formed part of the research were mainly software developers, subject-matter experts, computing students, community representatives, problem owners, and business owners. Data collection was accomplished by firstly searching through the Web for hackathons-related online news reports, personal blogs, and hackathon events pages. This was done, as currently there are a very limited number of accredited research articles that have been published on hackathons, let alone their link with ICT4D projects. The case study evidence was analysed using thematic analysis. Thematic analysis "focuses on identifiable themes and patterns" of activities from research data (Joffe, 2011). The themes that emerged from the thematic analysis exercise informed the development of the proposed model as illustrated in Section 6.

4. Case Study – Computing Pro Bono

The research work presented in this paper originates from a community engagement project funded by one of the South African universities. The project has been running for the past two years (2012-2014). The project is called Computing Pro Bono. The main objective of the project was to exploit the expertise of the computing staff, students, external stakeholders (e.g. professional developers), and subject-matter experts to develop socially relevant computing solutions that have the potential to address social and

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humanitarian challenges affecting local communities. It should be noted that the project also encourages inclusive participation, thus not only computing students could participate, but even students from diverse disciplines with different skill sets.

For the case study, three (3) hackathons were organized and hosted in June 2013, December 2013 and June 2014. Over 200 participants, including computing students, subject-matter experts, researchers, business analysts, developers, and representatives of local communities gathered and collaborated to tackle different social challenges in various domains during the three events. The participation was voluntary and opened to all volunteers. However, volunteers were required to register for the event to indicate interest to participate. Challenges that were tackled by the volunteers mainly originated from communities in Tsakane Township (African School of Excellence), Tshwane municipality, Department of Basic Education, Non-profit organizations, and educational institutions. Developers themselves also initiated other social challenges, mainly motivated by their personal experiences.

5. Preliminary Results

In this section, we discuss the salient findings from the case study using thematic analysis to highlight the important themes that emerged from the study. For this specific paper, we shall only focus on observations and briefly highlight some insights gained from expert evaluations of the projects that digital volunteers participated in during the three (3) hackathons. The experts that participated in the evaluations of the projects were mainly from the ICT and academic background, and some had experience in ICT4D projects.

In all the three (3) hackathons, it was observed that the main activity was about delivering technological solutions within a short period of time focusing on addressing identified *social challenges*. The challenges were initiated by *different stakeholders*, such as local orphanages, non-governmental organizations, and in rare cases by the developers, who had an interest and passion in the challenge, such as crime and citizen participation.

One of the challenges that were tackled during the first hackathon was about enabling village citizens to use their mobile devices to report leaking and non-operational water taps to the responsible councillor. This project was initiated by members of a local community who were concerned about the loss of water caused by leaking taps. Within two days, the digital volunteers had a functional android application that was integrated with an online backend. This kind of a project, although not initially conceived as an ICT4D project, could have been deployed in communities with similar challenges to determine the appropriateness of such technological interventions within a very short space of time.

During all the hackathons, it was also solicited that although the main activity was about *software development*, other sub-activities were also performed by *non-technical participants*, such researching on the presented challenge, gathering requirements from subject-matter experts, managing the to-do tasks list, and designing of user interfaces. It was also observed that a majority of participants in these events were computing students who wanted to apply what they have learnt in practice, and at the same time network and interacts with professionals in their areas of specialization.

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During the second hackathon, it was observed that some challenges that were started in the first hackathon had not made much progress. Data collected from the interviews suggested that team members did not commit any development time to their projects after the “hack-days” had passed, because of limited time and lack of *project champions* to drive the projects to implementation. Nevertheless, it was mentioned also that the follow-up hackathons provided an opportunity for teams to meet and continue on the identified challenges, particularly for complex challenges involving heterogeneous components. From the data collected, it also became obvious that the *volunteers* were instrumental in making the hackathons successful, particularly the challenge owners, subject-matter experts, developers, and computing students.

In the hackathons, *participation* and *collaborations* are paramount. In addition, the spirit of teamwork and *collective programming* was observed in all the events. This suggests that participants are also keen in being part of teams that have a chance to produce meaningful prototypes over the period of the event. However, it has also been shown that ideas at these events need not to be completed over a two day period, but can be engaged from one event to the next one. It is therefore important to note that such events could be useful to ICT4D projects, especially for rapidly developing technological solutions that might not be fully functional, but at least have the key functionalities in place to be tested in the field.

Expert evaluations were also conducted at the end of each hackathon and ICT experts (e.g. software experts) and mostly four per hackathon were invited to evaluate the ICT solutions delivered during the hackathon. Generally, experts exhibited positive attitude towards a number of solutions, albeit with some reservations on the *impact* and *sustainability* of the projects. This was mainly because none of the solutions that came out from the hackathons had been trialled in communities targeted as beneficiaries. It is our view though that the trials of such solutions could be suitable starting points for new ICT4D projects.

This paper therefore posits that the high failure rate of ICT4D projects could be minimized by adopting approaches that rapidly provide researchers with prototypical solutions that could be deployed into the field within a very short space of time. This is to realize during the needs assessment phase if the investment into a long-term ICT4D project is worthwhile. The proposed model from this research work is unpacked in the following section.

6. Hackathon Model

The rapid and collaborative hackathon model is depicted in Figure 1. The objective of the model is to illustrate the potential value of hackathons in indirectly minimizing the high failure rate of ICT4D projects. The model encourages the notion of evaluating the envisaged ICT interventions at the initial stages of the project to determine if such interventions are actually worth implementing within a particular setting. This might be out of ordinary, especially at the beginning of the project; however, most ICT4D projects tend to also fail not necessarily because of inferior solutions, but misalignment of technological

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solutions with the current realities on the ground. Testing the prototype in the initial phases of the project could give the researchers opportunities to understand, for example, that a smartphone application might not be useful to a specific community or mobile applications would not be able to penetrate an identified challenge. However, what would commonly happen in some ICT4D projects is that project sponsors would decide to acquire smartphones for the limited number of users in the community hoping that one day all users in the community will have such devices to adopt their ICT4D solutions. Unfortunately, this way of thinking focuses on a technology-centric approach than on a community-centric approach.

The proposed model as depicted in Figure 1 is composed of elements derived from the case study and others adapted from the pr*ocess approach* coined by Walton and Heeks (2011). Some of the key elements from Walton and Heeks (2011) forming part of the process approach include *(1)* beneficiary participation; (*2)* flexible and phased implementation; *(3)* learning from experience; (*4)* local institutional support; and (*5)* sound project leadership. The essential elements derived from the case study include *(1)* human capital development, *(2)* collaborations and engagement with stakeholders, volunteers, and experts, *(3)* project champions, and *(4)* impact metrics and assessment.

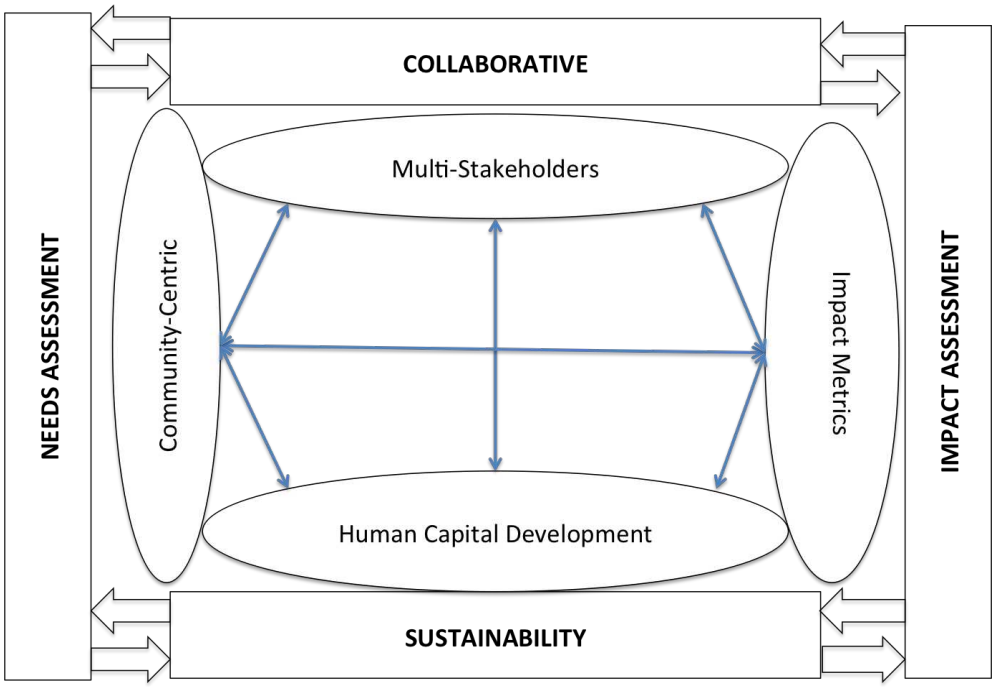

Figure 1. Hackathon Model for ICT4D Projects

As may be noted from Figure 1, the model is iterative and does not have an entry or exit point. It captures the critical elements that could be addressed in hackathons to rapidly and collaborative develop socially relevant computing solutions that are meant to address specific socio-economic challenges. It should be noted that the model is not necessarily about managing ICT4D projects, but is about how to rapidly develop solutions that could be tested in ICT4D projects within a very short space of time. It is assumed that such a model would be implemented within a hackathon setting, and would be driven by community project champions, ICT4D researchers and software developers.

The model suggests that it is important for any socially relevant computing project to have a complete **needs assessment.** This process needs to be focused on the **community** rather than technology. It is even better if the initiator of the challenge is the community or at least members of the community. In hackathons, challenges that digital volunteers work on mostly stem from the members of the community. However, it should be noted that it is not always possible for communities to come up with clear requirements when it comes to ICTs. This is obviously because communities are generally not technology-aware as researchers would, and probably are also not aware of the possibilities that technology have in addressing their specific challenges.

Hackathons are by design **collaborative** and involve **multiple stakeholders**. Stakeholders may include the community, authorities, project champions, subject-matter experts, and others. It is also important in this phase of collaboration to always establish relationships that are mutually beneficial. This is key in ensuring that the project is focused and would eventually benefit everyone involved from different perspectives. **Engagement and participation** by stakeholders are paramount in hackathons. This is important since digital volunteers who participate in hackathons are merely experts in technology, but not necessarily experts in social or community development. Thus, contributions from stakeholders, even if it does not make technological sense, need to be taken into account.

In order to ensure that the technological solutions that come out of hackathons are sustainable should they be implemented, it is important that **human capital development** forms part of the development stages, especially for knowledge and skills transfer (Conger, 2013). In hackathons, there are a number of students that participate, and some of these students are from the communities with the challenges being addressed. It is therefore beneficial to also focus on empowering these students such that they are able to **sustain** the solutions after the hackathons, and in certain instances they could even be empowered to be project champions (Renken & Heeks, 2013). Above all, hackathons are about providing students with opportunities to apply what they have learnt and work with experienced practitioners (Mtsweni & Abdullah, 2013).

The most important element that even hackathons have a difficulty in achieving is **impact assessment.** In order to evaluate if a technological solution is having the desired effect, it is critical to determine the **impact metrics** in the initial stages of developing the solution. These metrics could be derived from the field and in collaboration with the stakeholders during the hackathon and first stages of prototype evaluations.

The proposed model is still in its infancy stage and its core elements are rooted in the manner in which hackathons are coordinated, so there could be some limitations that were not considered. Nevertheless, it is our view that such a model could be quite relevant in ICT4D projects, especially because of the similarities with the process approach, and the speed and collaborative nature of hackathons.

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7. Conclusion

Most ICT4D projects have positive developmental objectives, and the potential to impact communities in various way. However, research suggests that many of these projects fail because of developmental divide and lack of technological approaches to rapidly and collaboratively build solutions that could be trailed in the field before long-term commitment to the project. At the same time, hackathons have been silently sprouting in different cities, where technologist and other stakeholders collaborate to address social challenges that emanate from communities. Hackathons provide an environment for communities and digital volunteers developers to work on social challenges within a short space of time with the intentions to deliver working prototypes with s short space of time.

Through an exploratory case study, this research work studied the hackathon events over a period of 18 months in order to understand various issues around hackathons. In this paper, a rapid and collaborative hackathon model is proposed in order to contribute in ICT4D projects by providing an environment where ICT4D researchers could engage and work with digital volunteers to deliver prototypes that could be tested in the filed before long-term commitment and overly making unattainable promises to vulnerable communities. The model is still in its developmental stage and has not been evaluated. Such a limitation of the model calls for further research and collaborations with ICT4D project champions in evaluating the potential benefits of the model in communities.

Acknowledgement

The authors would like to acknowledge the National Research Foundation of South Africa for supporting part of the work presented in this paper under the CSUR Grant with a unique Grant no: CSUR13901136075

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