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Digital platforms for research collaboration: using design science in developing a South African open knowledge repository

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ABSTRACT

Research involving the use of information and communication technology for development (ICT4D) inhabits an interdisciplinary space characterized by various philosophies, aspirations, realities and priorities. This diversity in the ICT4D research area complicates knowledge sharing between stakeholders in the field, which may inhibit the dialog between researchers, policy-makers and practitioners and limit collaboration. The purpose of this research was to investigate information technology (IT) enabled collaboration through the design and development of a sustainable open knowledge repository (OKR) according to the design science research (DSR) paradigm. OKRs are tools used to support knowledge sharing and collaboration. The theoretical contribution of this paper lies in the sharing of insights gained into the user requirements, system features and principles for guiding the development process of an OKR for Development Informatics research in South Africa and the implications for knowledge management. The research builds on existing knowledge by applying the four-cycle DSR methodology as a systematic and reproducible method of investigating an OKR as an example of IT-enabled collaboration. The practical contribution is the artifact (OKR) developed to enable the sharing of research knowledge.

KEYWORDS

Knowledge sharing;
knowledge repository;
community; collaboration;
knowledge management;
development informatics

1. Introduction

Information technology (IT) enabled collaboration for development research inhabits an important contemporary area of enquiry that attracts a range of disciplines (Tibben, 2015). The interdisciplinary nature of information and communication technology for development (ICT4D) introduces challenges in resolving different epistemologies that make varying assumptions about the nature of development, the role of ICT in the development process (Qureshi, 2015; Walsham, 2013) and the focal constructs of the theories proposed to explain and predict ICT4D (Weber, 2009). The variety of associated disciplines together with the diversity of stakeholders, which include researchers, funding agencies,

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government departments, participants and practitioners, complicate knowledge management (KM) and knowledge sharing (Conger, 2014). For example, practitioner-based articles are written with practitioners in mind: the logic of the arguments positioned and the presentation of the findings are aligned with the unique assumptions and frames of reference of practitioners (Jabagi, Jiang, MacLean, Chalmeau, & Yang, 2016). However, academic research may not resonate with the language, problems and concerns of the business world and practitioners (Pandaa & Guptab, 2014). The complexities in sharing ICT4D knowledge from dissimilar disciplines among diverse stakeholders from developing, emerging and developed economies (as discussed by Roztocki & Weistroffer, 2011) exacerbate the challenge of building on existing knowledge to formulate research standards, methodologies and theories (Burrell & Toyama, 2009; Walsham, 2012), reach agreement on how research quality can be ensured (Tibben, 2015; Weber, 2009) and achieve research collaboration between diverse stakeholders (Jabagi et al., 2016).

Kolfschoten and de Vreede (2009) developed a design approach for Collaboration Engineering that incorporates existing process design methods, pattern-based design principles and insights from expert facilitators regarding design challenges and choices. Conducted in the United States (Omaha) and the Netherlands (Kolfschoten and de Vreede, 2009), the study is useful in informing the stakeholder collaboration but the context is different from the resource-constrained environment in South Africa. Open knowledge repositories (OKRs) developed by individuals and institutions for sharing ICT4D knowledge do exist (see the examples in Table 2) but there is a gap in the literature on the design decisions and processes underlying the development of an open knowledge repository (OKR) in a developing country. The purpose of this paper is to report on an investigation of the design and development of an OKR to support ICT-enabled collaboration while documenting the user requirements, design decisions and processes. In terms of a taxonomy of theory types in information systems (IS) research (Gregor, 2006) this research could be considered under design and action. Design theory comprises two distinctive characteristics, namely a theoretical base and explicit guidance to practitioners, the latter being articulated in terms of three interrelated components, namely a set of user requirements, a set of system features or principles for selecting system features and a set of principles for guiding the development process (Gregor, 2002). In this paper the design is articulated in terms of the design science approach and the three interrelated components of design theory, namely user requirements, system features and process guiding principles as advocated by Gregor (2002) and Gregor and Hevner (2013). KM research in ICT4D projects is sparse, with the existing research dealing primarily with recommendations at the government policy level (Conger, 2014). The knowledge contribution of this paper lies in applying website technology (known solutions) to the new problem of designing an OKR for collaboration while documenting the design decisions from a KM perspective. According to Gregor and Hevner (2013), the extension of a mature solution to a new application domain is described as *exaptation*. Given the competition for resources and the variety of stakeholders, the ICT4D domain is a source of wicked problems. These are seemingly intractable problems composed of interrelated dilemmas, issues and other problems at multiple levels of society, economy and governance (Horn & Weber, 2007). The design of an OKR involves balancing issues of openness with security, abstraction with detail and inclusion with focus and scope. The solutions to wicked problems are value-laden, in other words, they are either good or bad, not true or

false (Pries-heje & Baskerville, 2008); that resonates with the design of an OKR which involves many sub-systems with competing priorities and power balances.

The design science research (DSR) methodology was selected to govern the design of the OKR in the study reported on. DSR seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts, and endorses relevance and rigor as part of the design process (Hevner, 2007). Therefore DSR offers an appropriate methodology to design information-based artifacts in a strategic and holistic way (Dinter, Kollwitz, Möslin, & Roth, 2016). The three-cycle view comprehensively conceptualizes the critical aspects of a DSR project, but it lacks a key dynamic perspective on how the DSR project relates to the organizational context in which it is embedded (Drechsler & Hevner, 2016). Gill and Hevner (2013) distinguish two artifact fitness types: (1) fitness as maximizing an economic utility function focusing on goodness of fit in a design context and (2) fitness as biological reproduction focusing on sustained design utility over changing contexts. In the three-cycle view, the former type of fitness can be placed between the design and the relevance cycle, but there is no place to integrate the latter fitness type into the model, since the three-cycle view does not cover changing contexts. This is problematic, since understanding the implementation context is an accepted principle in pursuing development goals (Davison & Martinsons, 2016; Heeks, 2014; Roztock & Weistroffer, 2011; Walsham, 2013).

To overcome this problem, Drechsler and Hevner (2016) propose a fourth cycle, the change and impact (CI) cycle, to cover a wider application context and integrate this source of contextual change and dynamics into the conceptual cycle model of DSR.

The three-cycle view has been applied in guiding successful IT-enabled collaboration in developing regions, for example in designing and implementing an ICT for a rural education development initiative in a resource-constrained environment in the Eastern Cape province of South Africa (Herselman & Botha, 2014). Dinter et al. (2016) used the three-cycle DSR in a conceptual framework for the integration of open innovation and KM, and found DSR to be appropriate in the construction of a socio-technical model for the IS domain. The application of the four-cycle approach in ICT4D extends previous studies by explicitly presenting the socio-technical system context.

The research process, which is mirrored in the structure of the paper, entailed the following consecutive phases with connecting cycles:

- Socio-technical system context: the first phase sought to present the socio-technical context giving rise to the OKR project and defined the external environment of the CI cycle. This was done to extract the community needs and requirements of the OKR. This phase of the research process entailed presenting the resolutions from three ICT4D community workshops and the findings of a survey on the relevance of an OKR in the given context.
- Immediate application context: the second phase considered the application context and enriched that view with an analysis of related OKR environments. This was done to draw on existing knowledge repositories. An OKR content category model was presented. The CI cycle is representative of the continued interaction between these two dynamic contexts.
- DSR: The third phase encompassed the design of the OKR and the development of a prototype according to the OKR model. This was done to develop the artifact. The

relevance cycle represents the interaction between the requirements of the application context and the limitations of the development context.

- Knowledge base: the fourth phase entailed the evaluation of the prototype through expert reviews. The rigor cycle represents the grounding of the evaluation in literature and the evidence-based additions to the specification of the prototype. This was done to evaluate and contextualize the theoretical and practical contributions.

A reflection on the application of the four-cycle DSR approach is presented in the discussion section of the paper.

2. Literature review

The literature review covers KM and the design of knowledge repositories in ICT4D.

2.1. KM and ICT4D knowledge repositories

Davenport (1994) defines KM as the process of systematically capturing, organizing and sharing organizational knowledge for effective re-use by others in the community. Chouikha and Dakhli (2012) refine the focus by stating that KM is the process through which organizations extract value from their intellectual assets. The objective of a knowledge management system (KMS) is to support the construction, sharing and application of knowledge in organizations (Leidner, 2000). This means that KM activities consist of the administration of knowledge assets of an organization and the sharing and enlargement of those assets (Chouikha & Dakhli, 2012).

No clear distinction has been drawn between the terms *knowledge transfer* and *knowledge sharing*. According to Paulin and Suneson (2012) authors who use the term *knowledge transfer* tend towards the objectivist perspective relating to knowledge, while *knowledge sharing* is associated with a more subjective perspective that is, sharing via synchronous or asynchronous conversations and communications between people. Knowledge exchange for the purpose of sharing ideas and resources is crucial for the development of any research field. As already stated, ICT4D inhabits an interdisciplinary space, which complicates KM and the accessibility of research-related knowledge (Tibben, 2015). Extant literature has shown that the effectiveness of IT artifacts can be demonstrated through knowledge sharing activities (Li, 2016); conversely these activities can generate valuable insight into the improvement of knowledge sharing in order to support communication and ensure a solid foundation for collaboration.

KMSs used in the ICT4D context are known by different names, including e-portals, online knowledge repositories and knowledge sharing platforms (KSPs). All of these systems are essentially Web-based collections of information providing varying degrees of access and interaction, but there are critical differences between the kind of knowledge that is made available, the target audience, the access and the interactions (Mosweunyane & Carr, 2014).

KM is recommended as part of any ICT4D project to optimize its probability of success specifically by sustaining and growing a user community of practice (Conger, 2014; Singh & Flyverbom, 2016). The goal of the study reported on in the present paper was to create

an OKR which supports identification of relevant research and possible collaboration, discussions and the formation of communities of practice among researchers, and also provides a repository to allow the sharing of information such as research agendas, methodologies, theories, models and frameworks.

In the design of any knowledge repository, the types of knowledge involved should be considered (Conger, 2014; Dinter et al., 2016). Taking a top-down, objectivist perspective of knowledge, Gorman (2002) provides a basic taxonomy in which four types of knowledge are distinguished, namely information, skills, judgment and wisdom:

- Information (what): the recall of facts and events
- Skills (how): knowing how to do something
- Judgment (when): the ability to recognize when knowledge is applicable to a particular instance
- Wisdom (why): meta-cognitive monitoring which may lead to a new course of action

These constructs remain useful when knowledge is considered in more subjectivist and contextual ways, for example, the creation of knowledge from information gathering and analysis in the development of theories.

Zack (1998) concurs in relating knowledge to the declarative (know-what), procedural (know-how), causal (know-why), conditional (know-when) and relational (know-with) types of knowledge. In terms of knowledge sharing, knowledge is categorized as either declarative (explicit) or tacit (implicit) (Gorman, 2002). Explicit knowledge is known, codified and shareable, while tacit knowledge is held in an individual's mind and relates to an individual's experiences with technical aspects in terms of skills (Wang & Noe, 2010).

Each knowledge type needs to be examined to determine the extent to which the project being documented needs that type of information and the extent to which the information can be codified (Conger, 2014). Recording searchable information and a directory of information sources are considered best practices, but in some cases there is a tension between codifying knowledge and preserving its richness, nuance and authenticity. Tacit knowledge poses a significant challenge to KM, as expertise and reasoning processes are difficult for individuals to articulate (Conger, 2014). Communities of practice (Soeftestad, 2001; Wenger, 2000) play an important role, as tacit knowledge is used and shared by the diversity of participants in social learning processes to identify appropriate action to deal with shared challenges.

As discussed previously, the addition of the CI cycle to the model of DSR introduces the reality that the research and artifact development takes place in an external context. This can be described as the embeddedness of researchers in a community of IS stakeholders (Blake & Tucker, 2006; Byrne & Sahay, 2007).

The KM requirements have to adapt to fit the needs of the intervention. In the context of ICT4D, the nature of the intervention has changed over time: Heeks (2008) refers to the phases ICT4D 0.0 (use of computers in the economy), 1.0 (ICT as development tool – tele-centers) and 2.0 (ICT as the transformative platform for development). Participation to foster innovation is key and Heeks (2008) in this regard refers to innovation strategies as being either pro-poor (for the poor), para-poor (working with the poor) or per-poor (innovation by the poor in their communities).

In terms of an ICT4D 1.0 approach, KM can be applied to sustain technology support and maintenance without the aid of the original development team (Conger, 2014) or remote experts (Geldof, Grimshaw, Kleine, & Unwin, 2011). An example of ICT4D 2.0 para-poor innovation is the development of a pharmacy system for the dispensing of antiretroviral drugs in South African public health clinics (Loudon & Rivett, 2011). The research and development team adopted the concept of *open development* (Smith & Elder, 2010), which emphasizes universal access to information, collaborative participation in knowledge creation and diversity of knowledge systems. In terms of this approach Loudon and Rivett (2011) consider that communities of practice may be the route to “actionable knowledge” (Hearn & Foth, 2005) developed and sustained after the end of research processes and projects.

In the broad ICT4D context there are multiple stakeholder communities including beneficiaries, practitioners, academia, government, civil society (e.g. non-governmental organizations (NGOs)) and private sector organizations. The diversity of the target audience for a KM endeavor poses difficulties if an open access environment is planned. For example, academics may seek examiners, reviewers and collaborators; funding agencies and NGOs may seek research experts in a specific field; while students and novice researchers may seek links to reputable sites, seminal publications and publication opportunities. The research approach influences the nature of the formal and informal knowledge production processes that need to be supported. These will be discussed in more detail in the research design section.

2.2. Use of e-government maturity models

Chouikha and Dakhli (2012) identify two practical dimensions of knowledge sharing. The first dimension represents the management of existing knowledge, which includes the development of knowledge repositories (memos, reports, presentations and articles), and knowledge compilation, arrangement and categorization; the second dimension represents the management of knowledge-specific activities, that is, knowledge acquisition, creation, distribution, communication, sharing and application. Both are relevant to the development of an OKR in ICT4D and useful in structuring and prioritizing the content and activities. Website maturity models have also been used to guide and benchmark the development of portals in developing countries (Karokola & Yngström, 2009). Maturity models for e-government have the goal of providing open access to a diverse community (Karokola & Yngström, 2009). That resonates with the goal of an OKR, and therefore e-government maturity models provide a feasible foundation for launching the development of a maturity model for ICT4D.

The e-government maturity models are designed to guide the implementation and development of applications in a stage-wise manner – from the immature (one-way communication) to the mature (digital democracy) stage (Hearn & Foth, 2005). Fath-allah, Cheikhi, Al-qutash, and Idri (2014) compared 25 e-government maturity models and identified *presence*, *interaction*, *transaction* and *integration* as the criteria that differentiated the first four maturity levels in most e-government websites. The levels of service and complexity are similar to those described for the European Union e-government model (Ziemba & Papaj, 2013). Based on Ziemba and Papaj (2013) and Fath-allah et al. (2014) and assuming that the higher levels include all the functionality of lower levels the following structure is proposed for knowledge repositories in ICT4D (Van Biljon, Pottas, Lehong, & Platz, 2016):

Level 1: *Presence* corresponds with the lowest level of simply having an online presence. Content categories would include the purpose of the site in terms of presenting a person or organization, and limited knowledge sharing. The knowledge level according to the taxonomy presented earlier would probably be mostly information (“What knowledge is presented?”)

Level 2: *Information* corresponds with one-way interaction (Fath-allah et al., 2014) allowing users to access information via links or downloads but not to respond or contribute. Content categories would include knowledge sharing, but only in terms of knowledge provision to users without any feedback opportunity. The knowledge levels would probably be information and skills (“What knowledge is presented and how is it presented?”)

Level 3 – *Interaction* refers to two-way interaction with users. Content categories would include knowledge sharing, social and business networking, news and search functionality. The knowledge levels would probably include information, skills and judgment (“What knowledge is presented, how is it presented and when?”)

Level 4 – *Integration* was chosen to represent level 4 since transactions are less common on ICT4D KSPs. Member management and knowledge sharing include content and distribution management and user relationship management strategies. Content categories would include knowledge sharing, social and business networking and news. Knowledge levels would include information, skills and judgment (“What knowledge is presented, how is it presented and when?”)

Level 5: *Personalization* represents portal and personalized capabilities and multi-media content such as videos and multiple language choices. Content categories would include knowledge sharing, social and business networking and news with personalization options. Knowledge levels would include information, skills, judgment and wisdom (“What knowledge is presented, how is it presented, when and why?”)

These levels are not prescriptive, but could be useful in prioritizing the content to be included in the OKR, as discussed in the research design section.

2.3. Criteria for sustainable KM of OKR in ICT4D

An essential starting point [for successful knowledge management], is the awareness of the feasibility of knowledge management as “management for knowledge” in the sense of control of contextual frameworks instead of a “management of knowledge”, which cannot operate sustainably for the specific characteristics of knowledge resources. (Neumann, Grilitsch, & Muller-Stingl, 2007, p. 23)

In ICT4D the control of the contextual framework refers to the context created by the various actors participating in a project. Singh and Flyverbom (2016) present two dimensions of types of participation narratives in ICT4D. The first is the hierarchical (top-down) or agent-driven (bottom-up) dimension, and the second is the dimension of conflict or cooperation. These two dimensions are used to articulate four types of participation discourses that pervade ICT and development efforts. Those ideal discourses include stakeholder-based discourses which emphasizes consensus, networked efforts among actors collaborating in network arrangements, mobilization discourses which account for contestation over the meanings of participation and oppositional discourses from “grassroots” actors (Singh & Flyverbom, 2016). To support these dimensions and narratives the following objectives are proposed as a means to obtain the desired functionality of an OKR:

- Provide support for a range of users from all sectors of society and with a diversity of roles, for example policy development, implementing development, researchers and participants.
- Collect material designed to communicate with this diversity of users, for example videos, audio (e.g. podcasts), infographics, participant stories, presentations, policy briefs, reports, news articles and academic publications.
- Refer users to relevant communities of practice and active members – project websites, event websites (e.g. conferences), curated sites and the social media (blogs, Twitter feeds, Facebook and WhatsApp). An example relating to ICT in education in South Africa is <http://maggie.za.net/blog/>.
- Reflect the diversity and reach of the ICT4D community via the use of an ongoing social community mapping process (De Moor, 2015). The mapping done by and for their own use by the members of the ICT4D communities (researchers, practitioners, NGOs and community-based organizations) may be supported through the development of agreed upon guidelines, mapping template processes and frameworks.

3. Method

IS research is characterized by behavioral science and design science paradigms; the behavioral science paradigm seeks to develop and verify theories that explain or predict human or organizational behavior while the design science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts (Hevner, March, Park, & Ram, 2004). Many IS researchers interpret the explicit guidelines and evaluative criteria for DSR (Hevner et al., 2004) as a “recipe” and hence think of DSR as a “method,” as opposed perhaps to a methodology. However, the purpose-driven creation of artifacts and the introduction of these artifacts into otherwise natural settings shows that DSR has its own particular facets (Baskerville, Pries-Heje, & Venable, 2007). The flexibility to use different research methods within a DSR project makes DSR suitable as a methodology for trans-disciplinary research and specifically this project with a pragmatic philosophy for the development of an OKR on ICT4D research. Figure 1 provides an overview of the research according to the four-cycle DSR view, after which the cycles are discussed in more detail.

3.1. Phase 1: socio-technical system context

The context information is based on the analysis of three workshop reports. Thematic analysis of the data was considered, but given the differences in the format of the data captured this turned out to be problematic. Instead the workshop report review was organized around specific themes (see Table 1) and examined as a source of insights into the collaboration initiatives. The following events were considered for analysis:

- In 2012 the first workshop of the series was hosted at the University of South Africa (Pretoria Campus). The program consisted of invited presentations followed by a panel discussion on ICT4D research agendas. The speakers were prominent ICT4D champions from the International Development Informatics Association (IDIA), which is based in South Africa, the CSIR and the University of South Africa.

Figure 1. Research overview according to the four-cycle DSR view based on Drechsler and Hevner (2016), here.

- In 2014 there was a concerted effort to connect the researchers from the northern part of South Africa with those of the southern part, and a widely advertised workshop was conducted at the 2014 conference of the South African Institute of Computer Scientists and Information Technologists (SAICSIT2014) in Pretoria. Many of the institutions had more than one representative, so the groups were given the opportunity to discuss and present their research focus areas. This was followed by a discussion on collaboration initiatives.
- The 2015 event at SAICSIT was hosted by the University of Cape Town in Stellenbosch. The program comprised contributions by two invited speakers followed by a group discussion on challenges and initiatives relating to promoting ICT4D research in South Africa and Africa.

To gain a better understanding of the needs and expectations of the wider community (not only those at the workshops) regarding an OKR, an online survey was conducted among the ICT4D community in 2014 and published in the IST-Africa conference proceedings in 2015 (Platz & Van Biljon, 2015). The findings from the CI cycle confirmed the relevance of developing an OKR for South African ICT4D research.

3.2. Phase 2: immediate application context

To gain information on the essential content categories, website analysis was done on existing ICT4D OKRs. Content categories were identified and prioritized for inclusion on the website. The content categories were presented for peer review and published in 2016 (Platz & Van Biljon, 2016; Van Biljon et al., 2016).

The peer review and publication of the ICT4D communities' needs for and expectations of an OKR (Platz & Van Biljon, 2015) confirmed the need for the OKR and thereby satisfies the relevance requirement of the DSR cycle (see Figure 1).

Figure 2. Screen depicting OKR.

3.3. Phase 3: DSR (artifact design)

A prototype was designed and developed using Google Sites. Figure 2 depicts a screen from the prototype which shows the structure of the pages and specifically the *Resources* page. The page names are self-explanatory except for the *Government* page, which provides downloads of relevant policies, the *People* page, which provides links to ICT4D champions and the *Connect-To-Collaborate* page, where the membership is explained.

Rigor cycle: The prototype was evaluated and updated continuously based on insights from literature and feedback from ten evaluators (all experienced ICT4D researchers). The feedback was captured during two focus group sessions with four evaluators each as well as structured interviews with two other individuals. The evaluations were focused on the content and functionality and not on user experience, although the practice of user-centered design was followed. After each session the site was updated, so it was not possible to compare the responses, but the feedback received during the expert reviews is presented in the results section.

3.4. Phase 4: knowledge base

The research process and decisions were continually peer reviewed, as is evident from the publication on the rationale and requirements (Platz & Van Biljon, 2015) and the publications on the content (Platz & Van Biljon, 2016; Van Biljon et al., 2016).

Methodologically the project was informed by the DSR paradigm and demonstrated the application of the four-cycle DSR view as advocated by Drechsler and Hevner (2016). Furthermore, the KM application was evaluated according to the requirements for ICT4D projects as proposed by Conger (2014) and in line with the requirements of projects according to the evolution of ICT4D developed by Heeks (2008). Documenting the application of methodologies and criteria from literature in support of IT-enabled collaboration for development and the reflections on the insights gained provide a theoretical contribution in terms of replicability. Developing an OKR is not a novel idea,

but previous developments have not been documented, so the design decisions and KM practices are unknown and hence not replicable or useful in informing the design of an OKR. Ethical clearance was obtained from the Research and Ethics Committee of the University of South Africa. The research reports from the workshops were sent out to all participants for feedback, updated based on the feedback and then redistributed in the public domain.

4. Results

The results are now presented, organized according to the DSR phases to evaluate the outcome of each phase.

4.1. Phase 1

Consideration of the summary of the workshop outcomes as provided in Table 1 reveals that collaboration and knowledge sharing between ICT4D researchers remain a challenge. Based on the workshop outcome of 2012, the need for supporting connections between the researchers became obvious. During the 2014 workshop a discussion of the impact of collaboration initiatives led to the suggestion that a knowledge sharing platform should be created. During the 2015 workshop the idea was revisited and formulated as the need for an open access knowledge repository. This was followed by an online survey to verify the importance of an OKR and gain a better understanding of the needs and expectations of the wider community.

The outcome of Phase 1 was the decision to design and develop an OKR in response to the collaboration needs identified in the survey involving South African ICT4D researchers (Platz & Van Biljon, 2015).

Table 1. Comparison of selected data from workshops.

	2012 UNISA	2014 SAICSIT	2015 SAICSIT
Attendance	Attended by 66 people. However, many of these were not involved in ICT4D research	Attended by 36 people, all of whom were involved with ICT4D	Attended by 32 people, all involved with ICT4D
Outcome	Discussions relating to a research agenda for improved collaboration between ICT4D researchers. General focus on the topics of ICT readiness and availability	Consensus on the need for collaboration initiatives. Developments and differentiation since 2012 made it difficult to identify a common research agenda, but the issues of uptake and impact were highlighted. The focus was on supporting collaboration among stakeholders	The goals related to structure and dissemination; research priority areas; engagement and collaboration; curriculum and teaching
Challenges	<ul style="list-style-type: none">• Connecting research groups• Identifying champions• The need for sustainable long-term networks of participants• Need to make a better world through ICT4D strategies	<ul style="list-style-type: none">• Publication opportunities• Collaboration opportunities	<ul style="list-style-type: none">• Publication opportunities• Knowledge sharing• Funding• Difference between the information and computer science research interests

4.2. Phase 2

Table 2 depicts the websites analyzed. To obtain a representative sample of ICT4D websites, we started with South African websites and African KSPs and then added other international websites from the searches. ICT4D research is conducted by a wide spectrum of stakeholders from both the formal and informal knowledge society, many of which are organizations and individuals not associated with universities. University websites were selected, since a verifiable list of South African universities exists, on which 11 traditional universities, 6 comprehensive universities and 8 universities of technology appear. Table 2 shows that only 5 ICT4D websites were found for the total number of 25 institutions. However, others (for example the University of Fort Hare) do indeed produce ICT4D research, but the ICT4D website either does not exist or could not be found using Google as search engine and when entering the keywords “ICT4D” or “development informatics.” Subsequently the following relevant sites were discovered, but unfortunately did not form part of the analysis: South African theses and dissertations (<http://www.netd.ac.za>), Institute of Development Studies (www.ids.ac.uk) and PSPPD knowledge repository (<http://www.pspdpknowledgerepository.org/themes/theme-1-poverty-and-inequalit>).

An important insight gained from the comparison of the data on existing research groups collected during the workshops and the website survey was that many South African ICT4D research groups did not have an online presence, or at least not an easily discoverable one. Based on the analysis of these sites, content categories were identified. Based on the maturity level (ML) content classification presented in Section 2.3, the proposed ML is indicated for the content categories as presented in Appendix. The purpose is not to be prescriptive, but rather to provide some guideline for developing a useful OKR under conditions of resource constraints including a lack of financial, KM and software development expertise.

Table 2. Examples of sites containing ICT4D research content.

University	Link to ICT4D site
Nelson Mandela Metropolitan University	http://news.nmmu.ac.za/News/ICT-solutions-for-developing-countries
Rhodes University (Information Systems)	http://www.ru.ac.za/informationssystem/research/ researchgroups/ ictfordevelopment/
Rhodes University (Computer Science)	http://www.ru.ac.za/computerscience/researchgroups/ict4d
University of Cape Town (Computer Science)	http://ict4d.cs.uct.ac.za
University of Cape Town	http://www.citanda.uct.ac.za/
ICT4D Centre (Royal Holloway, University of London)	http://www.ict4dc.org/
Centre for Development Informatics (Manchester University)	http://www.cdi.manchester.ac.uk/
Organizational sites	Links
IST-Africa (European Commission – African Union)	https://www.ist-africa.org
Research Africa (Open Society Institute)	www.researchictafrica.net
IICD	www.iicd.org
IFIP 9.4 (Social implications of computers in developing countries)	http://www.ifipwg94.org/
ICT4D Jamaica	http://ict4djamaica.org/html/
IDIA (International Development Informatics Association)	http://www.developmentinformatics.org/index.html
Individual sites	Links
Ismael-Pena-Lopez	http://ictlogy.net/
Tim Unwin	https://unwin.wordpress.com/
Kentaro Toyama	http://blog.ict4djester.org/
Richard Heeks	https://ict4dblog.wordpress.com/author/richardheeks/

In terms of the rigor cycle the publications of Platz and Van Biljon (2016) and Van Biljon et al. (2016) provided the peer review to validate content categories for selection and prioritization according to a website maturity matrix.

4.3. Phase 3

This entailed the development of the Google site (see Figure 2) and the evaluations. The evaluations were done continuously and the site updated accordingly. Two expert reviews are reported on here:

4.3.1. Internal expert review

This included three senior people involved in the ICT4D research group management. The link was sent before the meeting to allow the evaluators the opportunity to interact with the site. The focus was on the knowledge displayed on the site, and no user experience evaluation was done. The evaluators were satisfied that the knowledge categories presented were relevant. However, the following practical issues were raised:

- Content provision:
 - The lack of social media connections
 - Lack of a database with search functionality
 - Lack of facilities for uploading and downloading files
- The fact that the site did not have hosting services
- Governance:
 - Access rights, thus consideration of who would be able to make updates to the site
 - The need to balance knowledge provision (including useful documents to download) with copyright adherence
 - Security management of an open access model
- Ownership and maintenance of the website.

4.3.2. External expert review

This included three senior researchers in the field of ICT4D, two of whom were also usability experts. The link was sent before the meeting to allow the evaluators time to interact with the site. The reviewers were asked to focus on the functionality and the knowledge displayed on the site. No usability evaluation was outside the scope of this initial evaluation and was therefore not explicitly requested, but the reviewers were free to comment, and all the verbal comments were recorded in writing. The evaluators were satisfied that the knowledge categories presented were relevant, the governance and content provision including the copyright issue were reiterated and the following new issues were added:

- Structuring:
 - A reordering of some of the content to improve the knowledge architecture
 - The Discussions page and the Connect-To-Collaborate page should be combined
- Additions:
 - The inclusion of international ICT4D events

- The addition of policy documents
- The social media links should be on the home page
- User experience:
 - The look and feel of the site was described as pedestrian and uninspiring, and warrants attention

The responses dealt with the knowledge architecture, governance (including security) and user experience. The expectation was that the site would function at least on ML 4 (integration) to provide interactive knowledge sharing functionality. The discussions highlighted the complexities inherent to diverse users. Given the purpose of providing open access to the wider community, the idea of targeting specific audiences had not been considered. However, at this point it became clear that there might be a conflict in providing for both novice users and expert users. A more prescriptive approach which included definitions and links to seminal papers and champions would be useful to novice researchers and students, but that would require some subjective decisions relating to content selection, which could introduce bias. The alternative would be to provide alphabetic links to information sources and identify significant research issues and questions rather than supply definitions or seminal articles. However, the latter course of action would not fulfill the expectations of novice users, who need an effective entry point into the area of ICT4D knowledge. This difficulty resonates with the dimensions mentioned earlier, namely the hierarchical (top-down) versus the agent-driven (bottom-up) dimension. A top-down structure of knowledge dissemination may seem more effective, especially for novice users, but that may be experienced as biased, which could limit the involvement of expert ICT4D researchers and practitioners. This may be related to the issues of just-in-time support (Snowden, 2002) and just-in-case support, and adjustable interfaces were mentioned for future research. From a practical perspective it was decided that a technologically more sophisticated platform is needed. The following specifications were documented for a Web-based functional software application (to be developed as the second prototype):

- Basic text and graphics to be displayed while keeping cost and bandwidth limitations in mind.
- Facilities for uploading and downloading files.
- Links to the stakeholders' profile pages. The provision of links to web pages rather than uploading information would support maintenance and avoid copyright infringements.
- A moderated discussion forum.
- A search function which uses author name, institution or thematic area as indexing field.
- Social Media integration (Facebook, Twitter and LinkedIn).
- Application programming interface (API) for external institution integration into repository.
- Statistics of system activity should be available.
- Visualization of research groups' location in the country.
- Compliance with the Protection of Personal Information Act, and all data and files to be stored in secure locations.

Three user types were identified:

- Read-only access users (visitors).

- Members, who would be allowed access to additional information and functionality such as the discussion forum.
- Moderators with update privileges.

4.4. Phase 4

The rigor of the research was continuously enforced by peer review in terms of publications (Platz & Van Biljon, 2015, 2016; Van Biljon et al., 2016); given the focus on KM, the project is now discussed in terms of the key KM requirements for ICT4D success as proposed by Conger (2014) and the changes in ICT4D according to Heeks (2008). All ICT4D projects have unique characteristics, and therefore not all of the criteria apply. The fact that the ICT4D community stakeholders are diverse influences the relevance of the criteria. However, for the sake of comprehensiveness, an attempt was made to respond to all the requirements listed in Table 3.

5. Discussion and reflection

5.1. Reflection on methodology

On a philosophical level the four-cycle DSR methodology provided structure and guidance in developing and evaluating an artifact to be used for development according to what can be described as a pragmatic stance. The OKR as an artifact for IT-enabled connection and collaboration between ICT4D stakeholders makes a practical contribution to development in South Africa. At the methodological level the four-cycle DSR methodology proved a guide for structuring and aligning the project components. The clarity of structure aided in the delineation and the alignment of the activities. The CI, relevance and rigor cycles ensured consistent and cumulative evaluation.

KM is implicit in the design of any knowledge repository and was made explicit in the fourth phase (Knowledge Base) as depicted in Figure 1, ensuring mindful consideration of the knowledge constructs and sharing processes. Both the objectivist perspective (knowledge as a commodity to be structured) and the subjectivist perspective (knowledge as a force influencing socio-technical interactions) are relevant in developing an OKR. The publications as specified for the fourth phase added value in ensuring the proper consideration of the content and evaluation of that understanding through peer reviewed publication of the research presented at international ICT4D conferences. The evaluations of the first prototype were useful in identifying functionality issues and refining the specifications for the second prototype.

5.2. Reflection on design theory and implementation

The design theory components of user requirements, system features and process design and management principles (Gregor, 2002) are set out in Table 4.

Considering functionality in terms of maturity levels, the first prototype was implemented on ML 2 (information presented for one-way interaction). The design of the second prototype included two-way interaction and interaction integration of member management, which places the OKR on ML 4 (prototype available from <https://www.ict4dsa.com/>).

Table 3. Evaluation against KM criteria.

Project key requirements for success (Conger, 2014) and support of innovation processes (Heeks, 2008)	Application to this project
Develop a project strategy with long-term and short-term goals	A comprehensive project plan with long-term and short-term goals was drawn up and presented for a research grant
Emphasize sustainability, including economic and socio-political sustainability	The research grant was successful and provided funding for 5 years. This provided short-term funding, but future economic sustainability will depend on the usefulness of the OKR. Socio-political sustainability will depend on adoption by the research community and the participants (or beneficiaries of ICT4D projects), and therefore initiatives are planned to market the OKR once the second version has been implemented
Develop committed, enthusiastic, competent leaders; incentivize stakeholders to support the project; invest time in building partnerships with all stakeholders – politicians, NGOs, local community, etc.	The development of new champions is embedded in the project plan. Specific events have been organized and are still being organized to build partnerships with all stakeholders including academics, students, politicians, NGOs and the local research community. The philosophy entails being open and inclusive, contributing to other initiatives where possible, but never claiming ownership of any ICT4D knowledge or market
Attend to cultural differences in gaining trust and cooperation	This is an ongoing concern to be evaluated continuously
Define a local champion, maintenance and help support staff. Draw on the local actors for project governance. Train and work with locals, eventually giving them control over daily operations	The project has a research leader, administrative and research assistants, and postgraduate students who are being developed for future leadership roles. Active participants in ICT4D projects will be identified and asked to collaborate in the OKR project
Develop trust and openness towards mutual respect, and understanding of locals	Towards the end of this phase the project team consulted widely and continuous updates were made to accommodate requests where possible. The consultations will be extended to active participants in ICT4D projects in the next phase of the project
Balance demand for and supply of resources	This project funding provided resources for the development of the site. The user demand will only become evident once the site is operational
Design appropriate, fully working technology that is based on local needs, adapted as required, and involves the local community. Heeks (2008): Support innovation processes of varying degrees of co-creation	The initial OKR was developed as a Google site, but due to the limitations experienced (primarily in hosting a database with search functionality) it is being redeveloped as a content management system Co-creation can be identified, for example, as inputs to shape ICT4D services. Inputs may be verbal or textual. The OKR needs to accommodate video and audio data as well as IM texts and e-mail
Ensure that all problems are remedied	Problems are investigated and dealt with as they arise
Have project team study ICT4D to better understand local needs. Heeks (2008): Study ICT4D in action to support collaboration and co-creation	The introduction of ICT4D courses at the university where the research team is located is considered. Project team to observe interactions between ICT4D researchers and the participants
Manage expectations	Six-monthly reports to be submitted to the funding organization and communication with the user community
Monitoring and evaluation	The project is monitored in terms of the project goal, the explicit and continuous evaluation undertaken as well as the publications which ensure external review and evaluation
Deal with issues of physical accessibility, computer skills and literacy. Heeks (2008): Support participation by all in co-creation of innovation	The open access format was selected to provide accessibility. Most of the target community is literate and has computer skills, but the issue of accessibility needs to be monitored constantly and the development of a mobile application is being considered. The OKR needs to be designed for the range of devices used by participants in

(Continued)

Table 3. Continued.

Project key requirements for success (Conger, 2014) and support of innovation processes (Heeks, 2008)	Application to this project
	ICT4D to access applications, e.g. laptops, tablets, smartphones and feature phones. Interactive voice response and text-to-speech can be used for voice-only applications for the illiterate. The scope will grow as use of the OKR increases. User experience evaluation is planned to improve accessibility.

Considering implementation level guidance the conceptual data model proposed by Dinter et al. (2016) for open innovation and KM for a community of practice provide a useful representation of the abstract class *Artifact* and the subclasses *ArtifactActivity* and *Community-Member* and how those relate to the activities of the *community members* and their *roles* on the implementation level. Abstracting those classes allows flexibility in acknowledging the different target groups without implementing the functionality for all the groups. For example, the users could be researchers, politicians, funding agents or students, each with specific needs. The initial prototype focused on researchers, and only academic expert users were involved. It was considered necessary to evaluate the first prototype (ML 2) and the related content before implementation of the higher levels of functionality.

5.3. Reflection on evaluation

Besides the peer review as evident from the papers published (Platz & Van Biljon, 2015; Platz & Van Biljon, 2016; Van Biljon et al., 2016), the project was also evaluated in terms of the prototype and KM criteria.

Table 4. Design theory components of this system.

User requirements (Platz & Van Biljon, 2015)	System features (Platz & Van Biljon, 2015; Platz & Van Biljon, 2016; Van Biljon et al., 2016)	Process principles
Philosophy of open, managed access to support community development and the visibility of ICT4D knowledge in South Africa	User groups include visitors, members and moderators (to ensure focus and quality). The user roles are knowledge sharers and knowledge consumers. Host the site independent of any specific institution, to enable transparent management for the benefit of the users	Roles and privileges for different groups. Tension between being inclusive and retaining focus. Difficulties associated with selecting content consistently and fairly so as not to privilege or disadvantage any individual or institution
User-centered design	Align the features with the ML by matching user requirements with constraints (financial, time and skills). Regular site evaluations and consideration of the user feedback to continually improve the user experience	Effectiveness, efficiency and user satisfaction evaluated against the expectations of the specific level. Evaluation of the user feedback and decision on if and how to implement the user's proposals
Support collaborations	Networking options include forums, blogs and social media for digital networking and ICT4D events for personal networking	Support multiple levels of connection and communication within the constraints of privacy and security
Governance	<ul style="list-style-type: none">Ensuring securityAvoiding plagiarism	Information provided as links to websites rather than downloadable information

The evaluations of the first prototype were useful in identifying functionality issues and refining the specifications for the second prototype. Given the known limitations of the development platform it was decided not to conduct the usability and accessibility evaluation on the first prototype, as that would only serve to confirm known limitations which can be resolved only by redevelopment on another platform. Hosting the database on Google Sites was possible, but it could not be done efficiently. This was possibly a skills limitation rather than a platform limitation, so it is necessary to differentiate between the kinds of limitations in order to provide cost-effective solutions. The prototype evaluation was done with researchers from an academic background and that is a limitation that will have to be addressed by evaluating the next prototype with students and representatives from governmental, NGO, academic and private corporate initiatives. The evaluation according to KM criteria (see Table 3) is on project management level and was found useful in ensuring that those aspects were considered, but more detailed criteria regarding the knowledge structures of an OKR should be considered for further research.

5.4. Reflection on difficulties faced in the context of developing economies and for ICT4D research

As mentioned earlier, an OKR for ICT4D knowledge has some of the characteristics of a wicked problem. The stakeholders have divergent and even competing information needs. There needs to be a balance between presenting the knowledge comprehensively and retaining focus, between being accessible and being within the rules governing copyright and information exchange. This pertains to which researchers should be included, which in turn is related to systems of power and prejudice. There is also tension between design decisions favoring open access and those ensuring governance in terms of security and copyright. The findings are limited by the fact that the evaluation excluded user experience evaluation, but, as explained earlier, that is a consequence of focusing on having the content and functionality evaluated within the time and resource constraints before redevelopment.

The second prototype namely, the South African Development Informatics and ICT4D Platform (SADIIP) has been developed and is currently being evaluated in terms of usability and content provision. Future research will focus on making SADIIP more accessible to stakeholders beyond the research community, e.g. government departments and practitioners. This is in agreement with Walsham (2017), who suggested *engaging with user and policy-making communities* through communities of practice based on particular themes and issues towards increasing ICT4D research impact.

6. Conclusions

This paper sought to describe the evidence-based design, development, implementation and evaluation of an OKR as an IT-enabled artifact for collaboration among stakeholders in ICT4D. The prototype was developed as an instantiation of the four-cycle DSR approach. The latter was found to be useful in guiding the project, which was monitored through peer review (publications), the evaluations of the prototype and the KM.

This paper contributes to the ICT4D field on both the theoretical and the practical levels. The research design describes the OKR project as a novel yet repeatable instantiation of

the four-cycle DSR methodology specifically in terms of the alignment between user requirements, system features and process principles. The knowledge contribution was initially considered as exaptation, which involves the extension of a mature solution (such as knowledge platform design and implementation) to a new application domain (such as an ICT4D repository for South Africa). However, other ICT4D repositories exist, and therefore the undisputed novelty lies in the articulation of the design and the description of the implementation actions.

The user requirements for an OKR in South Africa and the related design decisions and processes are a contribution on the design theory level. The research evaluation conducted according to extant criteria for ICT4D KM provides a reflection on those criteria to illustrate vulnerabilities and potential research gaps in the application of the evaluation criteria. The OKR makes a practical contribution to development through the creation of a platform for open, managed knowledge sharing among researchers and students in ICT4D in South Africa and beyond. Future work includes the evaluation of the SADIIP prototype which has been developed according to the specifications derived from the evaluation of the first prototype. User experience evaluation, including usability and accessibility, will be part of the evaluation. As the diversity of users of the OKR grows, the design will have to be adapted to accommodate the range of user literacies, skills levels and devices used. Extending the scope of the OKR to include other sub-Saharan countries with similar research interests is another prospect to consider.

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Appendix. Content categories

Purpose of the site	ML	Social networking	ML	Thematic area	ML
Description of what the site is about	1	Discussion forum	3	E-government	2
		Blog site	3	E-health	2
Member management		Twitter	3	E-learning	2
Login option	3	Facebook	3	E-agriculture	2
Membership based on personal information	3	Poll site	3	E-business	2
Membership based on personal information and payment	3				
User groups	3	Events		Contact	
Individual profiles	5	Internal events	2	E-mail - link only	2
		External events	2	Content manager to collect information about the visitor	3
Knowledge sharing	ML				
Downloadable information	2				
Publications	2				
Software downloads	2				
Career opportunities	2				
Funding opportunities	2				
Skills development opportunities	2				
Existing projects	2				
News	2				
Awards	2				