Research Article

End-User Engagement in the Design of Communications Services: Lessons from the Rural Congo

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Abstract

End-user engagement is considered essential when designing new socio-technical systems, but in the context of designing large-scale infrastructural systems, such as communications networks, this ideal is rarely put into practice. We examined the challenges in engaging end-users in the design of communications services, by exploring how communities from 15 villages in the rural Congo, incorporated mobile phones into their daily lives. To analyze the changes in social and cultural capital that resulted from mobile phone use, we applied Bourdieu's capital theory. This analysis exposed the difference in perceived value of the communication services between end-users and the business owners of the infrastructure. The paper concludes by suggesting new forms of partnership with end-users in order to craft ways in which infrastructures, and related organizations and practices, can best cohere with local cultural views, specifics, beliefs, needs, or realities of concerned participants.

Keywords: End-user Engagement; Communications Infrastructure; Social Capital; Co-Production; Participative Approach.

Introduction

Communications infrastructures and mobile phone services shape the geographic, economic, and social configurations across a region (Foxon, 2011; Heeks, 2007). Research into the

interconnections across the physical, social, technological, and economic structures in an environment has resulted in a growing literature suggesting that infrastructures, such as communications networks should be regarded as 'a service for end-users' rather than just the means of provision of a single utility (Hall, Tran, Hickford, & Nicholls, 2016; Roelich et al., 2015). Investment into infrastructures, however, is usually decided upon and designed by central governments working with large corporate players; the concerns of end-users are remote from this process and not usually regarded as a central concern. This paper proposes new forms of partnership with end-users, in order to craft infrastructural services, and related organizations and practices, which cohere with the local, cultural views, specifics, beliefs, needs, or realities of end-users.

Our research explored the perceptions of end-users based in rural areas of the Democratic Republic of the Congo (shortened to the Congo in this paper) as a region where the recent development of communications infrastructure had provided new access to mobile phone services, which had in turn, impacted on rural villagers with a tradition of growing corn and of fishing. We investigated the impact of communications infrastructural development on end-users in these rural communities at a micro-level. Our aim was to give voice to these communities on how they perceive infrastructure development and to help articulate their view of the services such infrastructure could provide to benefit local communities on a day-to-day basis.

Roelich et al. (2015) argued that as end-users are the determinants of the demand for resources, it is important to include their needs when considering the design and implementation of infrastructural systems. We sought to offer empirical evidence for this view and so we analyzed the micro-level changes in social and cultural capital across the villages in our study area, through the lens of Bourdieu's (1983, 1986, 1994/1998) capital theory and found differences in the perceived value of the communications infrastructure between the end-users in the community, and the business owners and investors. Our analysis suggests that there is a gap in perspective between the different community, business, and investor stakeholders. We argued that addressing the challenges associated with developing infrastructural services requires an innovative approach to collaborative problem solving that will necessitate end-users, governmental agencies, developers and investors co-producing plans and designs, and adaptations to services and undertaking evaluation assessments collaboratively. End-users have local knowledge, social networks, and access to the cultural norms and traditional practices that are often unavailable to external stakeholders. Local communities are also the first responders in extreme events, such as El Niño or flooding. This ability to respond quickly and in context, places end-users as key players

in achieving value from infrastructure investment and we suggested that utilizing this resource makes economic sense as well as offering social benefits to local communities.

Research into information and communication technologies [ICTs] has suggested that currently little to no role is ascribed to end-users (Aker & Blumenstock, 2015; Asongu & Nwachukwu, 2016, 2017; Bowman, 2010, 2015; M. Bowman & D. Bowman, 2016; Diga & May, 2016; Gagliardone & Golooba-Mutebi, 2016; May, Dutton, & Munyakazi, 2014; Ndemo, 2017; Otenyo, 2017; Sam, 2017). Additionally, researchers have tended to adopt quantitative approaches in order to give large-scale accounts of ICT development in the developing world, with minimal involvement of local populations or end-users. As Qureshi (2015) lamented, ICT for development research

> fails the poor because few researchers engage in advancing policy positions needed to make a difference, choosing instead to focus on highly specialized, largely quantitative studies… ICT4D researchers do not engage closely with the users of their research findings thus disconnecting findings from real-world issues. (p. 511)

Diga and May (2016) noted, "rural areas are continuously placed at the periphery when provisions of ICT infrastructure and tools are brought to the fore" (p. 5). But rural societies constitute the largest portion of the world's population, particularly across the African continent (World Bank, 2016). Bowman (2015) undertook a study in Rwanda, and wrote,

> The Rwandan people had little input into whether ITC is a good way to move forward for development; they also had little input into how it should be configured and where it should be distributed. They were not empowered to put forth alternative imaginaries. (p. 83)

In this paper, we advocated research and policy that give a central role to end-users in the design, implementation, and provision of communications infrastructures. The paper makes three contributions. First, by exploring the micro-processes across these rural communities and analyzing how patterns of interactions and practices gave rise to social and cultural capital, we found that the literature on mobile phone adoption assumed a Western model of subscription and phone ownership that was not in evidence on the ground in these communities. This Western view of individual mobile phone ownership and subscription adoption was used by the mobile phone operators in the region to make investment decisions and to model the returns they expected. In practice, this approach was found to limit engagement with the end-users and so hindered realization of the economic potential and social benefits from the investment. Second, we collected examples of how local communities used mobile phones to integrate community social networks,

to manage information and knowledge exchange and local demand for resources, sometimes in difficult environmental conditions. The evidence demonstrated how local communities were able to influence the social and economic well-being of the local population, and develop new social and cultural capital by creating a more connected, joined-up, approach to managing resources in challenging conditions. Third, we suggested that a culturally appropriate, co-produced approach to designing and adapting communications services can facilitate more effective benefits realization from technology investment and the development of long term resilience that serves the socio-economic interests of end-users, private investors, and governmental institutions.

The paper is organized into six sections. Section 2 gives some background to the concept of infrastructures-as-service. This section also sets out an overview of the literature on end-user engagement in systems design and explores if the idea of 'end-user involvement' in infrastructural design is a reasonable expectation. Section 3, offers an overview of Bourdieu's (1979/1984, 1994/1998) capital theory to establish the relevance in this context, and sets out our research design and work in the field. Section 4 discusses the research data in the context of capital theory, and Section 5 puts forward the argument for the co-production of infrastructural services with end-users to better manage scarce resources. The final section summarizes the contributions of the paper.

Research Context

The Congo had a population of 57 million inhabitants in 2005, and almost 75 million in 2014 (World Bank, 2015). In 2007, the International Telecommunications Union (ITU) reported the Congo to have 10.5 % of mobile phone subscribers whereas Sub-Saharan Africa was shown to have 18.2 % (ITU, 2007). Four years earlier, in 2003, the Congo had 1.9 % mobile phone subscribers and Sub-Saharan Africa 2.8% (ITU, 2007) so usage is growing, but more slowly in the Congo than in other areas of Africa. DeMaagd (2008) observed that rapid adoption of mobile phones did not necessarily result in increased economic productivity, as usage in different parts of the world can vary considerably from the 'one device – one owner' model that is prevalent in the developed world. Mansell (2012) argued convincingly that understanding the 'diffusion of devices' does not give insight into how mobile phones are used in context, so in this research, we did not examine the diffusion of mobile phones across the region, we focused on the micro-level practices of communities in central and southern regions of the Congo, where mobile phone access had only been available since 2007.

Infrastructure as a Service for End-users

Understanding Infrastructures as Interconnected, Complex Systems

There is growing evidence that end-users of essential resources, such as water, food, energy, transport, communications, have a critical role to play in managing demand and that it is the behaviors, choices, and attitudes at a local level that determine efficiency and resilience across infrastructures (Faruqui, Sergici, & Sarif, 2010; Grubler 2010; Janssen & Jager, 2002; Steinberger, van Niel, & Bourg, 2009). Loring, Chapin, and Gerlach (2008) have promoted the idea of customers and providers co-creating value from infrastructure, but the fundamental shift from selling individual utility products to offering services has not been achieved. A transformation to a service-oriented perspective requires a more connected, 'joined-up' approach to thinking about infrastructure. But, to offer services, as opposed to single utility products requires more co-operation between designers, owners and managers across infrastructural sectors and better understanding of the interdependencies between infrastructures (Hall, Tran, Hickford, & Nicholls, 2016). These interdependencies are often better understood at a local level as it is this micro-level knowledge that drives innovation and socio-economic development, rather than large scale intervention in a context (Grubler, 2010).

Research into infrastructures has only recently started to examine cross-sector issues with the World Bank (2013, 2015) launching the 'Thirsty Energy' initiative and the United Nations (2014) focusing attention on the Water-Food-Energy nexus to increase awareness of the interdependencies and potential conflicts across water, food, and energy resources. Hall, Tran, Hickford, and Nicholls (2016) argued that current models and methods for planning and design of infrastructural networks do not explore the interdependencies across sectors and are not well suited to incorporating changing conditions, such as the introduction of new processes, or new technologies.

Etzo and Collender (2010) and Mercer (2004) criticized approaches to communications infrastructure research that fetishize communications technology. We worked from a more systemic perspective of resources and systems as a connected whole in order to move past this problem. Regarding infrastructures as complex interconnected systems gives insight into the multiple layers and into the dynamic complexity across constituent networks. Such a view is also essential to move toward a view of 'infrastructure as service' and for understanding the increasing complexity and interdependence across infrastructural sectors. Communications infrastructures have an important contribution to make in achieving more joined-up, connected approach to management of natural resources, and so understanding the micro-level detail of how end-users

interact with, and adapt communications services, is essential to a successful transition toward an 'infrastructure-as-service' model of delivery. Technologies and communication infrastructures expedite information, knowledge exchange and decision making in complex networks and in doing so, facilitate interconnections between physical and social systems on the ground.

Communications Infrastructure as an Integrator

The current literature on communications infrastructures focuses on how investment in these technologies and infrastructures can improve market efficiency and/or reduce transaction costs (Aker, 2010; Aker & Mbiti, 2010; Asongu, 2013; Priya & Mathiyalagan, 2012). But May, Dutton, and Munyakazi (2014) suggested that current research, largely conducted at a macro-level, is too generic to provide insight into how end-users engage with communications technologies on the ground. Several authors have questioned the assumption that access to mobile phones is directly responsible for economic benefit in the developing world, and a consensus is now forming that the relationship between technology and economic development is nuanced (Heeks 2007; DeMaagd, 2008; Rashid & Elder, 2009; Wilson, Best, & Kleine, 2005).

Governments across the developing world however, are making significant investments in communications infrastructure in the expectation of transforming their economies (Dutta & Mia, 2010). Avgerou and Madon (2005) noted that such projects can lead to a 'digital divide' as access can be inequitably distributed across different social groups. Srivastava and Shainesh (2015) suggested that much of the research into the impact of communications infrastructures and into the digital divide has been based on a 'goods-centric' view where the emphasis is on provision of goods in the form of computers and mobile phones. Communications infrastructures and their associated data technologies can be applied to provide access to basic services for the poorest in society (Madon, 2005). To achieve this, it is important to understand how these end-user groups will adapt to new infrastructure and technologies. Communications infrastructures cannot replace other infrastructures such as energy, food, water etc., but can enhance access to critical resources and support their management (Aker & Mbiti, 2010).

End-User Engagement in Service Delivery

Re-thinking infrastructure as 'service' and engaging end-users, first requires a shift in the approach to design practices applied in infrastructure projects. Due to the size and complexity of these infrastructural systems, there is a tendency for design to be managed through structured, traditional top-down approaches, driven by quantitative metrics (Champion & Stowell, 2003). But as Jasanoff (2016) argued, "we must understand how power is delegated to technological systems" (p. 12, see also Jasanoff, 2017). Bijker (Bijker et al., 1987; Bijker 2016; 2017) also argued for an approach to

designing technological systems that acknowledges social, economic, and political questions and engages with end-users. Cherns (1976, 1987) laid the groundwork for engaging end-users in systems design, by setting out nine principles for socio-technical design (summarized in Table 1).

Table 1. Principles of Socio-Technical Design

Principles of Socio-Technical Design	Summary
Compatibility	Meaningful participation to ensure the design is fit for purpose
Minimal critical specification	Identify only what is essential
Variance control	Variances should not be exported across organizational boundaries
Boundary location	Boundaries should not impede knowledge sharing
Information flow	Information should be immediately available to those who have to act upon it
Power and authority	Those who need to act must have the power and authority to do so
Multifunctional principle	Limit the use of outside experts
Support congruence	Pay for what a person knows
Transitional organization	Train don't test
Forth Road Bridge principle	Constantly renew and revise

(Summarized from Cherns, 1987).

In their recent overview of socio-technical design approaches, Winter, Berente, Howison, and Butler (2014) highlighted that research in this field assumes that design activity occurs in a reasonably homogenous organizational context. This assumption, however, does not transfer to an infrastructural design context, where the resulting system will potentially impact across many communities and then be adapted on the ground by a network of end-users and other collaborators.

Geels (2004) and Van de Ven and Garud (1994) both suggested that end-users can learn new ways to amalgamate resources and create new and innovative responses to problems over time; but to achieve this, end-users would need to be embedded in the decision making process about the provision of services during the design, implementation and use of infrastructure. To understand how such an approach to infrastructural services might work in practice, particularly in the developing world, there was a need for research to analyze the micro-level of daily practice and engagement of end-users with communications infrastructures. To structure our research, we applied Bourdieu's (1994/1998) capital theory.

Bourdieu's Capital Theory as an Analytical Lens
Bourdieu's Capital Theory
Capital theory (Bourdieu, 1983, 1979/1984, 1986, 1994/1998) can be a useful lens to examine the micro-processes of how communities and networks come together to solve problems, and how the different forms of capital (human, economic, social, and cultural) support the design of new approaches and innovations (Freel, 2000; Glover, Champion, Daniels, & Boocock, 2016; Romero, 2011). Bourdieu used the concepts of 'field', 'habitus' and 'capital' to structure the analysis of micro-processes. A 'field' is regarded in capital theory, as the social space people occupy; their 'habitus' refers to people's habitual way of acting and thinking; and the resources available to people are regarded as 'capital' (Bourdieu, 1979/1984, 1986). Bourdieu (1979/1984, p. 14) identified four different types of capital: economic (financial, material, property wealth); cultural capital (knowledge, skills, qualifications); social capital (actual or potential access to social networks, business networks, groups with useful resources or connections); and symbolic capital (honor, position, and prestige). Bourdieu situated his view of capital in a class struggle for resources, with those in powerful positions owning most capital resources (Lin, 2001). Most authors agree that different forms of social capital are embedded in relationships and social structures and that investing in social capital can increase the likelihood of returns in kind (Coleman, 1988; Furstenburg, 2005; Putnam, 1993). Bourdieu went further and suggested that the

different forms of capital provide members of any particular network with "the backing of collectively-owned capital" (1994/1998, p. 51). This latter view seems directly relevant to exploring how the networks across rural communities, experiencing access to communications infrastructure for the first time, respond to the potential offered by mobile phones in their daily lives. Social and cultural capital are considered to be particularly important for problem-solving and for a dynamic response to an issue or event (Corti & Storto 2000; Perez & Sanchez, 2002). In this research, we applied capital theory to understand the micro-level processes associated with access to communications infrastructures across village networks in our research area in the rural Congo.

The Research Method
The aim of the research was to investigate the micro-level practices of the end-users of communications infrastructures (through mobile phone devices) in rural communities across central and southern districts of the Congo. This region was chosen as the area had experienced significant investment in communications infrastructure since 2007, with many rural communities being given access to mobile phone networks for the first time. We adopted a participative research framework that was responsive to the traditional practices in these communities. The researcher in the field was a native to the Congo, able to speak all three of the local dialects and who, for the purposes of collecting data for this research, spent four months living with the villagers who participated in the research. The field researcher participated fully in village life during this time, growing vegetables and contributing to the community by helping with odd jobs and joining in communal activities.

We strived to give voice to local participants and their values, and so in this context, we judged that coding the data collected would be a manipulation of and distraction from the voices expressed and the values encountered. Our choice resonates with Saldaña (2016) position when he declared,

> No one... can claim final authority on the utility of coding or the "best" way to analyze qualitative data. I must also emphasize at the very beginning that *there are times when coding the data is absolutely necessary, and times when it is most inappropriate for the study at hand* [emphasis in original]. (p. 2)

Further, Miles, Huberman, and Saldaña (2014) clarified,

The ultimate power of field research lies in the researcher's emerging map of what is happening and why. So any method that will force more differentiation and integration of that map, while remaining flexible, is a good idea. (p. 93)

Since we sought to give primacy to the values of end-users per Bourdieu (1979/1984, 1986), coding as a method became unsuitable to our research. The field research focused on exploring how mobile phones impacted on the micro-practices of village life to understand how the community gained value from access to the communications infrastructure and to gain insight into how social and cultural practices changed. The aim was to collect empirical evidence of how the villagers crafted their social practices around the mobile phones in a way that was coherent with their local, cultural views and realities. A diverse range of participants took part in this research, (see Figure 1). The active participation of the community was achieved due to the researcher being embedded in the field and being able to be a member of their community through language and practice.

Figure 1. Participants in the Field Work
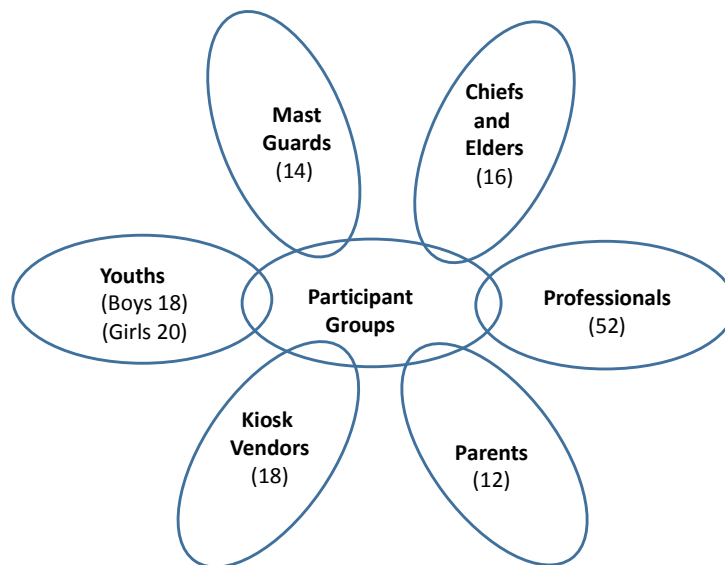
Note 1:
Professionals included:
Midwives, artists, craftsmen and women, healers, builders, traders, teachers and story tellers.
Note 2:

Numbers in brackets denote number of participants in the group.
Note 3:
No interviewee is counted twice

Most of the interviews took place at common meeting places such as a village plaza or market place, and a small number of interviews with village elders took place during house visits. Only chiefs and elders could be seen alone. Interviews were often interrupted by the needs of children or other family members and so the length of interview was variable.

This area of the Congo has experienced a recent history of violent unrest in neighboring Rwanda, and during the fieldwork there was also growing unrest in Burundi. This political situation impacted on the way that interviews could be conducted. During the unrest in nearby Rwanda there had been an influx of migrants to this area of the Congo and in some areas, lists of names had been circulated which were associated with people being taken away and imprisoned, tortured or executed (*Burundian Time-Bomb*, 2016). For this reason, inquiring about someone's background and history was deemed socially unacceptable and chiefs and elders put limits on what details could be recorded; taping or filming interviews was similarly forbidden. With the permission of the chiefs and knowledge of the community, a field notebook was used by the field researcher to take notes and write down quotations with participants identified according to their group or profession. It is important to state that to ensure participants were comfortable with the research process, the field notes were often written up after the interview or meeting to act as an aide memoir for the field researcher and so few direct quotations were recorded. Participants from fifteen villages took part in the research and the conversations and interviews were conducted by the field researcher in one of the three official dialects of the Congo: Lingala, Swahili, and Ciluba, depending on the chosen dialect of the interviewee.

By being flexible in the way the research was undertaken, a detailed picture of how mobile phones were used and incorporated into daily life emerged. By living with the villagers for four months, the researcher in the field was able to check his understanding and also witness various activities that were mentioned in the interviews. More traditional research approaches would have alienated participants and no data would have been collected. The aim of this research was to gain a deep understanding of how end-users interacted with communications infrastructure and we argued that the research approach was sensitive to the concerns of the participating communities and was of sufficient rigor to offer useful insight. The experience of undertaking this research has

resulted in learning that is also valuable in framing approaches to engage end users in the design of infrastructures and this is discussed in the last section of the paper.

The qualitative data collected for this research was mainly in the form of interview notes and field observations recorded in a series of field notebooks. The notes from the interviews were recorded in the language in which they took place and then these notes translated into English and reviewed thoroughly. Themes from the data were identified through constant comparison and thematic analysis, to identify concepts, which were then linked back to the data (Glaser, 1996). The aim of our research was to allow the community to speak for themselves, hence we did not suggest universal prescriptions about mobile phone devices in other developing countries, but rather, we identified or inspired some "lessons learned" that applied to the rural Congo and could be used beyond "the setting for the specific case" (Yin, 2014, p. 40).

Empirical Findings and Discussion

Our findings are grouped around three key themes taken from Bourdieu's (1979/1984) capital theory: social capital, cultural capital, and an 'amplification effect' being where new value is created from combining different sources of capital. We also explored the data for evidence that symbolic capital was important to creating value from the communications infrastructure. Bourdieu referred to symbolic capital as accumulated prestige or honor and in this research, symbolic capital could be regarded as being held by village chiefs and elders. We found that these individuals held positions of honor in these communities because of their age, experience and knowledge. Respected community members or volunteers often acted as 'keepers' of mobile phones in social networks, but holding the phone for others to use did not add to their symbolic capital, rather they kept the phone because of their symbolic position. For this reason, we focused our discussion on social and cultural capital and the combinations of capital that created new value from the communications infrastructure.

Social Capital

Bourdieu (1979/1984) defined social capital as networks and connections that could be accessed to offer resources and introductions. As part of this research we explored the social networks across the research area and also how mobile phone access had changed the reach and range of these networks for the benefit of the communities. One of the most important aspects of these community networks, was the approach to mobile phone ownership found in this region of the Congo. We found that mobile phones were usually regarded as being owned by a community or network, rather than a single individual. A senior member of the community, often a matriarch/grandmother, would act as 'keeper' and lend the phone out for use to whoever needed it at that time. Mobile

phones were then used by members of the community that needed the phone for specific purposes such as a visit to the city, or to arrange a family gathering. Most people in the region where this research was conducted, did not own a personal phone, but could, if needed, get access to a phone through their family or community network.

To explore mobile phone usage and to understand how ownership of a mobile phone operated in the community networks, interviewees were asked to tell the interviewer about how and when they obtained access to a mobile phone, and in what context. Many interviewees, from across the various participant groups, had first used a mobile phone device on some type of 'special occasion', such as a trip to the city, or the death of a relative, and had been loaned a phone for the time needed to cover the special occasion. For example, a person had borrowed a phone to arrange a funeral gathering in one of the villages to help them contact people living in the city. Other examples of special occasions included being close to giving birth, so borrowing a mobile phone in order to call a midwife, or to arrange for visits from friends and relatives in other villages or locations. Most of the phones were owned on a 'pay-as-you-go' basis, which meant that if a person borrowed a phone, they were then responsible for putting more credit on the phone after they had finished using it. Charging the phone device was often a communal responsibility as charging could only take place in certain locations with access to a power supply, so this activity would be undertaken by someone within the network who was going to a location where charging could take place. After a person had finished with a mobile phone, it would be returned to the 'keeper' ready for the next person who needed a phone.

Mobile phones would also be used to access information to facilitate certain activities. For example, communal trips to market in order to swop goods and services would be arranged and the prices for goods at other markets could be checked to ensure fair pricing. Mobile phones would also be used to report on the health of vulnerable community members and also to co-ordinate odd jobs and repairs to village huts, or equipment. In these situations, the mobile phones supported access to people with professional knowledge such as nurses, so symptoms could be checked. This communal usage of mobile phones fitted within the traditional structures and practices of the region, where communication networks facilitated village and communal activities. Jasanoff (2016) observed that "a more immediate result of technological advancement… is fragmentation and loss of community, in short, the weakening of the social ties that make human lives meaningful" (p. 6). Perhaps one reason for this finding is the strong communal culture found in this region.

The best explanation of the communal culture prevalent in this region of the Congo is through the concept *Ntu* (Tshiamalenga, 1975, 1985) taken from Bantu languages meaning: life, existence, being, etc. The concept *Ntu* rose to prominence in the 1990s under the Zulu (South African) term *Ubuntu*, a term used by President Nelson Mandela (Kimilike, 2008; Kithaka, 2015; Oppenheim, 2012). The idea conveyed is that of the rapport of a person with self, others, things, and the wider community. A Zulu proverb says, "*Umuntu ngumuntu ngabantu*" [a person becomes a person through and with (the help of) others] (Esongi, 2011, p. 26). Or as a Ciluba (Congo) proverb says "*Buena muntu budi ndambu ndambu*" [Humanity lies in sharing the little a person has] (Kalamba, 2013, p. 30). These traditional practices of sharing and joint ownership across a community impacted on the way mobile phones were used across groups. For example, one mobile phone could be used, charged, topped up, repaired, etc. by a person's neighbor, uncle, friend, sister, husband, or grandma, etc. The mobile phone was shared across a chain of relationships and uses, extending the social capital for all individuals involved in the network.

Cultural Capital

Cultural capital (Bourdieu, 1979/1984) arises from holding educational qualifications, having valuable skills or also the possession of cultural objects that are viewed as having inherent value. The community relied extensively on family/community skills and knowledge. Chiefs, story tellers, and senior members of the community would tell stories of how problems had been solved in the past and also of how members of the present community had developed their skills and expertise, particularly if the story had humor, or peril. Chiefs and storytellers also told stories to increase awareness and knowledge across the community, and this knowledge could sometimes be applied by younger, different members of the community, without direct experience of the events being narrated. One example of this happening in practice is when a particular area became flooded and made travel dangerous. In this instance a younger member of the community remembered a story of similar flood and used a mobile phone to communicate to nearby villages the extent of the flooding and to remind them which paths had been safe in a previous instance of similar flooding.

Across these rural communities there were many examples of older, more experienced villagers passing on knowledge and skills (cultural capital) to the next generation as might be expected. Collaborative problem solving was also apparent and mobile phones extended the number of circumstances where advice could be sought, and also extended the network of people that might be contacted to seek advice. This could be seen most directly in the way phones were used to take pictures and record text, creating a portable library of information and shared memories. These information stores also facilitated better problem solving in some circumstances.

For example, if one family or farmer had a problem with crops, mobile phones made it possible to take a photograph of the stricken crops and then either message or show the photograph to someone with more experience to diagnose the issue and suggest a solution. These sorts of activities extended the reach of problem solving networks and facilitated new and timely social actions to improve the well-being of the community.

Within this research context, mobile phones were observed to improve the speed of access to knowledge and also the quality of advice given in certain circumstances, due to the facility to contact people that would otherwise be a half-day, or day's walk away from the problem situation. This access to social and cultural capital (Bourdieu, 1979/1984) were prerequisites for successful problem solving.

The Amplification Effect

The focus on micro-level impacts and interactions between end-users and communications infrastructure and the use of Bourdieu's (1979/1984) capital theory as a lens in which to analyze the changes in social and cultural capital across these villages established that better problem solving was one of the most valued aspects of access to a communications infrastructure. For example, the sharing of pictures of problems with crops, or of damage to a hut could allow a family to connect with the needed help much more quickly than before. By sharing news of weather, the state of a road, knowledge of where the fish were swimming, or if someone who lived very remotely had sufficient supplies through the mobile phone network, communities were able to organise a swifter, more connected and joined-up response to need and to opportunities. Cultural capital, i.e. access to skills and knowledge was also extended via the communications network and this also resulted in improved problem solving and innovation.

To date, ICT research undertaken in developing regions of Africa has overwhelmingly focused on the capital investment, and on economic benefits (Asongu & Nwachukwu, 2016, 2017; Diga, 2013), and on issues of usability arising from technological features. Diga (2013) criticized these approaches, arguing that "the key assumption underlying this work – that the poor could be moved out of poverty simply by providing them with ICT and information access and usage – was a limited one" (p. 127). This view is also confirmed by Sam (2017) when from his work exploring mobile phone use with the poorest in Sierra Leone, West Africa, he commented: "it is not strongly evident that the use of mobile phones completely emancipates them from socio-economic and political exclusion" (p. 359). Our work provides additional evidence for the views of Kolko,

Putnam, Rose, and Johnson (2011) who argued that the "distance between technology design teams and end users" (p. 575) is part of the problem. In this paper, we followed Bourdieu's (1986) lead that capital should not be reduced to a materialistic or monetary agenda. While the issues of economic benefit and technology features are important, the application of Bourdieu's (1986) capital theory gives an additional and necessary perspective.

Interviews were conducted with many different groups during the field research (shown above) and these exposed some stark differences in the way that the villagers (the end-users of the communications infrastructure) perceived the value of the services mobile phones offered and the business models of the communication infrastructure investors and mobile phone companies. One group of stakeholders did perceive problems with the way in the community were given access to the communications infrastructure: the kiosk vendors. This group sold mobile phones and the pre-paid cards from kiosks, or huts, or market stalls to the villagers. The majority view from this group could be summarized as concern about the lack of equity between the people selling pre-paid cards in the city, to those selling the cards from kiosks or stalls in rural areas. One kiosk vendor commented that a great deal of investment into selling mobile devices had occurred in the city but that he had received no help:

> *"as a kiosk vendor I could use a table or the back of a container to put out my merchandise"* (Kiosk Vendor VIII).

Another kiosk vendor suggested:
> *"I sell the prepaid cards, and I am on my own. Mobile phone carriers don't even know where I live, whether I have a house, where I sleep. The tiny leftovers of credits, if there are any left of course, are your profit or salary, I would say"* (Kiosk Vendor XVII).

The differential treatment between urban and rural communities expressed in these comments was perceived as going against the local Utu culture. The communities involved in this research found value from mobile phones in the way that the phones could support and extend Utu, their way of living with each other. In contrast, the mobile phone companies gained profit through the increased sale of individual phone contracts (Gough, 2005) and this was reflected in the increased investment in city areas, as more contracts could be sold in an urban environment. This supports the findings of Kolko, Putnam, Rose, and Johnson (2011) who highlighted the problem of there being an increasing gap between technology designers and end-users, and raises the question of how mobile phone companies can adopt more sustainable and ethically appropriate practices when investing in developing countries.

We suggested that to achieve full realization of the possible benefits from investments in infrastructures, and to support and promote connections and services across utilities and across different urban and rural communities, there is a need for a more holistic view of how value is created in developing countries. The lessons from this field work suggest that 'end-user' engagement in the design of services would be a start, but moving toward a situation where end-users are actively engaged across the design, planning, implementation and evaluation for regional infrastructures would offer a more effective route to understanding how multi-utility services could significantly increase the well-being and resilience of communities and promote innovative new approaches for sustainable resource management.

The Co-Production of Infrastructural Services

We suggested that to achieve the full benefits of infrastructure investment on a sustainable, long-term basis, and to move from a 'product' to a 'service' mentality, end-users need to be fully engaged in the design and implementation of services. This requires end-users to be co-producers throughout the design, implementation and evaluation of services. 'End-users' have a unique role to play in facilitating knowledge and information exchange in their region. In the developing world in particular, the manner in which information and knowledge is spread is situated in the micro-level social practices, routines and traditions of the end-user community.

Co-production is the idea that end-users are engaged with professional providers in the decision-making processes about public goods and services, and was initially developed by Ostrom and colleagues in the 1970s (see Ostrom, 1990 for an overview). Since then, the range of applications and contexts where co-production has been regarded as legitimate and valuable has grown. Fledderus, Brandsen, and Honingh (2013) noted that co-production arises from a belief that citizens can "no longer be treated as passive clients or consumers, but as (potentially) active co-producers of the services they receive". Co-production is often seen as a radical re-interpretation of the relationship between users and providers of services (Bovaid, 2007 and several authors suggest that working within this approach has also been shown to produce outcomes that are trusted, more valued and more likely to be transforming (Alford, 2002; Boyle & Harris, 2009; Considine & Lewis, 2003).

We suggested that co-production in the context of providing infrastructural services can be defined as:

The processes whereby infrastructural services are designed; planned; implemented; managed; adapted and evaluated by infrastructural service providers working together with end-users as equal partners.

This definition places end-users as equal players in the design, delivery, and evaluation of infrastructure. Our research also demonstrated that applying such a participative approach will require appropriate methods and means of engagement with different communities. This work was undertaken in a manner that was ethically appropriate for the communities in this area of the Congo, by a researcher familiar with the languages and practices of the region and so gave voice to these villagers.

Conclusion

In this research, we focused on how local communities in the rural Congo integrated mobile phones into their lives and across their social networks at a micro-level. We explored if access to new communications infrastructure and technology changed the ways in which these communities responded to different events and how the end-users perceived the value of mobile phones in enabling the social and economic well-being of their community. Re-imagining infrastructure-as-a-service will require end-users to frame services, with co-production being a means of managing scarce resources in ways that better cohere with the local, cultural views, specifics, needs, or realities of concerned end-users.

In this study, we worked to foreground the experiences and views from our research context in the Congo, through a culturally appropriate research method. In doing so, this research highlights the need to re-conceptualize how we assessed what impacts large infrastructural projects might have on the social and cultural structures and networks in a region. We intended to focus our future research on these issues in order to understand how to effectively engage end-users in the co-production of infrastructure services for future sustainability.

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