Using Activity Theory to Understand Technology Use and Perception among Rural Users in Uganda

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ABSTRACT
Implementing technologies in developing communities often involves working with people that have a very different context from the researcher in terms of lower literacy and less experience with technology. Having worked with three rural communities in Uganda and introduced an Information and Communication Technology (ICT) intervention for water management, we use activity theory to analyse people's activities in relation to the use and uptake of the community-based ICT tool. To understand the contextual factors that influence the use of the tool, we proceed from our activity theory analysis and we unpack the perceptions and attitudes that rural technology users have towards technology. Our findings provide insights into what motivates and demotivates people in rural communities to use ICTs. We use our findings to substantiate the relevance of the intangible impacts of ICTs such as empowerment, social cohesion and improved self-worth for rural technology users. We recommend that technology designers be open to the unintended uses of the technologies they introduce in rural communities.

CCS Concepts
• **Human-centered computing~HCI theory, concepts and models** • **Human-centered computing~Field studies**

Keywords
Activity Theory; Technology Appropriation; rural communities; ICT intervention; Human Factors.

1. INTRODUCTION
Information and Communication Technologies (ICTs) are intended as leverage in the fight against under-development, poverty and other structural dislocations that affect service provision and lead to the marginalization of an economy or a segment of it [30]. The implementation of an ICT is often considered a process of expanding human capabilities as well as access to opportunities in social, economic and political spheres and hence, improving the quality of life [17, 19, 24, 39, 40]. ICTs are also recognized for their ability to extend and enhance agency of individuals as well as communities [10].

The potential of ICTs is continuously being exploited in developing regions and has created high expectations from both technology implementers and beneficiaries with regards to improving the lives of the underprivileged and disadvantaged groups [19, 36]. In resource constrained environments, the adoption of ICTs is usually seen as a competitor for the limited resources with other developmental interventions such as health, education, infrastructure development (like roads, communications) and water services [29]. However, we see technology as an enabler of development that supports the extension of services to previously isolated communities and empowering people with information to demand for better services [17, 43]. Even within communities that experience political instabilities, ICTs are seen as enablers to enhance and develop skills among user groups and empower them to actively contribute to their own development [44].

Despite the existence of documentation on the impact of ICTs on communities, there is limited considerations for the 'intangible' outcomes such as empowerment, social cohesion and improved sense of self-worth for individual technology users [34, 43]. Although these outcomes have been mostly measured quantitatively in the social sciences using instruments such as self-efficacy and self esteem scales, less attention has been paid to them in ICTD (ICTs for Development) research. This has been attributed to the fact that these outcomes are quite difficult to measure [29] and are only meaningfully expressed qualitatively [43]. It is also common for ICTD research study outcomes to focus on 'easily measurable' impacts such as income or economic growth, education and health while overlooking the intangible impacts that might be equally valuable to the technology user [43, 45] or different stakeholders.

ICTD research has further been criticised for lacking in the use and development of theory despite its being multi disciplinary and cutting across disciplines that are 'theory-heavy' such as psychology, education, information systems and sociology [4, 20, 23]. A number of researchers have borrowed theories from these disciplines and attempted to apply them to ICTD research [2] but this is apparently problematic due to the difference in focal issues for the different disciplines. Karanasios [23] and Andersson et.al [2] argue that since the ICTD field is more focused on social economic development, empowerment and poverty reduction using ICTs, we need to increasingly use theories that make the relationship between technology and development more visible.

The use of activity theory is not only considered a good starting point for theorising ICTD research but also an appealing approach to bolster insights into the relationship between ICTs, change, development and human activity [23]. We therefore contribute to the ICTD research body by using activity theory to structure technology use and uncover people's attitudes towards

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technology. In looking at how technology impacts individuals in intangible ways, we discuss some of the key factors that guide motivation for use. Our findings are limited to a group of participants that were previously involved in the design and development of an ICT intervention to support rural water management within their communities. Given the context-specific settings of our study, it is not our intention to generalize our results but to provide researchers in similar studies with pointers for reflection on how technology use and perception can be structured, analysed and uncovered using activity theory.

1.1 The Pay Me For Water (PM4W) Project

Pay Me for Water (PM4W) is our ICT intervention (a mobile application) that we developed as part of our research and community engagement with three rural communities in Kabarole District in Western Uganda. It is meant to be used by communal water managers to keep track of community finances and water users as a way of ensuring accountability and transparency. It allows caretakers to register water users, and provide information on daily or monthly collections (sales) as well as expenditures. It allows community treasurers to record information on total payments submitted to the water boards. Water board treasurers are able to provide information on the financial status of community accounts and send notifications (SMS-based) to community members.

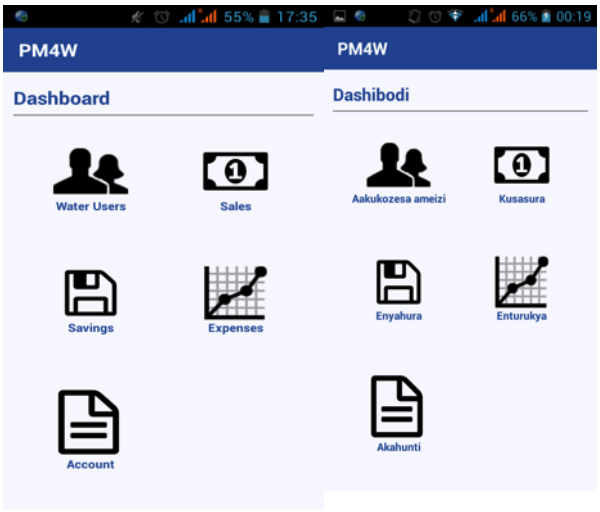

Figure 1: Sample interfaces of the PM4W application: (a) - the home screen for the caretaker to register and view water users, log daily and monthly collections (sales), log expenses, post savings and view accounts status; (b) - the Rutooro (localised) version of PM4W

The PM4W system is intended to support the community based model for managing communal water supplies by facilitating community financial management practices. It is on the assumption that if communities are supported to efficiently manage and use the communal finances in a transparent way, water users will be more willing to pay their water fees. Therefore, more funds will available for operations and maintenance activities and eventually lead to improved functionality of water sources and access to clean and safe water. The initial prototype (English version) was deployed in January 2015 while the Rutooro (localised) version was deployed in August 2015.

The PM4W project was developed for and with rural communities and is therefore a suitable study for understanding the perceived value of technology within a rural context. In focusing on how the intervention is used (as an activity) and the environment in which it is situated, we are then able to unpack the intangible outcomes of technology use in a rural setting.

2. HUMAN ACTIVITY AND TECHNOLOGY USE

Within the consciousness of individuals are the reflections and representations of needs, interests, values and social relationships with other members of society with whom an individual performs joint activities [26]. In understanding human activity, it is also useful to look at the environment and the other factors that shape and influence activity. Ashok and Beck [3] argue that subjects (people) and objects (artefacts) cannot be analysed separately if we are to understand what people do and how they use artefacts. An analysis of artefact usage should therefore examine the person's interactions with the technology within a meaningful social context that represents or gives the historical and cultural perspective.

It is through human activity that skills are developed, social conditions transformed, new forms of cultural tools generated and new forms of life and self are created [32]. To make sense of any change in human activity especially as a result of the introduction of a technological tool, Karanasios [23] argues for the use of an analytical framework or theory that is well suited to change and development contexts. A number of theories and frameworks have been developed to understand how people interact with technology and with each other, e.g., Actor-Network Theory, Structuration Theory, Technology Acceptance Model, Activity Theory, Distributed Cognition, Situated Action [2, 7, 23, 37] to name but a few. From the analysis of theories used in ICTD research conducted by Andersson and Hatakka [2], it is clear that Activity Theory has been neglected despite its ability to provide a better understanding of the dynamics of human activity when mediated by a technological tool [23, 28].

In order to understand the drivers for technology use and perceptions among our study communities, we chose to use Activity Theory as an analytical framework that is considered appropriate within a context-specific setup [7]. In using Activity Theory, we approach technology use with the view that technology has the ability to transform human activities and does shape behaviour.

2.1 Activity Theory

Activity Theory (AT) emerged as a psychological theory of human consciousness, thinking and learning and has mostly been operationalized in the fields of psychology and education [28]. It has evolved into a tool used to describe the structure, development and social context of human activities [31]. In AT, an activity is defined as an engagement of a subject (a human agent) motivated by a goal and mediated by a tool (artefact) in collaboration with others (community) but constrained by cultural factors within a specific context (cited in [27]). AT makes use of the concept of mediation (formulated by Lev Vygotsky) as a way of grounding the interaction between a human agent and the world [28]. Miettinen et al [28] and Karanasios [23] echo Vygotsky in focusing on human activity as a unit of analysis, which points to elements that contribute to change and learning.

AT has been applied in several studies as an analytical tool to study, analyse, describe and understand human activity and the use of technology [6, 14, 32, 35]. By shifting the unit of analysis

to activities, tensions between the different elements of the entire system that is, the user, the environment and the artefact can be identified [37]. For example, in Information Systems, AT is broadly used to analyse specific work activities as part of the formulation or development of work processes to guide decision making within organizations [14]. De Freitas et.al [14] apply AT to assess the need of an information system for an Anti-Retroviral Treatment (ARV) clinic in South Africa and argue that the framework gives a more holistic approach to understanding system development needs. Neto et al [31] integrate activity theory with ethnographic analysis (Context of Use Analysis) and organisational modelling techniques to derive organisational system requirements. Bardram et al [6] use AT to analyse observations of work procedures of a physician and surgeon in a hospital to guide the design of an information system. In education, AT has been used as an analytical tool to identify possible tensions that impact the use and usefulness of a webinar tool [27] and to analyse goals and interactions between learners using an Online Collaborative Learning (OCL) intervention [32]. McNely et al [26] use AT to highlight the mediation capabilities of scrum – a software development framework, in facilitating articulation and coarticulation of actions of students within a shared objective. From the highlighted examples of AT use, we have not encountered studies that use AT outside organisations or educational institutions except for Ashok and Beck [3] that use AT to develop a framework for the design of rural health technologies.

Our use of AT focuses on its principle of *artefacts as tools for mediation*, which can influence the way users as intentional actors interact with them to undertake activities. When we consider the mediating role of an artefact, we look at its properties that cause people to engage with it and its representation of the social and cultural practices of the environment. Yoo et.al [45] argue that the form and function of a tool can provide insight into users values and the intersection of those values with technology. This notion, coupled with the understanding of how people consciously use artefacts, can guide us in understanding why people use technology a certain way.

The social context within which an artefact is used also influences use. Even when a user seems to work as an individual, he or she engages in activities that are given meaning by a wider set of practices [37]. The environment or community usually defines these practices. Since human activity is socially and culturally determined, AT provides a suitable mechanism to uncover contextual factors that potentially influence the use of a technology.

Community based ICT interventions are connected to both community practices and individual community members. To assess how beneficial and sustainable these interventions are, different contextual layers of the environment in which they are being implemented have to be analysed.

To incorporate contextual layers and AT perspectives on technology use, we amended an analytical framework developed by Nihra et al. [32] for our study. Figure 2 specifies the components of our analytical framework and the layers within which we analysed the use of an ICT intervention by rural users.

- *Institutional level:* We analysed the intervention from a broader perspective and support structures meant to foster continuous engagement. We also focused on the affordance that the environment provided for the technology to be continuously used.
- *The Community level:* We analysed the technology from the user's perspective and focused on the users' interactions with technology and with one another (fellow participants and or family members). At a later stage, we will include the analysis from the perspectives of the wider community members who are also considered beneficiaries of the intervention.

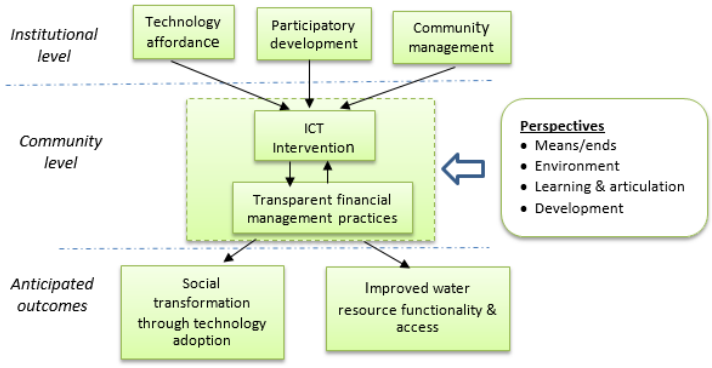

Figure 2: An analytical framework informed by Activity Theory used to understand contextual layers and technology use in rural communities (adapted from [32])

- *Outcomes:* We analysed the intervention in line with anticipated outcomes of meeting a community need (improved financial management for communal water facilities) as well as adoption and integration of the technology within communal practices.

To evaluate how people learned to interact with technology and eventually made use of it, we used the four AT perspectives that are informed by the principle of *tool mediation* [21]. A detailed description of the perspectives and how we used them for our analysis is presented in Sections 3.3.1 and 4.

2.2 Technology Appropriation

Rural users tend to have a lifestyle that is different from urban dwellers. With their limited access to technology, low literacy and agrarian livelihoods [3], diffusion and adoption of technology is simply not straight forward.

Community-based ICT initiatives or interventions are usually aimed at achieving a particular development goal. However, new and unexpected interactions with technology are emerging and thus calling for a more holistic understanding and assessment of technology in a development context. Activities are dynamic in structure and can easily lose their motive and be considered as part of other 'un-intended' activities [5].

We use the term 'technology appropriation' to refer to the unintended use of technology. Technology is becoming more ubiquitous and weaving itself in many activities. Although mobile phones are flexible, mobile applications on the other hand are seemingly quite rigid [11], causing frustrated users to abandon them or use them differently. Technologists are now finding themselves in positions where they have to design tools that are open and can support increased awareness and relinquish control to the use and free interactions [1] after all, tools are likely to introduce new ways of working [23]. These un-intended interaction have been referred to as 'play' by Ferreira [13]. The

ability of people to play with technology or use it differently in a way that seems valuable to them is seen as a capability in itself as users have the freedom to act as they wish. The focus of technological implementations should therefore not be tied to only satisfying a pre-defined set of socio-economic needs but allow for possible uses [13]. Dix [12] argues that although it might be difficult to design for unexpected use of a system, we can design to allow for the unexpected use.

Looking at how people appropriate technology is important because it gives an indication of user acceptance as well as the motivators and de-motivators of use. When people improvise and adapt technology in their own ways, it is not a sign of failure but rather an indication that users are comfortable enough with the technology to use it in their own ways [12]. Baerentsen et al [5] highlights that technology designs need to ensure that the intended use is visible for the user without necessarily eliminating the possible uses.

We have worked in rural communities for over six years and have experienced technology appropriation by rural users. We therefore consider these unintended interactions as legitimate activities since they are valuable to the users even as basic forms of expression of freedoms.

3. METHODOLOGY

3.1 Research Context and Stance

This study is shaped by a qualitative interpretive methodology that attempts to explain the reality through an understanding of the interactions that rural technology users (participants) have with using an ICT intervention that was developed using a co-design approach. We sought to understand users' experiences with the technology as well as their understanding of desired outcomes.

Our study on which this paper is based, is part of a long-term engagement with three communities in Kabarole – a rural district located in western Uganda where we have applied Community-based Co-Design as a method of engaging inexperienced technology users in technology design [8]. For this paper, we focus on people's activities, with the activity of interest being the use of PM4W to manage financial and water user information.

3.2 Participants

Between June 2014 and August 2015, we worked with a total of forty participants in six iterative action research cycles. Of these, twenty two were water source caretakers (collecting daily or monthly fees from community members), six were water board treasurers (who supervise care takers), eight community representatives (selected by their respective caretakers), two district water officers (DWO), one Community Development Specialist (CDS) and one Non-Governmental Organization (NGO) representative. The participants' ages ranged from 25 and 65 with a mean age of 43; 35% of the participants were women. Mobile phones running the PM4W application were only given to the caretakers and treasurers, as they are the key people in the financial management of communal water funds.

3.3 Methods

We engaged with users through semi-structured interviews, design workshops and focus group discussions. We also used system logging to monitor actual use of the application. We combined these methods with observations to investigate how participants interacted with the mobile phones and the developed system. During the interactions with participants, we asked users what motivated them to use the technology and or what constrained them from using it. We documented all our interactions in the form of field notes, photographs and audio recordings. The District Water Officer, as our intermediary with the rural communities, organized our field visits and co-facilitated some of the workshops.

The results we present in this paper are not from a single workshop but a collection of responses analysed from several conversations and discussions we have had as we worked with the participants in the several cycles right from conducting the needs assessment, design, deployment, feedback assessment and re-design. The interviews were transcribed by the lead researcher and thematic analysis [9] was applied to identify patterns within the collected data. The researcher generated codes and categorized them in terms of the AT perspectives as themes. The authors then established consensus on how to fit the different codes within the themes.

3.3.1 The Activity Checklist

The Activity Checklist is an analytical tool that is shaped by and developed to operationalize AT [21, 22]. It was developed as a guide on specific areas that highlight the context of use of a technology and intended to be applied in analysing how people use technology as a tool for mediation. It has four sections that correspond to the four main perspectives on the use of a target technology. The perspectives (summarised in Table 1) also translated into our main themes.

Table 1: AT Perspectives used to assess technology use within the context of a rural community

Perspective	Dimension
Means and ends	Extent to which users' activities are supported or constrained by the technology
Environment	Extent of integration into work practices with existing resources.
Learning	Extent of support of new ways of action
Development	Extent of positive changes triggered

- *Means and ends:* We analysed the extent to which the technology facilitated or constrains users to attain their goals. Under this theme, we looked at how the technology met the needs that users expressed, the problems faced while using it as well as how it supported their values as individuals and community.
- *Environmental Aspects:* This theme focused on the extent to which the technology was integrated with the requirements or community needs and existing systems. We further looked at the available resources and social rules to support and guide its continued use within the rural environment.
- *Learning and Articulation:* We examined the extent to which the technology supported the internalization of new ways of action (or working) and articulation of processes that were connected to participants' activities. Our focus was on the knowledge gains and forms of empowerment that participants got out from using the intervention and for participating in the study.

Table 2: Sample data extracts coded under specific themes informed by the AT perspectives on Technology use

Participant	Reactions
Theme 1: Means and ends	
Caretaker R:	People cannot say I cheat them because I show them records on the system.
Treasurer F:	When I access it fully, it helps me access all my people without having to go to their houses.
Caretaker V:	It helps me on record keeping and giving information to top officials
DWO2:	It can be hectic for some people because they were used to very simple phones but they are learning
Theme 2: Environment:	
CDS:	Seeing this innovation has made me reflect about financing rural water systems and I now have a different perspective how to support communities
DWO2:	We are here to advise and help them to work with the system
Theme 3: Learning:	
Caretaker S:	I am a pioneer and I go spreading it in other sub-counties like kibito and they learn from me.
Treasurer K:	I feel very proud that now I am like a consultant
DWO1:	I now expect people doing programs in this community to do the same, to consult with all stakeholders like here we have done.
DWO2:	I have seen these people are interested to put their own airtime to call their friends and they use the phones to pose (show off) because these are very good phones.
Theme 4: Development:	
Caretaker J:	The good thing in being involved in this I call it innovation is that first of all you own it.
NGO rep:	We are now able to interest and motivate water users to pay.
Treasurer S:	Water users are going to pay because we bring them a new system, the accountability and then for the phone. I can scare them that I am putting them on the internet if they don't pay.

- *Development:* We looked at the extent to which the use of the technology had caused any positive changes within the environment and its effect on the anticipated outcomes for individual participants and the communities. It is under this theme that the intangible impacts of the intervention were analysed.

In the following section, we describe our application of the AT checklist to structure and analyse the use of PM4W among the study participants.

4. FINDINGS AND DISCUSSION

AT provides a structure to code observations into the relevant themes. We categorized the patterns from the data collected into AT perspectives of *means, learning and articulation*, *environmental factors* and *development.* Table 2 shows sample data extracts coded under these specific themes.

4.1 Analysis

4.1.1 Means and ends

Support of Needs: The way in which people engage with technology is linked to the individuals' requirement to meet a need. Having a tool that supports users in meeting their needs of their work created a motivation for using the PM4W system. As the CDS highlighted, *"We see water sources breaking down and the committee chair says the money is not there, and then the people say no, we have been paying the money but the money gets lost, we don't know where the money goes because the accounting process has been very poor. But when we get such an electronic system that can take information to and fro and there is feedback, you can see the records and know who has not paid. I think this is a very big achievement we should be proud of."*

The users who actively used the system, that is, four caretakers and two treasurers, attributed their motivation to the relevance of the functionalities of the system. The system allowed them to register water users and log their financial transactions (including collections and expenditures) that were previously a challenge. Baerentsen and Trettvik [5] emphasize that the intention and conditions that directly relate to the attainment of the goal are consciously noticed by participants. Figure 3 is a summarized system log indicating the main features of the system that are frequently used, that is registration of water users (28.6%), view savings (19.5%) and adding sales that is, money collected from water users (18.4%).

Values: In the context of our work, we use the term 'values' to refer to what a person or groups of people consider important in life[1]. Our engagement with the communities revealed what people considered important to them and as such, they appreciated technologies that complemented and supported their value systems. Community water management structures are sustained through voluntarism [18] and will easily break down if trust and respect are lost. With regards to PM4W use, community members valued accountability and transparency of communal funds while the communal water managers valued their reputation. The water managers wanted their water users to trust them as this had direct implications on their positions within the communities. As caretaker B said, *"They will also see us as people who are not about cheating them. This thing when we are keeping someone's records and they come and sometimes you can easily show them how they have been paying, so you are not stealing his money. So it is a useful system."*

Trust within rural communities is very important and has not only been considered indispensable in such social relationships, but also a necessary ingredient in efforts geared towards collectively solving local problems [15, 16, 33].

Constraints: 90% of the participants were semi-literate in English that is, able to read and write (in English) on an elementary level. Although the use of English within the system had not been a problem in previous engagements with the communities, some

[1] http://www.oxforddictionaries.com/definition/english/value

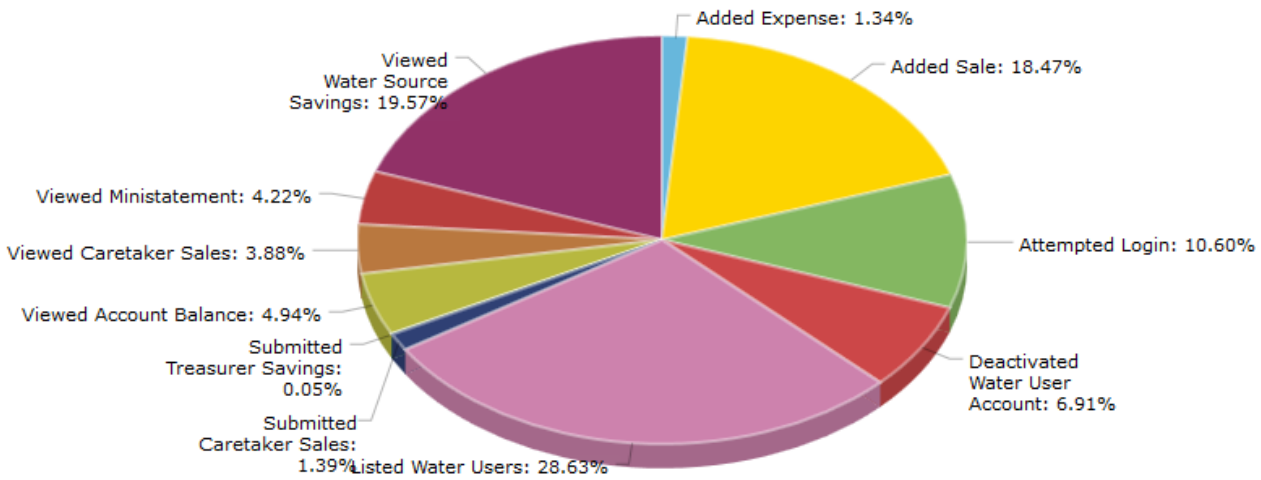

Figure 3: Summarized system logs showing the frequently used features of the PM4W system

participants attributed their minimal usage to the difficulty with the language. Furthermore, unstable communication networks resulted into infrequent use due to poor connectivity to log transactions. The language and connectivity challenges were easily mitigated through the implementation of a system version that was translated into Rutooro - the local language spoken by the communities in Kabarole district and the use of an offline database that automatically synched with the online database once connectivity was established.

For one community that was experiencing pipe renovations for all communal taps, there was no system usage for over 4 months since no fees were being collected and community members had resorted to alternative sources of water. The PM4W users in this community then appropriated the phones for other personal activities until the water supply was restored.

4.1.2 Environmental Factors

Structural/Institutional Support: The implementation of PM4W brought together different stakeholders mandated to support communities in managing their water supplies. The participation of the District Water Officers (DWO) and Community Development Specialist (CDS) who supervise and support communal water managers, allowed for reflections on how institutions could utilize technology and also support communities in using the deployed intervention. The CDS commented, *"Actually there has been in-depth thinking that I think anybody who is here has a different perspective about financing the water facilities."*

The involvement of key institutions within communities creates opportunities for institutional support of the technology implementation and possible integration of the intervention within existing community structures [42]. This makes sustainability of the intervention more achievable.

Several mechanisms existed within the communities that facilitated engagement of community leaders with residents for example, the monthly village meetings. The meetings are used by community leaders to bring community members together to voice their problems and discuss possible solutions. These interaction mechanisms have become spaces for continuous community engagement to further improve accountability and transparency measures, complementary to what the technology afforded the communities and PM4W users to do.

Resources: The biggest challenge with implementing community-based interventions is sustainability in terms of continuity in the face of poor infrastructure. This commonly translates into limited financial resources and intermittent connectivity. Poor connectivity had been countered through the use of an offline database that allowed users to load information when out of network reach which automatically synced when a connection is established.

The financial resources required to keep the system running involved the purchase of monthly Internet bundles and meeting the cost of charging the phones. Monthly, users spent $0.50 on mobile Internet bundles and approximately $2 on battery charging. Through our interactions with the PM4W users, we established that the participants were able to afford these costs as caretaker B said, *"Charging the phone is not a problem because I have been having my phone now I can put my sim card in the new phone. I can buy Internet to help me in connecting and coordinating one with another. I see most people here want to put their airtime to call their friends."*

Implementing a usable community based technology means that people can afford to use it with minimal (monetary) dependence on the researcher or implementer, otherwise it becomes unsustainable for the communities. Densmore [11] further emphasizes that finding a balance between cost and manageability of an intervention for users is part of recognising their needs and can lead to continued use.

4.1.3 Learning and Articulation

Knowledge gains: All the participants did not have prior experience with touch screen devices but got comfortable either through the training sessions with the researchers or from their own family members. Some participants explored the capabilities of the smart phones on their own and appropriated them to other activities for example, using photographs to show water facilities that have broken down or been repaired, recording of radio programs, to name but a few.

The mobile phones also created some form of respect for the participants within the communities. As some participants noted: *"we even use these phones to pose [show off] because they are good phones compared to the other ones [the basic feature phones]." "People are getting to feel proud of themselves now."* Family members of participants also gained rewards from these phones. For example a treasurer was helped to learn to use the phone by her son and in return, the son was allowed to use the phone for his personal communication not related to the activities for which the phone was given.

Empowerment: This can be seen in the form of enhancing people's abilities to make decisions as well as their access and management of resources[29]. Exposing people especially those not quite experienced to technology, like our participants, allows them to reflect on the technologies around them [38] and identify possibilities with the systems around them, be it technical or non-technical. The experience of caretaker S who also worked as a pump mechanic (repairs broken taps) was quite enlightening, *"since the system helps us manage finances for water, it can also be designed to help us find spare parts cheaply in neighbouring districts, so we don't have to wait for parts from Kampala [the Country's capital] where we take long to get them and they are expensive."* For this caretaker, using the PM4W system uncovered other possibilities of what technology can do and how it can be developed to facilitate his other activities.

Empowerment also came in the form of being able to critique existing structures and community leaders who were failing to support the water managers. A participant criticized a colleague who collected money but did not log any transactions, *"we disconnected defaulters but when I went to the village, I was told they have water. When I asked for the receipt, they said our person collected money and reconnected them."* Using the system partly forced participants to be accountable since community supervisors like board treasurers have access to the payment records. As noted by Shrivastava and Battacherjee [41], ICTs can contribute to the creation of an atmosphere of transparency and openness that helps to identify corrupt behaviour.

The participants also used the technology as a way of scaring community members into paying their water fees. This can be easily interpreted as manipulation but to some of the water managers, it was the only way they could get perpetual defaulters to pay their contributions. Two participants said: *"They see the phone and fear that if they refuse to pay, I am going to put you on the Internet."*[Treasurer S]

"When they see the messages reminding them to pay instead of us going to their home, they get scared and start paying." [Caretaker J]

Mobile phones have become tools that mediate community practices [25] (pp. 109) especially regarding information sharing. Some researchers have however identified these same devices as ways of introducing inequalities. Like Sen [40], we acknowledge the potential negative impacts of technology within communities but in general, we assert that mobile phones as shareable technologies increase freedoms and capabilities of not only the phone owner but to all those that benefit from them through their use.

4.1.4 Development

In the context of our research, we approached this theme from the perspective of positive changes both in the communities and in the lives of the individual study participants.

Changes: As participants reflected on their experiences in using the technology, we observed the changes in the way they cooperated with each other and viewed the technology.

- Increased community interaction: the implementation of PM4W brought together all stakeholder groups based within the communities. During several workshops, information about challenges within the three different communities was shared. Aspects such as what was working well and how the others could best deal with their challenges were discussed. This participatory space also provided the service providers (like the DWO and NGO representative) the opportunity to know what communities struggled with and together, build consensus on how to improve delivery of water services and exploit the intervention to manage financial information.

- More positive attitude towards ICT intervention: A number of ICT interventions had previously been implemented in these communities in several sectors like health, agriculture and education. However, because the local people were never consulted prior to the deployments, there had been some resentment about technology and its lack of focus on what the communities considered priority. With the development approach of the PM4W tool, participants' attitude towards technology improved when they saw themselves important and relevant, as one caretaker said, *"I feel very proud that now I am like a consultant."* In addition, the DWO was able to critique other technology implementation approaches that didn't involve users as much as he commented, *"I now expect people doing programs in this community to do the same, to consult with all stakeholders like here we have done."*

- A better sense of connectedness: Community water managers were now working more closely in monitoring communal water finances and demanding accountability from each other. With information becoming more accessible, treasurers were working better with caretakers to ensure that all water users were registered and that monthly collections matched up with total numbers of households attached to a communal water source.

- Improved personal relationships: Even though mobile technology has penetrated rural areas like in our study communities, all participants were new to the use of smart phones and were assisted by family members in addition to the facilitated training we provided. These devices have become shared resources between different family members and are being used for personal communication and other services such as, accessing mobile (money) payment services that allow rural dwellers to receive money from relatives living in the towns.

Outcomes: Our expectation was that in using the ICT intervention, communities and participants would experience social transformation through technology access, improved information access and management and eventually integrate the technology into their work practices. In so doing, we hoped that supporting these activities with a technological intervention

would lead to improved functionality of communal water sources and therefore into better access to water. However, the findings at this point reveal that there have been more individual gains than community gains. For the participants, the gains have been in the form of learning new ways of using mobile phones and articulating their needs and experiences. For the community members, it has to a small extent allowed them to get more accountability and transparency from their water managers. This has been achieved through monthly SMS notifications that are sent to water users (through the contact of the head of each household) with information on how much money has been collected and spent.

4.2 Perceptions and Motivators of Technology use in Rural Communities

Engaging with participants in their community settings reveals patterns of thought and social relationships that are relevant to successful technology deployment and use. These observations have contributed to our understanding of what motivates people to use the technologies deployed within rural communities.

We use the term 'perception' to refer to one's understanding and interpretation of something as a result of experience[2]. Perception is therefore drawn from knowledge that is only acquired through learning. We have found that human activity and perception are inherently integrated in and adapted to the environment. Participants have picked up information within their environment and from their activities and have drawn up possibilities and potential constraints to technology use in terms of what they can do and perceive to be able to achieve with the artefact. For example, in using the intervention to manage financial information, those who repair broken water taps or pipes have been able to see the possibility of extending the functionality of the system to connect them to suppliers of spare parts.

The experience of an intervention is associated with individuals' perception of it and will determine what they will do with it, that is, to either accept it or not. When participants understand or appreciate a system or its feature, they will frequently use it but stay away from features they do not appreciate. For example, the most used features of the PM4W application include *registration of water users* and *sales* while the least used is *logging expenses.* An awareness of what the community needs are will quickly translate into expected or anticipated outcomes and users will tend to focus more on the functionalities that meet those needs.

The PM4W intervention is appreciated for the convenience it affords in providing information on water users and financial collections. At the same time, it is considered instrumental in improving the reputation of the water managers as trust is rebuilt with community members through accountability.

The technology has created a sense of responsibility, making users to be consciously aware that other people have access to the information they provide. They think of it as a monitoring tool that can be used by community leadership to either discredit them or approve their work.

The appropriateness of the technology is a motivator for technology use. The user, not the developer, defines appropriateness. The requirements for technology in rural areas are very specific – too modern a technology brings additional burden that is not useful and side-tracks from the actual requirements. The main focus of the rural users we worked with was having their water management needs met. Such needs could include access to information directly or indirectly linked to their work and communication with other community members or family members.

Technology appropriation is not only considered a significant step towards acceptance, but a sign that users are comfortable to adopt it. Our approach is therefore to not push for adoption of a technology but allow for appropriation and let users define their own ways of using the technology. This then allows us to learn more about our users and their changing needs, thus opportunities to re-design the tool.

Lastly, it is important to actively engage and consult with users throughout the technology implementation process. In our study, we observed that involving users contributed to acceptance and use of the technology. As treasurer B commented, *"People are eager to perform their work because they have seen themselves as important as well for having to be considered people to start with this system as pioneers, and I hope our people shall be cooperative."*

User engagement has further created a sense of ownership within the communities and participants have taken it upon themselves to teach others outside our study communities about the PM4W tool. We have had people who are not part of our study group come into the community workshops to learn about the system. Furthermore, with the user engagement and ownership, we can be certain that participants will be willing to sustain the intervention within their communities if their local institutions support them.

4.3 Reflections on the use of Activity Theory

The motivation for using activity theory was the need to go beyond how people use technology and uncover motivations for and attitudes to technology use. The different perspectives that the theory informs through its principle of *artefacts as tools for mediating activities* provided a basis for analysing participants' activities in relation to the technology.

In analysing the specific AT perspectives as themes, we were able to reflect on the usefulness of the tool from the viewpoint of users, the support that the environment was capable of providing to ensure continued use and the new ways of action and articulation experienced by the users. In discovering what people did with the technology, we were able to uncover their attitudes towards technology and the factors that influenced their use of the technology in ways that were at times different from what was intended.

Activity theory provided the flexibility of looking at the different aspects such as: the context in which the technology was being used, the technology itself, the activity that was being supported and the users. Other frameworks that are used to evaluate how users interact with technology do not collectively consider these aspects. This therefore made using activity theory as a framework appropriate for our study.

Although activity theory has been used in a number of studies to design and evaluate technologies, none has specifically applied the framework (and or the checklist) to uncover human attitudes as a result of perceptions of technology as shaped by experiences with technology in rural environments.

[2] http://www.merriam-webster.com/dictionary/perception

4.4 Future Work

While our broad study focuses on community engagement in technology design, our current results as presented in this paper focused more on the water managers directly using the PM4W tool. The project being a community intervention was aimed at contributing to community development. Since there is a deep connection to community practices, it is important to study the implications of the intervention (and the key activities it supports) on the communities as a whole. Our next steps will therefore entail expanding our focus groups and interviews with the wider community members who are considered beneficiaries of the project. We will then be able to extend the community level assessment (from our analytical framework) to include the analysis from the community perspectives.

5. CONSEQUENCES AND CONCLUSION

The introduction of ICTs into rural communities should create a new level of consciousness of what the technology or the implementation process can offer to the individuals and the communities. In understanding how rural people use implemented technologies, we are better placed to shape expectations on Community-based ICT implementations.

In this paper, we have used activity theory as a framework to extract principles for practice rather than as a method. Our approach to this framework focused on the mediation capability of an ICT intervention. The analysis of our findings shows that the use of such a mediating artefact can change the types of activities in which technology users engage due to the capabilities the technology provides.

It is important to know that environments and needs for which interventions are developed and used change. We certainly cannot design for appropriation because it is quite difficult to envisage the different ways people will domesticate or improvise with the technologies we give them. However, in allowing users to adapt technology to their way of life, ownership is established as users acquire a sense of control and agency. Therefore, as technology implementers, we can support users to explore possible uses as opposed to controlling use, and allow them to attach their own meaning to the technologies we give them.

Lessons from technology appropriation provide opportunities to re-design tools and support discovered uses or needs of technology. We therefore recommend that designers be open to the unintended uses of the technologies they introduce into communities. In addition, funders of community – based ICT projects should broaden their scope of understanding and evaluating impact of interventions beyond the intended pre-defined development outcomes.

We have applied activity theory in a rural technology space as our contribution to the ICTD body. We hope that other researchers implementing technologies within communities can appropriate activity theory to uncover the motivators of technology use and report on their findings.

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7. REFERENCES

[1] Akah, B. and Bardzell, S. 2010. Empowering products: personal identity through the act of appropriation. *CHI'10 Extended Abstracts* (2010), 4021–4026.

[2] Andersson, A. and Hatakka, M. 2013. What are we doing? - Theories used in ICT4D research. *12th International Conference on Social Implications of Computers in Developing Countries, Ocho Rios, Jamaica* (2013), 282–298.

[3] Ashok, A. and Beck, C. 2007. Using Activity Theory to Develop a Design Framework for Rural Development. *CHI 2007* (2007), 2255–2260.

[4] Avgerou, C. 2010. Discourses on ICT and development. *Information Technology & International Development*. 6, 3 (2010), 1–18.

[5] Baerentsen, K.B. and Trettvik, J. 2002. An Activity Theory Approach to Affordance. *NordiCHI 2002* (Aarhus, 2002), 51–60.

[6] Bardram, J. and Doryab, A. 2011. Activity analysis: applying activity theory to analyze complex work in hospitals. *Proceedings of the ACM 2011 conference on Computer supported cooperative work* (2011), 455–464.

[7] Baumer, E.P.S. and Tomlinson, B. 2011. Comparing activity theory with distributed cognition for video analysis. *Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11*. (2011), 133.

[8] Blake, E.H. et al. 2014. Towards communication and information access for Deaf people. *South African Computer Journal*. Special issue on ICT and development (2014), 10–19.

[9] Braun, V. and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 3, 2 (2006), 77–101.

[10] Cai, T., Chiwasa, H., Steinfield, C. & Wyche, S. 2015. Participatory videos for smallholder farmer training in Malawi: an analysis of knowledge gain and uptake. *ICTD'15* (2015).

[11] Densmore, M. 2012. Claim Mobile: When to Fail a Technology. *SIGCHI Conference on Human Factors in Computing Systems* (2012), 1833–1842.

[12] Dix, A. 2007. Designing for Appropriation. *Proceedings of the 21st BCS HCI Group* (2007), 27–30.

[13] Ferreira, P. 2015. Why Play? Examining the Roles of Play in ICTD. *Aarhus Series on Human Centered Computing* (2015), 12.

[14] De Freitas, M.R. and Byrne, E. 2006. Activity Theory As an Analytical Tool: A Case Study of IS Development for an Anti-retroviral Treatment Clinic in South Africa. *SAICSIT 2006* (2006), 90–99.

[15] Gopakumar, K. 2007. E-Governance Services Through Telecenters : The Role of Human. *Information Technologies and International Development*. 4, 1 (2007), 19–35.

[16] Greider, T. et al. 1991. Local Identity, Solidarity, and Trust in Changing Rural Communities. *Sociological Focus*. 24, 4 (1991), 263–282.

[17] Hamel, J.-Y. 2010. *ICT4D and the Human Development and Capabilities Approach*. Technical Report #37. Available: http://hdr.undp.org/sites/default/files/hdrp_2010_37.pdf

[18] Harvey, Peter, A. and Reed, Robert, A. 2006. Community-managed water supplies in Africa: sustainable or dispensable? *Community Development Journal*. 42, 3 (2006), 365–378.

[19] Hasan, M.M. 2015. ICTD Systems Development : Analysis of Requirements Elicitation Approaches. *ICTD'15* (Singapore, 2015), 1–4.

[20] Heeks, R. 2007. Theorizing ICT4D Research. *Information Technologies and International Development*. 3, 3 (2007), 1–4.

[21] Kaptelinin, V. et al. 1999. The Activity Checklist : A Tool for representing the "space" of context. *Interactions*. July-August (1999), 27–39.

[22] Kaptelinin, V. and Nardi, B. 2006. *Acting with Technology : Activity Theory and Interaction Design*. The MIT Press.

[23] Karanasios, S. 2014. Framing ICT4D Research Using Activity Theory : A Match Between the ICT4D Field and Theory ? *Information Technologies & International Development*. 10, 2 (2014), 1–17.

[24] Kleine, D. 2010. ICT4What? – Using the Choice Framework to operationalise the Capability Approach to Development. *Journal of International Development*. 22, 5 (2010), 674 – 692.

[25] McCarthy, J. and Wright, P. 2004. *Technology as Experience*. MIT Press.

[26] McNely, B.J. et al. 2012. Articulating Everyday Actions: An Activity Theoretical Approach to Scrum. *30th ACM International Conference on Design of Communication, SIGDOC '12, Seattle (WA), USA, 3-5 October, 2012* (2012), 95–104.

[27] van der Merwe, T.M. and van Heerden, M.E. 2013. Ease of use and usefulness of webinars in an open distance learning environment. *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference on - SAICSIT '13*. (2013), 262.

[28] Miettinen, R. et al. 2009. Re-Turn to Practice: An Introductory Essay. *Organization Studies*. 30, 12 (2009), 1309–1327.

[29] Mthoko, H. and Khene, C. 2015. Assessing Outcome and Impact : Towards a comprehensive evaluation approach in ICT4D. *ICTD'15* (2015), 4–7.

[30] Nath, P. 2014. *ICT for Economic and Social Transformation: An Empirio -Theoretical Review of Indian Initiatives*. Technical Report #4. Avaliable at: http://www.jnu.ac.in/SSS/CSSP/CSSP-EWPS-4.pdf

[31] Neto, G.C. et al. 2005. Integrating activity theory and organizational modeling for context of use analysis. *Proceedings of the 2005 Latin American conference on Human-computer interaction - CLIHC '05* (2005), 301–306.

[32] Nihra, M. et al. 2014. Using Activity Theory as Analytical Framework for Evaluating Contextual Online Collaborative Learning. *International Journal of Emerging Technologies in Learning*. 9, 5 (2014), 54–59.

[33] Oxendine, A. et al. 2003. The importance of trust and community in developing and maintaining a community electronic network. *International Journal of Human-Computer Studies*. 58, 6 (Jun. 2003), 671–696.

[34] Pal, J. et al. 2013. Marginality, aspiration and accessibility in ICTD. *ICTD'13* (2013), 68–78.

[35] Petersen, M.G. et al. 2002. The usability of everyday technology: emerging and fading opportunities. *ACM Transactions on Computer-Human Interaction*. 9, 2 (2002), 74–105.

[36] Ramachandran, D. et al. 2007. Social dynamics of early stage co-design in developing regions. *Proceedings of the SIGCHI conference on Human factors in computing systems (CHI'07)* (2007).

[37] Rogers, Y. 2012. HCI Theory: Classical, Modern, and Contemporary. *Synthesis Lectures on Human-Centered Informatics*. 5, 2 (May 2012), 1–129.

[38] Rogers, Y. et al. 2014. Never Too Old: Engaging Retired People Inventing the Future with MaKey MaKey. *CHI 2014* (2014), 3913–3922.

[39] Sen, A. 1999. *Development as Freedom*. Oxford University Press.

[40] Sen, A. 2010. The Mobile and the Web [Special Edition Harvard Forum Essays]. *Information Technologies & International Development*. 6, (2010), 1–3.

[41] Shrivastava, U. and Bhattacherjee, A. 2015. ICT as a Corruption Deterrent : A Research Note. *ICTD'15* (2015), 1–5.

[42] Ssozi-Mugarura, F. et al. 2015. Designing for Sustainability : Involving Communities in Developing ICT Interventions to Support Water Resource Management. *IST-Africa 2015 Conference Proceeding* (2015), 1–8.

[43] Tabassum, G. and Yeo, A.W. 2015. Measurement of Tangible and Intangible Impacts of Telecentres on Rural Communities. *ICTD '15* (New York, New York, USA, 2015), 1–4.

[44] Yafi, E. et al. 2015. ICT's Impact on Youth and Local Communities in Syria. *ICTD'15* (2015), 10–13.

[45] Yoo, D. et al. 2013. A Value Sensitive Action-Reflection Model: Evolving a Co-Design Space with Stakeholder and Designer Prompts. *CHI 2013* (2013), 419–428.