The Role of Outcome Mapping in Developing a Rural Telemedicine System

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Abstract: We describe the use of Outcome Mapping to guide the design of a rural telemedicine consultation system in South Africa. While Outcome Mapping was not primarily intended to guide design, we show that it tied in well with a cyclical participatory design method for an Information and Communication Technology for Development project.

Keywords: ICT design methodology, telemedicine, telehealth, Outcome Mapping, Action Research, Iterative Software Engineering, ICT for development

1. Introduction

We have been iteratively evolving a telemedicine consultation system for rural hospitals and clinics in a remote part of the Eastern Cape in South Africa (see Figure 1) over a period of four years [7][8][9][15][20]. Our aim is to enable the nurses at clinics to treat a wider range of problems locally by consulting with hospital doctors whom they normally never meet nor speak to. The system, called MUTI, enabled nurses and doctors to use a wireless communication system to contact one another. Another goal of this Information and Communications Technology for Development (ICT4D) project was to stop unnecessary travel by patients from the clinic to the hospital, as transport in these poverty-stricken and geographically dispersed areas was difficult and expensive for local people.

As we expected, integrating new technologies into people's everyday work lives was not straightforward or easy. The system had to cope with technical issues, e.g., frequent power outages, and with social issues, e.g., the fact that the doctors and nurses were so busy they barely had time to use the system.

The overall aim of our various ICT4D projects was to investigate methods of creating useful systems for socio-economic development in deprived areas [2]. This was essentially a design problem. One aspect of our strategy was to experiment with Monitoring and Evaluation (M&E) tools in ICT4D design, but this is not their intended use. The advantage of such tools is their focus on development issues and their sophistication in evaluating impact, sustainability and so forth. In related work, we also used the Real Access/Real Impact criteria of bridges.org [3], done in collaboration with the bridges.org NGO and their consultants [4]. In this paper we focus on the *Outcome Mapping* method [11] developed by the IDRC[1] in a project partly funded by the IDRC and assisted by their experts.

The problem with using M&E tools for design is that they do not provide design guidelines. One relatively easy way to begin to incorporate such tools in design projects is to use them in the evaluation of one of the cycles of modern iterative and agile software design

[1] The International Development Research Centre (IDRC) is a Canadian Crown corporation that funds developing countries to find solutions in science and technology for the problems they face; see www.idrc.ca.

Figure 1. Rural environment in the Libode District Eastern Cape of South Africa

Villages are spread out for kilometres. Most homes are traditional rondavels constructed with a circular mud wall (now mixed with cement) and a thatch roof. Almost no one has electricity or running water. The Lwandile clinic is in the centre of the picture, behind the rondavels.

methods [13], or equivalently in the evaluation phase of an action research cycle [2]. That still does not remove the fact that such tools do not really give the ICT designer assistance such as, for example, design patterns. More subtly, from the point of view of an ICT designer, M&E tend to treat ICT in a static fashion and not as something that is easily mutable and adaptable. This means planning incremental adaptation is more difficult. Mutability is a very important to a designer: it is a great boon in that the technology is essentially a universal enabler of solutions, but it is a curse as well in that the design options are so wide and ICT designers need methods to circumscribe the design space.

We view ICT for Development projects as projects aiming to make a positive change in the society and our approach is based on Action Research ideas merged with those from Software Engineering [2]. We do not believe that "Change Management" as it has evolved to become a tool of dealing with change in the developed world is effective in our situation. In a sense we have gone back to the roots of change management in the works of Kurt Lewin (one of the pioneers of Action Research) and chosen a more people orientated view.

1.1 Introducing Experimental Telemedicine Systems into a Region

We wanted to learn how to develop a usable and sustainable system which fitted into the social context of its use. We first gained the approval of local community leaders and both regional and provincial Department of Health managers. Rural WiFi networks remain legally problematic in South Africa. Our goal is to influence national policy to "open up" these technologies for empowerment of disadvantaged people across the country [6]. We adopted the terms *First Mile* and *First Inch* as a battle cry to place the users first and to think firstly of how they actually use the system. The term *First Mile*[2] has gained wider currency as a way to turn around the telecom approach where the line to the subscriber, the local loop, was referred to as the *Last Mile*. The term *First Mile* reversed that form of thinking where the user was placed last in the planning of the system. The *First Inch* was the user interface to the system, a place where meaningful access can also break down.

Telemedicine has long been proposed as a way of overcoming relative underdevelopment of rural areas ([5], [14] and recently [12]), coupled with wonderment at its slow "normalization" [16]. Telemedicine has had a number of definitions [19] but the basic idea is the provision of health care where interaction is mediated by ICT. A useful distinction is

[2] The term was originated by the Zimbabwean poet and development worker Titus Moetsabi in 1997 [17].

made in telemedicine between two different delivery methods [1][19]: (A) With *real-time* or *synchronous* telemedicine, communication between participants happens at the same time, e.g., a video-conference. This requires reliable communications with relatively high bandwidth. (B) With s*tore-and-forward* or *asynchronous* telemedicine, information is recorded in digital form by the sender and sent to the receiver who can view it at a convenient time. This can deal with communication interruptions and lower bandwidth.

2. Application of the Outcome Mapping Methodology

Our research programme employed a modified action research approach to learn how to develop an appropriate technical system and also to learn how to support the stakeholders to participate in the system's design and deployment [2]. We paid a great deal of attention to the human computer interface with a user-centred development approach [15]. We used the participatory M&E tool *Outcome Mapping* (OM) to evaluate the development of our system in conjunction with other tools. OM, our focus here, recognizes that "development is essentially about people relating to each other and their environment" [11]. This accords with our own participatory approach to ICT design.

The first step in OM is to state the intentions or *vision* and *mission* of the project, and then to identify the people involved in the project who are affected by its outcomes. These are called *boundary partners* and one then identifies the desired changes in their relations and behaviour that we set out to achieve. These are called *progress markers*. The vision and mission can be summarized as: enhancing rural healthcare provision with ICT, developing the system together with healthcare professionals, and enabling a sustainable system.

The primary boundary partners were the direct users of the system: doctors and nurses at the hospital, and nurses at the clinic, all with similar progress markers (see Table 1).

Table 1. Progress markers for doctors and nurses

Boundary partner	*Doctors and nurses*
Outcome challenge	To support healthcare professionals to use IP-based communication as a part of their everyday work processes.

	Data collection method
Expect to see:	
1. Use MUTI to make real-time calls (laptop)	MUTI system logs
2. Make weekly appointment for MUTI meetings	Check appointment book
3. Use MUTI to send messages (iMate)	MUTI system logs
4. Call TransCape if there are MUTI problems	MUTI system logs
Like to see:	
5. Tell us what they like about MUTI	Interviews and focus group discussions
6. Tell us what they do not like about MUTI	
7. Tell us what we can change to improve MUTI	
8. Follow up on patients referred to/from the hospital	OK
9. Contact doctor for medicine	MUTI system logs
10. Contact doctor for lab results	MUTI system logs
Love to see:	
11. Prefer MUTI rather than cell phone	System logs & interviews
12. Better treatment for patient	Interviews and focus groups
13. Good relations between nurses and doctors	

Other boundary partners included:

- Clinic managers who drive from clinic to clinic in the district;
- The hospital manager at Canzibe hospital, responsible for staff at the hospital only;
- Libode District Department of Health management: CEO, district manager, and others;
- Support team at the Transcape NGO who supported the project in the field;
- ICASA, the national communication regulator; and
- The research group itself. We wanted to continually critically reflect on our own behaviour and have our operations externally evaluated, e.g., by bridges.org [4].

We prioritized our interaction with the nurses because they were the least familiar with ICT in general. If the nurses did not use the MUTI system, it simply would not be used. The strategies are mechanisms to encourage the nurses to use the system more often. The strategy map (Table 2) shows several strategies targeted to the nurses (I-1, I-2 and I-3) and the overall environment (E-1, E-2 and E-3). We tried very early to get their feedback into the system design process. This was more difficult than it sounds. The nurses were not confident with ICT, and perhaps did not feel that they actually knew enough to offer criticism or suggestions. To build confidence, Transcape sent a Xhosa-speaking woman to train the nurses on a weekly basis and make the technology less intimidating to the nurses.

We also tried to engage the nurses' managers about the project but were not very successful in this regard. Of all of the boundary partners, the clinic managers were the ones we had the least amount of contact with. We therefore placed much of the burden on the doctors to be responsive to the nurses when they did use the system.

There is a rather large gap in the strategy map as we leap from the users and their managers to the wider environment. The goal was for the wider environment to exert some influence on the nurses to be more open to participating in the development process.

Table 2. Strategy map for the clinic nurses

Causal	**Persuasive**	**Supportive**
I-1	***I-2***	***I-3***
Paper prototyping to learn to construct better interfaces	Train nurses to use software and ICT in general	Training supplied by local NGO on a weekly basis
Interviews to get feedback	SMS the nurses to follow up	Update management
E-1	***E-2***	***E-3***
Managers make MUTI a part of the job description	Academic and industry conferences and journals	Engage Transcape NGO
ICASA legalizes rural WiFi	Publish information on web	Engage doctors

3. Technology Design

We were introduced to rural telehealth by the CSIR who had built a real-time voice system over a rural WiFi network and installed PCs and VoIP handsets in a hospital, clinic, school and police station [10]. Our MUTI system was developed over several long-term iterative cycles, with a particular version corresponding to each action research cycle. Each cycle included an OM progress marker evaluation exercise. The goal was to use OM to inform the next design cycle and its subsequent technology intervention. The rest of this section is organized according to the MUTI versions deployed.

3.1 MUTI v1

We built the first version of MUTI for the Sulenkama hospital and Tsilitwa clinic in the Qumbu district in 2004 based on our evaluation of the CSIR system. We observed that the

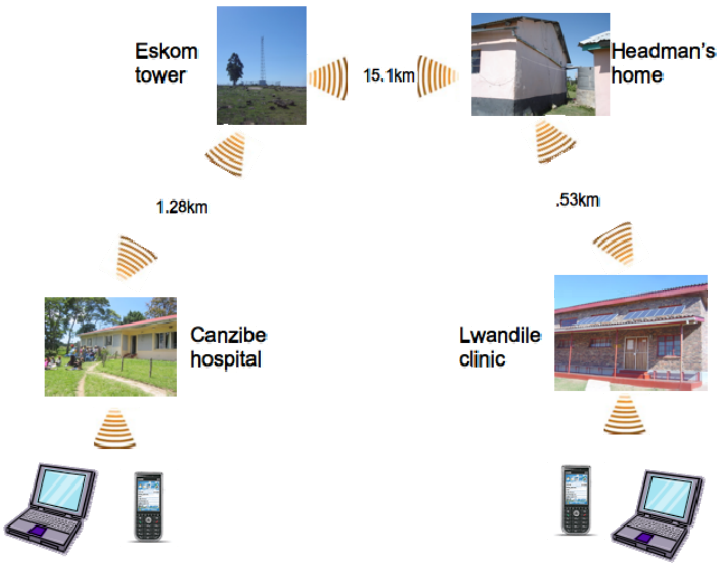

Figure 2. Canzibe/Lwandile network diagram

This rural wireless network connected Canzibe hospital to Lwandile clinic, roughly 15km apart. Because the hilly terrain prevented line-of-sight, we built two secure intermediate relay stations.

network was frequently down due to power outages, malfunctioning UPS, vandalism, etc. We took the wireless network as given and provided a new telehealth system to deal with these shortcomings. MUTI v1 provided synchronous voice, and asynchronous text, voice and images. This essentially gave the users a store-and-forward interface rather than a real-time one. We ran MUTI v1 on laptops (not the PCs installed by the CSIR) chosen to maximise battery life to overcome some of the problems with power supply.

Outcome mapping revealed that the user interface was not very user friendly. It was difficult to train the nurses to use MUTI. Even when they did use the software, the doctor hardly ever answered because the laptop (as well as the CSIR PC) was locked up in a room in the hospital. The doctor was alone, and did not have the time to answer any calls anyway. We had hoped they would use the asynchronous (store-and-forward) messaging facility because of this. They used it, but not very often.

Near the end of 2004 the MUTI project relocated to another site to prevent confounding the results from the CSIR and MUTI studies. This also allowed the establishment of a different network infrastructure.

3.2 MUTI v2

Based on our initial experience we continued work on the MUTI system in 2005 in the Libode district. We built our own WiFi network based on the CRCNet model [18] — see Figure 2. This network connected Canzibe hospital to Lwandile clinic, roughly 15km apart as the crow flies, but on the road it was more than 30km and took over an hour by 4x4 (it could take 3-4 hours with local transport). The wireless 802.11b links were enhanced for longer distances. Because the hilly terrain prevented line-of-sight, we built two intermediate relay stations. All four units use a low voltage router board running Linux. We put Access Points at each end, effectively creating hotspots for mobile laptops and WiFi handsets.

The power issues were similar to the first site. The hospital had mains power with a backup generator. The Lwandile clinic was a completely solar site. We chose to continue deploying MUTI on a laptop because of long battery life. MUTI v2 provided synchronous and asynchronous communication in text, voice and video.

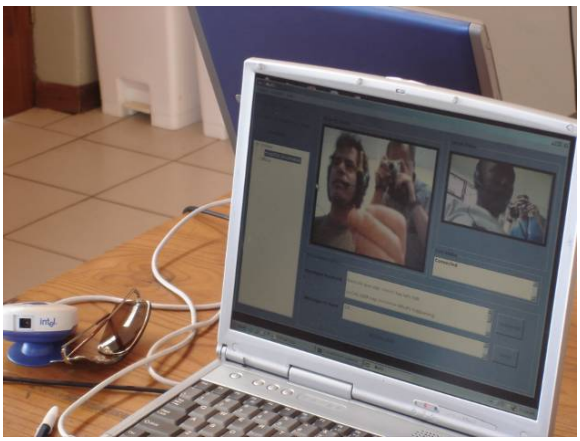

Figure 3. (a) MUTI v2 on a laptop with video

The development team installing and testing out the real time video component for the first time (hence the camera in the photo!).

(b) v3 on a WiFi-enabled GSM cell phone

MUTI software on a mobile phone handset — all of the peripherals from the laptop are all neatly integrated into this leading edge device.

The partners become more involved in the system design: the nurses suggested that we provide thumbnails for both voice clips and images in the store-and-forward messages; while the hospital manager suggested using the system for reporting test results.

Outcome Mapping revealed that the interface was slightly improved, but was still not very easy to learn or use for the nurses (see Figure 3a). The doctors, while pointing out numerous deficiencies, were nevertheless able to use the system. Because the clinic had no other form of communication at the time, the nurses used the real-time voice and video functions the most. By early 2006 we realized that the nurses were not using the asynchronous functionality purely because of interface difficulties. We learned that the peripherals caused many problems, e.g., orienting the web cam to get a good picture, or fumbling with the microphone headset. Users ended up only plugging in the microphone and using the built-in speakers in order to hear the ring for a call. The doctors answered the synchronous calls when they could, but they were usually quite busy, and there was only one laptop kept in one doctor's office.

3.3 MUTI v3

Because of the feedback regarding the interface on the laptop, we ported the store-and-forward functions to a WiFi handset for MUTI v3 (see Figure 3b). We also wanted to port the real-time component to the handset but at the time, open source real-time development libraries on mobile handsets were only starting to appear. Just for clarity: although the platform is a mobile phone, its WiFi capability allowed us to port the essentials of our existing laptop based system to the phone.

Outcome Mapping revealed that the store-and-forward functionality was a good fit. All of the peripherals from the laptop (microphone, headphone, camera, video, even Bluetooth and WiFi) were all neatly integrated into one device. Combined with the fact that cell phones were already part of everyday rural life, the cell phone was an attractive platform for the First Inch — the user interface.

The user interface was greatly improved and resembled SMS text messaging. The nurses were already familiar with SMS on cell phone handsets, and found the handset much less intimidating than the laptop PC. Unfortunately the battery life did not compare with the laptop. The handset consumed the battery rapidly when the WiFi was turned on. Our software attempted to manage that by automatically turning it on and off when needed. The

handset still functioned as a normal GSM phone, and the nurses could either use that, or the MUTI v2 system on the laptop to make a voice call.

4. Results and Discussion

As mentioned this paper is concerned with the development of a telehealth application and with the extent that Outcome Mapping was able to assist us in that process. We now examine how the various partners and their behaviours affected the project's outcomes.

Long term engagement with users and NGO. Our approach was to get new research ideas directly from the participants. We found that the longer we were involved with the users, the more comfortable they became with the technology, and with us. This enabled them to make informed suggestions to us, ones that we could follow up on. It turned out, however, that most of the suggestions came from the Transcape NGO. They dealt with the users on a regular basis while providing technical support. Transcape became the surrogate champion of our cause because a firm champion did not emerge in the user community.

Making friends in the community. Getting to understand the local social environment was very difficult: we were not resident at the site, nor did most of the research team speak the local language, Xhosa. We were very fortunate in 2004-2005 to have a native Xhosa speaker as a research student who came from a similar rural area. The Xhosa-speaking users and boundary partners found it easier to communicate with him. He was also instrumental in pointing out cultural customs, e.g., to grasp your elbow when shaking the hand of a respected elder. We also set aside a significant amount of time to socialise with the foreign doctors, and especially our local support staff. We have become genuine friends. Because of this friendship, we found the information flowed very openly.

Obtaining the support of the next highest power. We found the higher power on the chain of boundary partners to be supportive, but distant. We therefore focussed attention closer to the bottom. We visited with the hospital manager every visit, kept her posted, and asked for her advice. But at the district and provincial levels, we were not able to get them actively involved. They did, however, attend periodic group meetings.

Continuous assessment and (re)design. Our methodology was based on iterative cycles. We revised the software on a regular basis, and one can see that embodied through three versions of MUTI thus far. We have revised the OM intentional design recently, and will continue to do so as we learn more about the social and technical aspects of the project.

Engaging in organizational reflection. As we are a boundary partner ourselves, we often reflected on how to change our own behaviour. One example was that we tried to stay longer in the field. This enabled us to build stronger bonds with our users and boundary partners. We also went through external evaluation to learn how to better incorporate best practise into our research efforts. As computer scientists, we spent the past several years using this project as a vehicle to learn how to build a methodology that examined ICT within the local South African digital divide context. Just as we revised our software, we also revised our "socially aware" methodology as we gained more experience in the field.

5. Conclusion

The MUTI system offered the capacity to handle a range of communication between users including text, voice, pictures and video. From Outcome Mapping data collection, we found that for the most part the users preferred to use real-time voice or VoIP. The second most used function was real-time video. Since we only recently introduced MUTI v3 on the WiFi handhelds, we must wait and see what happens.

The system was designed in an exploratory fashion employing monitoring and evaluation tools such as Outcome Mapping to help in the design process. This was instrumental in

focussing our attention on all of the partners whose cooperation was needed to make the project successful. The engagement of the partners brought them into the design loop.

Software design is normally concerned with the more immediate users of the system but even there one has to have the backing of all boundary partners for the system to be effective. In that way, Outcome Mapping encouraged a wider perspective on the design aspects of the rural telemedicine system.

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