Repair Worlds: Maintenance, Repair, and ICT for Development in Rural Namibia

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ABSTRACT

This paper explores the nature and centrality of maintenance and repair ('M&R') work in the extension and sustainability of ICT infrastructure in the global South. Drawing from pragmatist traditions in CSCW and the social sciences at large, we develop a concept of 'repair worlds' intended to map the varieties and effects of such maintenance and repair activities. Empirically, our analysis builds on ethnographic fieldwork into local practices of maintenance and repair that have accompanied and supported the extension of mobile phone and computing infrastructure in the Kavango region of northeastern Namibia.

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Maintenance, repair, infrastructure, theory, ethnography, development, ICTD.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Management, Theory.

1. INTRODUCTION

This paper explores the centrality of maintenance and repair work in the ongoing project of building robust, appropriate, and sustainable ICT systems in countries of the global south – a project to which CSCW has much to contribute. It also argues that CSCW has much to (re)learn in this process: about the nature and variability of socio-technical activity (especially as played out over cultural and infrastructural difference); the work required to sustain and adapt systems over time (including beyond initial moments of design and adoption); and the distinctively different worlds of design and practice that appear to us when we take erosion, breakdown, and decay ('broken world thinking') rather than novelty, growth, and progress as our starting point.

This perspective runs somewhat counter to the way we usually approach questions of design and development, in both CSCW and the ICT and development (ICTD) fields. Most accounts of ICT and development have emphasized encounters between organizations, communities and technologies at the front end, emphasizing pathways, patterns, and problems that accompany the introduction of (new) technological forms to (new) geographic and cultural communities. ICT-related development statistics and studies have long reflected this bent. We keep track of figures like ICT penetration, adoption, and diffusion, but rarely breakdown or abandonment. We capture statistics on cell phones purchased, but rarely cell phones discarded. We study how communities embrace or adapt to new technologies, but less often how they organize to sustain, manage, repurpose, or simply live with what they have. (As a thought experiment, consider how our statistical and design universes might shift if we imagined a fundamentally contracting technological world, and what we measured was technological breakdown, withdrawal and decline – a recessionary rather than a progressive, informatics?).

That we don't (usually) live in such a world may have less to do with any inner logic of economic or technological advance than with the remarkable and diverse human capacity for repair: the ability to make broken and breaking systems work, and to sustain what we have for at least a little while longer. This sensibility has long animated an important branch of American social thought, from John Dewey's insistence on disruption as site and instigation to thought [1], to the breaching experiments of ethnomethodologists like Garfinkel [2], to later Chicago School sociologists' concerns with infrastructure, articulation, and invisible work [3-5]. Social order, such work insists, is not the natural or inevitable outcome of 'structure,' but rather a remarkable and often fragile accomplishment. Social things, the pragmatists remind us, take work to maintain. And so, too, does technology.

In the paper that follows, we explore maintenance and repair as distinctive sites and categories of CSCW work, with particular focus on ICT and development efforts in the global South. Drawing on original ethnographic fieldwork conducted during summer 2010 in the Kavango region of Northeastern Namibia, we offer the beginnings of a thick

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description of the distinctive repair worlds that characterize, shape, and sustain the emerging ICT ecologies of the region. In the process, we open up new sites and themes for CSCW scholarship – many of which take us back to challenges and problems foundational to the field.

2. LITERATURE AND METHODS

CSCW has a rich albeit uneven history of attention to maintenance and repair concerns. In its design guise, such themes are often implicated in CSCW work attending to 'downstream' tensions in the relationship between design and use, leading to ethnographic descriptions and/or programmatic calls for tailoring, end user involvement, and more iterative or ecological approaches to the design problematic [6-8]. A related body of work has explored instances of breakdown and non-adoption confronting the deployment of CSCW artifacts and systems, including through contradictions embedded in the relationship between technical and organizational form [9-11].

Our own approach, building from pragmatist traditions, is to treat such instances of breakdown and failure as fully ordinary, and ask instead (with genuine curiosity and wonder) how it is that *any* sociotechnical arrangement can be made to work and persist through time. Here we connect to a third strain of CSCW work emphasizing the diverse and subtle forms of work that go into the ongoing operation of artifacts and systems as 'infrastructure' (vis-à-vis given forms of collective activity and variously situated social groups). Star and Strauss have analyzed forms of articulation work, much of it invisible, supporting the introduction and maintenance of collectively shared artifacts and systems [3]. In their 1994 CSCW study of the WORM community system, Star and Ruhleder advance an influential definition of infrastructure, emphasizing the embeddedness of infrastructure (in social arrangements and technical form); its tendency to remain invisible (except at moments of breakdown); its connection to membership in specific communities of practice; its relationship to an installed base (from which it inherits both strengths and limits); and its tendency to change in local and modular increments – in part through the resistances and breakdowns it occasions and encounters [4]. Subsequent CSCW scholarship has built on this definition, further developing the active [12-13], relational [14], agonistic, [15-16] and dynamic [16-17] dimensions of Star and Ruhleder's original formulation.

Our work brings a parallel sensibility to the analysis of ICT and development efforts in rural Namibia, with special attention to the distinctive problems and solutions surrounding sustainability in this space. The vehicle for our discussion is a distinctive notion of repair worlds, drawn from the same social worlds tradition (discussed below) that has informed and inspired much CSCW scholarship around infrastructure. We argue, in short, that ICT maintenance and repair activities in the Kavango region of Northeastern Namibia constitute a distinctive and complex kind of 'world,' whose function and variety is central to the nature and overall success of ICT development in the region.

To this end, we offer ethnographic data drawn from fieldwork conducted by two members of the project team between May and July 2010 around ICT and educational development efforts in the Kavango region of northeastern Namibia. This included 34 semi-structured interviews with regional technology providers, managers, technicians, and users, conducted in a combination of English and Rukwangali (the leading regional language) and focusing on patterns, practices, tensions, and barriers to effective and sustainable ICT adoption; and field observations at 14 different rural and urban sites in which primarily educational technologies (usually computer labs) were being deployed. Participants ranged in age from 20 to 55 years old, were evenly split between men and women, and were recruited according to their involvement as technology users, providers, or promoters in the region. Interviews and fieldnotes were translated (where necessary), transcribed, and coded by all three members of the project team according to the principles of grounded theory analysis [18-19]; early rounds of coding thus came to guide subsequent data collection efforts, including more focused attention (per grounded theory principles of theoretical sampling) to the dynamics of maintenance and repair that emerged as an early and central theme of the fieldwork. This initial fieldwork has since been supplemented through ongoing interactions with a team of local partners, who continue to conduct occasional interviews and supply materials relevant to the themes of the study. More broadly, our findings draw on one of the author's prior experience as an IT and education volunteer in the Kavango region between November 2006 and January 2009.

3. REPAIR WORLDS

For Strauss and fellow travelers in Chicago School sociology traditions, social worlds display a number of common properties. In each world, at least one primary *activity* (along with related clusters of activity) is strikingly evident: e.g., climbing mountains, researching, and collecting. There are *sites* where activities occur, implicating place, landscape, and a shared built environment. *Technology* (understood broadly as inherited or innovative modes of carrying out the social world's activities) is always involved. And while social worlds may begin from temporary and provisional divisions of labor, at some point *organizations* typically evolve to structure and manage key aspects of the world's activities [20].

Each of these broad categories can be further specified through a series of subprocesses, some of which may constitute distinctive and legitimate 'sub-worlds.' These may include partially autonomous activities dedicated to the finding, funding, protecting, and competition for sites; innovation, manufacturing, marketing, and training in technical skills; or the building, extending, defending, and repurposing of organizations. The discovery and study of

such sub-processes and of their relationships, including conflictual ones, are essential features of social worlds research.

Social worlds are also subject to complex processes of boundary formation, both internal and external. Externally, relations and intersections between adjacent worlds may be sites of tension, innovation, and strategic action. Internally, social worlds may follow complex patterns of segmentation, giving rise to subworlds that will themselves exhibit some of the dynamics (including boundary dynamics) of worlds of a more general type. At such junctures, a number of crucial questions arise. Who has the power to speak, decide, claim membership, and represent on the part of that world and its inhabitants? How are newcomers socialized, and what is the range of allowable relationships (from core to more 'orbital' and overlapping memberships)? How do social worlds – and the more formalized instantiations like arenas and organizations that grow from them – form and change, and how do they relate to larger processes of social transformation (economic, cultural, political, etc.)?

A leading example of these ideas in action is provided by Howard Becker's Art Worlds [21], which approaches the making of art as a form of materially and collectively organized activity. To succeed as art, argues Becker, objects depend on a wide and heterogeneous list of components: ideas and possibly inspiration; but also forms of physical execution; materials (canvases and paint brushes, cameras, etc.); support work (from editing and ticket sales to the bringing of coffee); an audience, readership, or other network of response; a rationale or other (collective) justification of value; networks of training; and certain conditions of civic order which provide a stability of expectations against which the basic operations of the world can proceed. In stable and coherent worlds, these components will reinforce and overlap – for example, in the way aspiring artists and actors constitute a significant portion of the audience for experimental or emerging art forms. They also generate constraints and conventions that will shape and regulate the form and process of art – for example, conventions around symphony length and orchestra size, which shape and limit the nature of creative work in this space.

For IT and development scholars and the wider CSCW field, such perspectives carry important advantages. To begin, in contrast to structuralist traditions of social thought, social world analyses start from an explicit concern with social change – a significant advantage in the technology and development context – which nevertheless takes instances of stasis and consistency as equally central phenomena of interest (and requiring explanation in any careful analytic account). Second, in its gathering of 'human' and 'technical' elements under the undifferentiated notion of worlds, social world analyses offer us tools for thinking even-handedly across the interlinked worlds of people and things, opening up both dimensions of human signification embedded in the world of things, and the possibility of strategic 'switching' between human- and object-centered approaches to collective goals (this principle is nicely captured in Bruno Latour's example of the sleeping policeman [22], or Lawrence Lessig's principle of code [23]).

Finally, social world analyses have been historically good at calling attention to the kinds of support work, people, and artifacts that underlie the actual practice of distributed collective activity. From invisible work [3] to infrastructure [4,5], interactionist traditions have drawn new attention to people, practices, and artifacts operating beyond or beneath the margins of more formally recognized systems. In the process they have opened a space for precisely the sort of maintenance and repair concerns pursued here. In Star and Ruhleder's influential account cited above, for example, infrastructure is defined as a sort of social and material substrate or scaffolding to action that remains "invisible until breakdown" – at which point underlying processes are made visible, and new repertoires of action may kick in [4]. Ethnomethodologically inspired traditions of CSCW scholarship have relied on this same basic insight: for example, seminal studies by Lucy Suchman, Julian Orr and others which follow (not by accident) the experience of Xerox copier maintenance and repair workers to produce new insights around planning, design, and the nature of technically-mediated collective action [24, 25]. And growing efforts by CSCW and HCI researchers to foreground sustainability as a design value offer new opportunities to push questions of maintenance and repair back to the center of the field [26-27]. In the sections that follow we build from social world and interactionist principles to describe the repair worlds of the Kavango region in Northeastern Namibia.

4. ICT, MAINTENANCE AND REPAIR IN THE KAVANGO

In the past five years Namibia has seen an enormous growth of technological availability in both cellular technology and networked computing resources. Mobile phone ownership rates currently stand at over 50% of the population [28]. While low by global standards, Namibia's IT infrastructure remains among the most advanced in sub-Saharan Africa. And investment continues to grow. In 2008, Namibia's largest cellular provider, MTC, spent an additional NAD76 million (~US$10.1 million) in fiber optic backbone, bringing the company's total investments from 1995 through 2008 to NAD1.6 billion (~US$213 million) [29].

But such overall statistics mask significant regional variations. As with other national numbers, technology and wealth indicators in the country are dominated by the capital city of Windhoek, which continues to function as the reference point for questions of availability, pricing, and access. Because of this, nation-wide technology policies are often detached from the realities of the poorest regions,

such as the Kavango, where development energy and dollars are most needed. Reflecting apartheid policies in place before national independence in the 1990s, Namibia is characterized by a Gini coefficient of 74.3, representing the largest national wealth disparity in the world [30]. This gap is largely reproduced in the balance of technology resources between Windhoek and the Kavango, and again between the regional capital of Rundu and the towns, villages, and rural homesteads that surround it.

To redress this gap, the Namibian government and foreign donors have begun heavy regional investments in computing infrastructure, centered primarily in schools. Since 2006, the national government's Tech/NA! program – an ambitious and country-wide school computerization initiative – has been operative in the Kavango. As of July 2010, Tech/NA! labs and training centers had been set up at the Rundu College of Education, two Teacher Resource Centers (TRCs), and several senior secondary schools. This has been accompanied by a series of parallel volunteer and donor-driven initiatives, including Computers for Kavango, a project started by U.S. Peace Corps volunteers that uses donations raised through Facebook to purchase rebuilt computer systems that are then shipped to Namibia and set up in smaller regional schools. The net result of these and other initiatives has been a steep increase in the number and availability of computers in the region: from an estimated fewer than 50 in 2006, to over 500 by May of 2010. Regional cell phone use and coverage has expanded even more dramatically, with population network coverage expanding from less than 50% to over 90%.

Nevertheless, as recently as 2007, there existed few formal operations in the Kavango region dedicated to ICT maintenance and repair. Users with broken mobile or computing devices faced the prospect of working with locally available parts recycled from old and broken machines; a trip to the national capital of Windhoek, ten hours away; or a visit to the town's informal repair market (described below). General computing equipment (memory sticks, printer cartridges, blank CDs, etc.) was available in limited and sporadic supply, and only in the regional capital of Rundu. In 2008, the two national cellular carriers, MTC and CellOne (now Leo), opened their first formal sales operations in Rundu; however, these remained focused on billing, phone, and SIM card sales, and offered no repair services beyond simple replacement.

4.1 Private Sector Sites

By 2009, the local repair ecology had begun to change. Three new 'tech shops' had opened, combining computer sales and repair operations. A representative example of this shop type was opened by 'Tom,' a hulking Afrikaaner from South Africa. To northern audiences, Tom's shop will look much like a family-owned small business: the shop occupies a permanent and prominent location at the center of town, the majority of the staffing is done by Tom's family, and the owner himself completes all repair tasks. Training is obtained by the owners outside of the Kavango region, and in many cases outside of Namibia (of the three formal technology repair businesses currently found in Rundu, two of the chief proprietors were educated in South Africa, and one in Egypt). The shops' supply chains follow similar lines: two receive their parts from South Africa and the third through an Egyptian supplier. Repairs at these shops usually consist of replacing failed hardware components, re-installing software, and removing computer viruses (a nearly universal feature of the Namibian computing landscape).

An even larger and more varied market has developed around cell phone repair. By 2010, no fewer than ten such shops had opened in Rundu, with an additional three to be found in the smaller regional towns of Nkurenkuru and Divundu. Most of these operate out of single room roadside stalls, in some cases converted shipping containers. Others have attached themselves to more established and apparently unrelated businesses, such as bars, clothing shops, or our favorite, Cell and Leather World. Shop owners are uniformly male but show a significant diversity of backgrounds. Many started as apprentices in other phone repair operations (often in the national capital of Windhoek) before opening their own businesses in the Kavango. Others were educated abroad, with one individual having obtained an MBA degree in his native Pakistan. While some have formal IT training (e.g. at universities and polytechnics in the capital), the vast majority – reflecting patterns in other local repair cultures (e.g. auto mechanics, tire repair shops) – have acquired their skills, networks, and reputations through apprentice relations. The most common activities engaged in by these workers are swapping batteries, unlocking phones, re-flashing operating systems, and replacing cracked screens.

At the opposite end of the spectrum from these semi-formalized operations lies the Rundu repair market. This open-air market is located at the center of town and houses a multitude of informal and small-scale enterprises grouped in a bazaar-like arrangement. While nominally a trading center, the open market functions as a defining social institution of the Kavango in general. It serves as a daily stop for many of Rundu's residents, whether to eat food, buy fabric, sell a chicken, or watch a soccer match. Over ten individual shops/stalls in the market deal in technology (both computer and cell phone); no fewer than five of these are dedicated to repair. The workers here offer skills and services built up over years of experience in this environment, dominated above all by an ad hoc capacity for tinkering. This tinkering culture is identifiable by three main characteristics. First, there is a tremendous amount of reuse and recycling of parts extracted from broken systems, rather than the purchase of new replacement components (it is hard indeed to find new parts in the Rundu market). Second, these repair shops operate largely beneath the expertise of a single person, occasionally supported by apprentices (usually family or at least ethnically related).

Lastly, the cost of procuring repairs at the market is lower than any other local option. This makes the open market notably cost-accessible, and thus the single busiest site by volume of maintenance and repair work in the region.

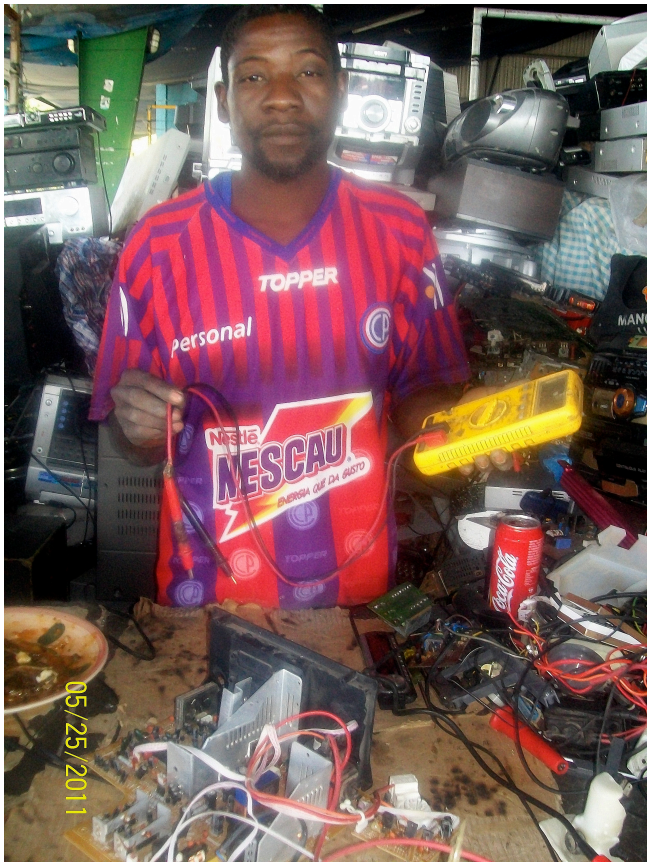

Figure 1: Repair worker in the Rundu open market, surrounded by discarded electronics to be salvaged for working parts.

4.2 Public Sector Operations

In addition to these private sites, a number of regional repair operations have grown up to serve the growing market in government or donor-supported computing initiatives. Reflecting the older but slower spread of computing infrastructure in the region, the vast majority of computers in the Kavango today remain the property of government ministries, and in particular the Ministry of Education. Official maintenance policies (explored in greater detail in [31]) state that all computers purchased by the government must be serviced by government-owned or approved operations. This poses significant challenges, for the projects themselves and for local repair worlds, as discussed below.

The primary regional computer repair center operated by the Namibian government is located in the Rundu Teacher Resource Center (TRC), a center administered jointly by the Ministry of Education and the National Institute for Education Development (NIED). Traditionally, the TRC was a place where teachers could make photocopies, attend workshops, and check out library books. However, in recent years the main resource utilized at the TRC has been its technology. Beyond its large and functional computer lab and reliable broadband connection, the TRC also houses two IT repair experts who serve as de-facto doctors for all school computer illnesses in the Kavango. Over our three months of observation, an average of three computers a day were brought in and repaired at the Rundu TRC.

The Rundu TRC's success as a repair center depends on the on-site knowledge of its staff and its regionally unique combination of resources. The TRC has become a drop-off point for old computers as the staff has the knowledge to extract working components from non-working systems. When this stockpile of parts does not fill the need for a given repair, the TRC staff act as liaisons to the private sector shops, such as Tom's. In addition, the TRC's generally solid broadband connection provides the rare ability for large software updates to be downloaded, in particular updates to operating systems and anti-virus software. The same Internet connection allows TRC staff to search for additional information when diagnosing and resolving unfamiliar maintenance and repair issues. As the typical computer lab in a Kavango classroom involves a wide array of hardware and software components, including sometimes spotty second-hand donations from the United States or Europe, such situations arise frequently.

4.3 Rundu Institute of Computing

A second quasi-public repair operation can be found in the Rundu Institute of Computing (RIC), located in a re-purposed concrete structure near the center of town between the new Chinese built shopping mall and a series of road-side stalls made from wood and discarded sheet metal. The center provides a variety of technology related services, but its most profitable are the repair of computers and cell phones. The shop and its owner, Andreas, enjoy a reputation as the best place to take any cell phone that is broken. Andreas performs most of the computer repairs himself; his former students turned employees perform the bulk of cell phone repairs. Like the stalls in the open market, the Rundu Institute offers prices lower than those at shops like Tom's. Also like the market, most components are repurposed or sourced locally (albeit with a higher reputation for quality and provenance: the RIC is not known to participate in the growing black market for stolen phones). In addition to the expertise of Andreas and his staff, the RIC depends on a now-considerable stockpile of components drawn from the dead and unfixable machines and handsets periodically brought to its door. The business has been in operation in one form or another for 7 years, and at its current location since 2005.

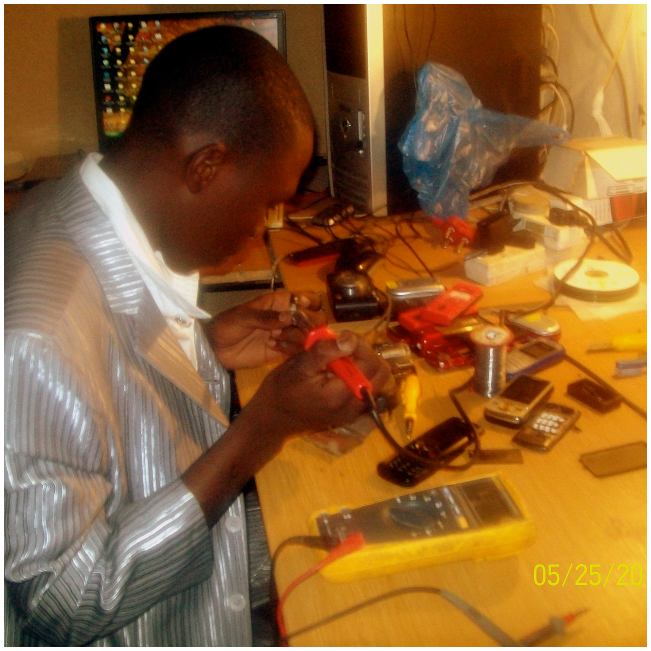

Figure 2: An apprentice at the Rundu Institute of Computing repairing a broken cell phone.

5. CHALLENGES AND INNOVATIONS

The variety of sites detailed above contributes to a significant range and heterogeneity in the repair worlds (and sub-worlds) of the Kavango region, each of which can be arrayed differently along axes of formality, quality, profitability, and institutional and social sectors served. This has produced a relatively varied and robust landscape of maintenance and repair in the region, with important (albeit overlooked) contributions to the spatial and social extension and sustainability of ICT infrastructure in the region. It has also produced some distinctive challenges and innovations, shared in story form below.

5.1 Cell Phone Hacking

One of the most common cell repairs performed at the Rundu Institute of Computing is the unlocking or re-flashing of cell phone operating systems. The institute's owner, Andreas, initially repaired only computers but quickly realized that the cell phone market was much larger and profitable. He used his knowledge of electronics and software systems to teach himself basic cell phone repairs. While he did not yet own a computer, he would visit Rundu's first dial-up Internet café in a local photocopy shop in order to research the subject. This allowed him to learn many aspects of cell phone hardware repair at a time coinciding with their mass adoption in the Kavango. Since 2008 Andreas has had access to a personal Internet connection and his cell phone repair abilities have grown enormously.

Andreas has used his Internet connection to circumvent a key problem of cell phone software repair: most phones do not allow easy access to manipulate or reset foundational software settings. The pervasive practice of SIM card swapping amongst members of families and social groups extends the use of a single handset (as widely celebrated in the IT and development literature), but also leads to the phone often becoming locked by mistake; for example, when SIM card passwords are entered incorrectly. However, with the use of special hardware components, the phone's software can be effectively hacked when connected to a PC. This solution depends on distinctly non-local ties, however; the necessary hardware components are not sold commercially in Namibia, and have been sourced (in this instance) from Russia. In the absence of local infrastructure, Andreas is similarly dependent on remote partners for learning and adaptation in the fast-moving phone market; as he explains,

"I am still learning many things, as the cell phones are changing quick. I meet partners on the Internet, on forums, who help me with my ideas… I have one partner from South Korea; (he) gives advice and has taught me many things. I tell my students that your partners are the most important thing in this business."

5.2 Disc Sharing

A second innovative practice uncovered in the course of our fieldwork applies to the maintenance and repair of computers in schools. Most computers arrive at schools as second hand donations without any software discs. Key barriers to on-site repair are limited repair knowledge of school staff, a lack of reliable Internet connections to diagnose problems, and the challenge of transporting broken machines over distance to the Rundu TRC. Thus, the most common software repair technique is to reinstall the computer's operating system. It is common for a computer to be given a fresh install, become infected with viruses (spread with USB memory sticks), and then be given a fresh OS installation within 2-3 months. Most repair staff are capable of starting from scratch with a system with the use of a system disc. This represents the most basic level of repair knowledge, but is also the practical reality for most computers in the region.

The lack of broadband connections limits the availability of large operating system updates. It is not uncommon to find multiple copies of the same out of date version of Linux or Windows being used at many schools in the region. These discs (and their pirated software keys) trace interesting resource-sharing routes amongst the Kavango's repair world. We found that discs follow the paths of students as they graduate, eventually reaching as many as five schools. One lab administrator near a border town with Angola recalls the following example:

"I was only taught how to install. I use this disc every week (copy of operating system disc). I copied it at my first school Himarwa when I was in grade 12 from a teacher there. I moved here and I knew that I would need it… Yes, I also share with others; other teachers at schools down the

road. They need it to fix their machines."

The adaptation and use of social networks is an innovative and prevalent tool used by actors in the Kavango's repair world. Just as traditional tools are often shared amongst an extended family, operating system discs find their usage multiplied through sharing.

5.3 Computer Labs as Business Models

A key challenge for the maintenance and repair of computers at schools in the Kavango is providing the upkeep costs for their labs. Few projects allocate any funds for ongoing maintenance or eventual upgrades of computers, instead defining success as the computers working when they were installed at the schools. This is especially negligent given that many computers are second hand or donations and are living a second life after having been discarded by their initial owners. The limited capital of schools is thus a major challenge for maintaining labs of aging hardware. The more rural a school, the less breathing room in its budget, and the more expensive it is to obtain and transport replacement components.

To deal with this problem, the Computers for Kavango initiative has introduced a model whereby unemployed youth in communities are trained in basic maintenance and repair of computers. In exchange for maintaining the labs, the youth are allowed to make use of the computers for income generating small to medium-sized business enterprises, ranging from photo printing to basic typing and document services (including personal resumes). Lab administrators are also allowed to offer basic computer classes to the community at large during school off-hours in exchange for a small tuition. Several of the youth administrators we interviewed had high enrollment in their courses and took great pride in their role as technology liaisons for the rest of the community.

5.4 Biography and Career Trajectories

To be robust and sustainable, social worlds must also: a) offer their members viable paths to learning and advancement; and b) provide mechanisms for the social reproduction of the world itself. This raises important questions of biography and career trajectory (and restores to individual actors a degree of specificity and agency lost under more structuralist analytic traditions). In the limited space available, we offer two brief biographical sketches of key roles and actors in our immediate study sites.

5.4.1 "Andreas"

A defining characteristic of the Rundu Institute of Computing is its use of teaching and apprentice style relationships. Andreas himself brings a formal education in computer and electronic technologies from the University of Namibia. Before opening the institute, he worked in the formal industry sector for Telecom Namibia, and then for three years as a school teacher of computer studies in the Rundu area. In his time as an educator, Andreas developed a strong relationship with several of his students who later joined him at the institute upon its formation seven years ago. Andreas teaches a year-long course in electronics and computer repair that he developed himself.

Typically two to three youth under the age of 25 will complete this training each year, and the majority of them then work at the Institute itself. After an average of two to three years, many of the apprentices will move on and start their own repair-centered business. (Several of the semi-formalized cell phone repair shops attached to local bars are former students of Andreas.) Beyond serving the cell phone maintenance and repair needs of the Kavango region, the Rundu Institute for Computing also serves as a transit point between formal expertise (as represented by Andreas' UNAM degree and experience at Telecom Namibia) and less formalized forms of work in the regional repair economy. But this between space also poses challenges. To begin, the semi-formal nature of the Institute limits Andreas' ability to attract outside lending, and thus to expand and upgrade his repair operations by hiring additional UNAM graduates. This prevents Andreas from off-loading some of his administrative responsibilities to others, as he'd like to do; as he explains,

"I prefer (to work) in the research, in development. The basement of this business is where I belong. I am not good at bringing in people and handling administration matters, but (my) time is spent there now."

The Institute has also struggled to build productive partnerships with the many formal volunteer and international development agency projects that have grown in the region in recent years. By overlooking repair operations such as Andreas', projects in effect lock them out (to the detriment of both parties). The reality of the repair and maintenance landscape currently found in the Kavango is that there is no shortage of broken computers in need of timely and cost effective repair. However, due to its insufficiently formalized status, one of the most skilled technology repair institutions in the region is unable to access this valuable market.

5.4.2 "Wesley"

Social reproduction through career evolution is also apparent in the following account of repair practice in the smaller town of Nkurenkuru, an hour to the west of Rundu. A teacher at a local high school was quick to tell us the repair work that his son Wesley performs while at home during school breaks. During most of the year Wesley studies computing technologies at the University of Namibia, the country's flagship institution located in the capital of Windhoek. Outside of school, he finds many informal maintenance and repair jobs at other informal businesses around Nkurenkuru. His father shared with us:

"My boy is coming here now to the market to work on two computers just there. They know and wait for him to return from school. They call him on his cell phone. I saw him the

other day with some very nice shoes and trousers I did not give to him. They came from money he earned finding work on these computers."

In dialogues with other community members, it became apparent that many technology users around Nkurenkuru knew and depended on Wesley, and planned their computer repairs around the school holidays when he would return home. While Wesley's formal expertise and standing is identifiable through his status as a student at university, the majority of his practical repair expertise has been developed in the informal setting. Wesley's experience while still a student not only augments his formal education; it provides him and his family a greater source of income to help absorb the costs of such an education. In addition, he provides a low-cost repair solution that maintains the technology landscape of a smaller town such as Nkurenkuru.

6. CHALLENGES

If the above stories offer evidence of promising and innovative workarounds to address the distinctive challenges of maintenance and repair in the Kavango, other problems have proven more intractable. Our fieldwork uncovered other instances in which the range and heterogeneity of repair worlds in the region and their interface with other institutional realities have constituted liabilities rather than assets.

6.1 Policy Barriers

In several instances, we found significant mismatches between the formal maintenance and repair policies of computers for education initiatives in the region and resources and realities of local repair worlds. The Tech/NA! program, for example, follows a centralized repair model in which all maintenance and repair operations are to be conducted at the newly created National Education Technology Service and Support Centre (NETSS Centre) located in Windhoek. Strictly followed (as it sometimes is), this policy requires all machines requiring attention (including for simple software upgrades and other routine maintenance) to undergo the expensive and somewhat risky trip to Windhoek via the national post system. Machines then join a repair queue stretching several weeks to several months before being returned (or not) to their original location. In the course of our fieldwork we encountered several labs that had been effectively shuttered by this process, with little immediate indication of restarting. This was despite the presence of a similarly government-owned resource in the Rundu TRC (to say nothing of the other sites noted above) fully capable of providing a large percentage of the necessary repairs.

This conflict brings a power dynamic embedded in infrastructure development to the forefront of repair practices in the Kavango Tech/Na! labs. The Tech/NA! systems have their software installed and configured in Windhoek prior to their deployment, with only staff in the capital given high-level administrative passwords and settings. In additional to the logistical logjams created, such excessively rigid repair policies marginalize local repair actors and prevent them from evolving new technical skills. To solve at least the first problem, the local TRC staff has hit upon the solution of simply re-flashing the client by booting with a USB memory stick, restoring all software settings to their initial state and usually correcting the problem (though at the sacrifice of all stored files). To avoid the loss of computers through trips to the capital, the TRC staff now distributes these USB sticks with usage instructions to all affected Tech/NA! labs.

6.2 Problems of Lockout and Control

When computers are brought to the TRC for repair, it is quite common for them to contain many files that have been copied to the machines by users. It is common practice for the staff to back up local files before the installation of a new hard drive or operating system. However, a large percentage of these files may consist of music collections or personal photographs, which the TRC staff deems non-educational. They thus do not back up these music files, and speak to the school staff on the dangers of spreading computer viruses through USB sticks by sharing music. In addition, the TRC may discourage "inappropriate" use by disabling the sound card and other system settings (which can only be restored through an administrator account, which teachers and students are forbidden from attaining).

On the surface this appears as a pragmatic response to the real problem of users inadvertently breaking and infecting computers. But such control mechanisms also shape and limit the adoption of computers in schools. While the use of computers for educational purposes is a worthy objective of computerization efforts in the Kavango, the most powerful local incentives to engage these efforts often lie in other interests and activities (e.g. music and entertainment). Our own fieldwork and experience suggests that the students and teachers leading adoption in the Tech/NA! and Computers for Kavango labs are precisely those who have become most proficient at using (and sometimes hacking) the systems for entertainment purposes. Along with the restrictive repair policies noted above, this tension between freedom, innovation, and control constitutes the single largest tension attending use of the labs today.

7. DISCUSSION: IMPLICATIONS FOR POLICY AND DESIGN

The concept of repair worlds advanced here and the more specific case of repair worlds in the Kavango region produce few immediate design implications of the sort common to CSCW scholarship (and questioned in [32]). But they do carry important lessons of both a practical and wider theoretical sort.

The first and most obvious of these concerns the need for better bridges between formal development project initiatives and the local repair worlds of the regions in

which these projects are situated. The absence of this connection (as we see in each of the TechNA and Computers for Kavango cases above) represents a double loss: for the projects, which see efficacy severely undermined by the inability to effect timely and locally appropriate repairs; and for the repair worlds themselves, which lose an important chance for support, growth, and the upgrading of technological skills, which turn out once again under the old law of uneven development to be (re)centered on the capital [33].

Such efforts to lock out and control use through repair-unfriendly policies and design follows from a long and unfortunate history of control through design in the ICTD and wider international development context. From electric lighting kits [34] to telecenters [35] to hundred-dollar laptops, designers working in the development space have long shown a heightened concern with damaging or inappropriate use – and corresponding efforts to coax downstream users into 'proper' modes of engagement through design choices that lock out would-be tinkerers, modifiers, and adaptors. Sometimes this is for frankly paternalistic reasons – for example, perennial donor hand-wringing around the fact that development recipients may be using the resources of donor-supplied ICT resources for "trivial" reasons: checking football scores rather than crop prices; writing love notes rather than resumes. Regardless of inspiration, by limiting or short-circuiting the development of local repair worlds, such efforts to manage use through design and policy seem likely to undermine, rather than support, long-term goals of sustainability.

Our third and related point has to do with the distinctive opportunities for learning that breakdown, maintenance, and repair provide – within but also well beyond the international development context studied here. Our favorite example of this comes from parallel fieldwork in Madagascar, where we encountered Mr. Rakoto, a former electrician and now owner-proprietor of a phone and computing repair shop in the country's eastern Mananjary region. Here's how Rakoto describes his introduction to his current line of work:

"When cellphones first came to Madagascar, I was curious to see how they functioned, and how they might break. So I bought one, threw it into the river here and then took it apart to see how the water and soil damaged it, and how it might be fixed."

This represents, we think, a strikingly different way of approaching the problem of maintenance and repair than the one dominating northern imaginations of IT design and sustainability, in international development and possibly other CSCW contexts. It constitutes a local version of what we'd like to call "broken-world thinking": a gestalt shift in our ways of thinking about sociotechnical system development that moves moments of maintenance and repair, rather than just moments of design and adoption, to the heart of CSCW thinking and practice.

Finally, as alluded to above, the cases offered here challenge the presumed separation between the design of IT artifacts and the design of IT policies that has tended to limit CSCW work to date. In the repair worlds of the Kavango region, this line is difficult to draw. From the standpoint of programmatic interventions like TechNA! or Computers for Kavango, the design of artifacts and the design of policy are better imagined as an interrelated whole whose integration or appropriate relation will go a long way towards determining success of the larger enterprise. By holding too faithfully to this divide, CSCW may be neglecting important and necessary sites of intervention and thereby falling once again into what a respondent once identified to us as an "edifice complex" – the stubborn tendency to over-privilege artifacts or systems to the neglect of the supporting contexts in which their coherence and efficacy is sustained. This too is a basic lesson of social worlds scholarship.

8.CONCLUSION

As the sometimes rapid, sometimes halting spread of ICT networks, devices, and practices has unfolded over the past ten-plus years in Sub-Saharan Africa and elsewhere, the kinds of repair worlds described here have come to play an increasingly central role. Recognizing, analyzing and supporting this work promises important practical and theoretical gains. Repair worlds may constitute interesting and overlooked sites of local innovation and expertise. They may support important kinds of extension and tailoring, stretching and repurposing extant infrastructure to new geographic and social communities. They may remediate traditional relations of dependency and social exclusion, sometimes amplifying these and sometimes ameliorating them. And by supporting and augmenting locally appropriate infrastructures, they may support new forms of distributed collective work that can further broad developmental goals of economic, social, and environmental sustainability and justice.

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