Things Fall Apart: Maintenance, Repair, and Technology for Education Initiatives in Rural Namibia

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ABSTRACT
Repair and maintenance haunt the margins of ICT and development ('ICTD') and broader information school scholarship, but have rarely received central theoretical or empirical attention in the field. This paper attempts to fill this gap. Theoretically, it explores ideas from the growing but scattered body of social science work around infrastructure, maintenance and repair, and argues for maintenance and repair as key sites of difference, innovation, power, and sustainability in ICTD settings. Empirically, the paper examines patterns and tensions in maintenance and repair in Rundu and the wider Kavango region in northeastern Namibia. We conclude with key findings and lessons for future ICTD and iSchool scholarship.

Categories and Subject Descriptors
K.6.1 [**Management of Computing and Information Systems**]: Project and People Management – *life cycle, strategic information systems planning, training*

General Terms
Management, Reliability, Theory.

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

1. INTRODUCTION
Maintenance and repair are core practical problems in the ICTD and broader information science fields. But they have yet to receive the analytic attention they deserve. This paper argues for the centrality of maintenance and repair ('M&R') in the development and ongoing operation of complex sociotechnical systems (which we all, north and south, now inhabit). We argue in particular that M&R work constitutes four key moments or sites of ICTD work – sites of *difference*, *innovation*, *power*, and *sustainability* – and that these issues are only obliquely addressed in the (limited) ICTD theory and project literature tackling maintenance and repair themes to date.

There are good practical and theoretical reasons for this move. Practically, painful experience within and beyond the ICTD field has taught us that otherwise well-intentioned and designed interventions often falter and break down around issues of maintenance and repair. For decades, images of abandoned wells and tractors rusting under an African sun stood as cautionary symbols of the dangers of tied aid and inappropriate technology. In recent years, piles of broken computers and shuttered telecenters, stripped copper wiring and virus-ridden operating systems have assumed a similarly iconic status. In all cases, widespread and under-accounted for problems of maintenance and repair have effectively sunk expensive and otherwise hopeful development investments, at the cost of significant economic, social, and sometimes environmental dislocations.

More broadly, a growing body of work in the information and social sciences has come to focus on questions of maintenance and repair as central but overlooked aspects of the design, operation, and long-term sustainability of complex sociotechnical systems. This work has deep roots: from the emphasis on breakdown (and its recovery) as a constitutive site of thought and social action shared by scholars from Heidegger to the American pragmatists, to phenomenology and ethnomethodology's insistence on repair as the necessary constant in systems and relations otherwise forever in process of disintegrating. From this perspective, change and entropy are endemic to human experience and technological existence in the world (or to quote Chinua Achebe, "things fall apart.").[1] Broken is the normal state. Human action, and the possibility of order and constancy, lies in the perpetual work of putting things back together.

To flesh out our arguments, we offer a series of repair stories, drawn from our ongoing fieldwork and prior involvement in ICT development efforts in Namibia. From May to July of 2010, we conducted eleven weeks of fieldwork into the maintenance and repair ecosystems of the Kavango region in the northeastern part of the country. This culminated in 34 formal interviews, field observations at 14 sites across the region, and countless interactions of a less formal sort. More broadly, our findings draw on one of the author's prior participation in computerization initiatives as an IT and education volunteer in Rundu and rural Kavango over a two year period between November 2006 and January 2009.

2. MAINTENANCE, REPAIR, and IT for DEVELOPMENT
Why study maintenance and repair? One answer comes from the field of infrastructure studies. Blending insights from the history of technology [2-5] and American pragmatist conceptions of work

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and tool use [6] studies of infrastructure have explored the mutual embedding of human and technological forms, and sought to uncover some of the dynamics and tensions by which such complexes or assemblages change. According to an influential definition articulated in Star and Ruhleder [7]), infrastructure is defined by a number of key properties: it is learned as part of membership in specific communities of practice; it is built on an installed base of existing systems, standards, and social relations; in part because of this, it changes incrementally, rather than globally or all at once; and in 'normal' operation it disappears from thought and view, becoming visible only in moments of breakdown. Infrastructure is also *relational*, confronting differently placed actors in different ways, from those empowered by infrastructure to those effectively left out or marginalized by it (or as Jackson et. al. note, some are more on the receiving end of infrastructure than others). Above all, perhaps, infrastructure takes *work* to maintain, and its smooth functioning in the world is to be examined as a kind of accomplishment, embodying (even while obscuring in 'finished' form) a good deal of prior and ongoing social and technical negotiation. Infrastructural inversions of the sort advocated by Bowker [8] shine a light on these dynamics and relations, and offer us new insights into the nature of the invariably blended sociotechnical systems that confront and constrain our lives.

A second argument for repair comes from ethnomethodology. For Garfinkel and later conversation analysts, rupture and repair represented both an enduring fact of social life, and a method for studying it (as witnessed in Garfinkel's famous 'breaching experiments' with students) [9]. In contrast to structuralist traditions then dominant in American and European sociology, Garfinkel and his followers described a social world simultaneously fragile and robust: fragile because of the inherent tendency of social order to break down (in the absence of anything like 'structure' to sustain it); robust because of the relentless, often subtle, and never fully predictable work of actors to maintain it. As translated into the worlds of information and organizational science by scholars like Suchman [10], Orr [11] and Henke [12], ethnomethodological concerns cast new light on kinds of actors and action heretofore neglected in the design and theory of information systems and artifacts, from Suchman's and Orr's Xerox repair teams to Henke's technical workers. This repair turn called attention to a number of notable gaps – for example, between plans and situated actions, official accounts and the actual practice of technical work, or the relation between routine prescription and improvisation in fast-moving contexts of failure and recovery.

Still other scholars have traced these themes to roots in the philosophy of technology. Graham and Thrift [13], for example, locate the work of maintenance and repair in Heidegger's famous distinction between the status of tools as 'present-at-hand' versus 'ready-to-hand.' In the former state, the material world resists, calls attention to itself, obstructs action and therefore rises to human consciousness. Precisely because of their tendency to break down, we are required to *think* about our tools *as* tools (rather than simply use them): the world of technology has become 'present-at-hand.' In the latter state, technologies do and stay where they're supposed to, offering themselves up in harmonious and therefore invisible ways to support the intent of humans actors: they are 'ready-to-hand' (in the sense that we can pick them up and use them more or less unreflectively). But as Graham and Thrift emphasize, there is an enormous world of work required to move between these states, much of which floats invisibly behind the 'finished' or 'objective' state of received technologies. From this perspective, maintenance and repair may be conceived as the multi-faceted work that produces and sustains objects *as* objects, in a 'ready-to-hand' state that grants a (provisionally) seamless and peaceful coexistence with the worlds of human action and intent.

Such general theoretical insights, developed primarily on the basis of North American and European experiences, may have particular and underexplored salience in information technology and development contexts, including the examples of computerization and education discussed below. As numerous project evaluations and several retrospective assessments have noted, the field as a whole remains weak in its thinking around the long-term sustainability of ICTD initiatives [14, 15]. Part of this difficulty stems from the long-standing problem of accounting for failure endemic to the institutional structure and mission orientation of the field. We know, via practice and anecdote, that most development projects 'fail' (in the narrow sense that they fail to meet targets and expectations formulated at the outset). But outside these scattered stories and painfully accrued experiences, development research has few if any organized accounts or general corpus for reporting on failure. As represented in the public statements of major ICTD funders and their recipients, ICT interventions will or have had major developmental impacts, but the evidence is often weak or lacking (and outside of a few hand-picked champions, may be mostly negative). What evaluation we do have suggests endemic problems around sustainability tied to repeated failures to account for maintenance and repair as a central dimension and challenge of project success. More positively, commentators like anthropologist and blogger Jan Chipchase have noted with ethnographic wonder the sheer diversity of maintenance practices and 'repair cultures' at work in the varying local contexts he studies.

Building on these failings and insights, we argue for the centrality of maintenance and repair as four key moments or sites of information technology and development work:

M&R as site(s) of difference: Even more than contexts of production, access, and use, maintenance and repair may be the aspect of the real-world experience of ICT in developing countries that is most different from northern experiences. Paraphrasing Tolstoy, we might argue that 'all functioning systems are alike; all broken systems are broken in their own way.'[1] Moreover, in precise consequence of the failure by development institutions and national governments to account for M&R themes in their funding strategies, it may also be the aspect of ICTD work that is least touched by the programmatic structures and aspirations of development funders. If there are endogenous 'styles' of ICT appropriation[16] or post-colonial computing[17] in countries typically classed as developing, contexts of repair may constitute one of their most distinctive points of manifestation.

M&R as site(s) of innovation: As evidenced in our Namibian fieldwork, maintenance and repair work may constitute significant and overlooked sites of innovative ICT practice – again generally, but perhaps especially in the typically constrained circumstances of ICTD settings. M&R work may constitute an underappreciated facet or feature of innovative ICT ecosystems – a point relating to

[1] Cf. the opening lines of Anna Karenina: "All happy families are alike; all unhappy families are unhappy in their own way.

but extending well beyond theories of user-centered innovation. Such innovation may take the form of novel repair forms and practices. It may also take the form of novel (to western sensibilities) business models, from urban repair markets to rural recharge shops. Beyond its practical contributions, opening up maintenance and repair as sites of ICTD inquiry and practice may therefore contribute to current efforts to rethink (and reclaim) the nature of innovation in developing country contexts.

M&R as site(s) of power and dependency: As scholars of infrastructure have been at pains to point out, maintenance and repair may be places in which the operation and effects of *social power* are most in evidence. A part of this effect may be witnessed at the level of the object itself: for example, Madeline Akrich's classic work on (failed) efforts to user-proof photoelectric lighting kits designed for West African use to prevent unauthorized recipients from maintaining, fixing, or repurposing them [18]. Power effects may also be witnessed in the distribution, structure, and relative valuation of maintenance work vis-à-vis other kinds of activity. This is often a site at which gender and racial politics assert themselves, through the mutual alignment of higher status work with higher status groups (see for example arguments about the differing pay and status structures attending traditionally feminized forms of work). Where and how things break, and where and how they are repaired, may also hold up an interesting mirror to the traditional relations of colonialism, dependency, and development. Do patterns of maintenance and repair (as do patterns of transport and communication infrastructure more generally) continue to follow and embody forms of internal or external dependency of a recognizably (neo)colonial sort? (Or to repurpose the old imperial argument, does repair follow the flag?)

M&R as site(s) of sustainability: Finally, maintenance and repair figure as increasingly important phenomena as we begin to think through the puzzle of sustainable computing (and sustainable societies), both within and beyond the ICTD world. This is certainly true at the project level, where failures to anticipate or account for maintenance and repair work have frequently stalled or derailed otherwise well intended and conceived development interventions; from this perspective, more effective maintenance and repair regimes could significantly extend and enhance the impact of specific IT for development projects. More broadly, maintenance and repair (both 'first-world' and 'third') is intimately connected to the growing problem of e-waste noted by development scholars and sustainable computing advocates. From this perspective, locally robust maintenance and repair regimes may contain important lessons for more effective and sustainable ways forward in the IT and development and wider information fields.

For all these reasons, practices of maintenance and repair represent a crucial piece of the wider information science puzzle. IT and development contexts are particularly good and provocative places to learn from.

3. Ecologies of Repair in the Kavango Region

Namibia, and the Kavango region specifically, represent provocative and relatively understudied settings in which to explore the themes of maintenance and repair introduced above. A wide variety of technology for development programs have been recently launched or concluded in the region, ranging from large scale and top-down programs to grassroots, informal, and community based initiatives. In the past five years the Kavango region has also seen an enormous growth of technological availability in both cellular technology and networked computing resources. Population coverage of cellular networks in the Kavango has gone from below 30% in 2004 to 90% in 2009, and mobile phone ownership is currently over 50% of the population. [19, 20] The technology infrastructure of Namibia is one of the most developed in the region. Namibia ranks 78th out of 115 economies according to the World Economic Forum's networked readiness index for preparation to participate in and benefit from ICT – low by global standards but considerably ahead of many of its regional neighbors.[21] Finally, investment numbers by the Namibian government and other key actors in technology and education are significant in regional terms. In 2008, Namibia's largest cellular provider, MTC, reported spending NAD76 million (~US$10.1 million) in expanding its fiber optic backbone. MTC's total investments from 1995 through 2008 are estimated at NAD1.6 billion (~US$213 million).[22]

Such promising aggregate statistics mask significant discrepancies and variations, however. 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 Kavango, where development energy and dollars are most needed. Reflecting apartheid policies in place before national independence in 1990s, Namibia is characterized by a Gini coefficient of 74.3, representing the largest wealth disparity in the world.[23] This gap is largely reproduced in the balance of technology and educational resources between Windhoek and the Kavango. Similar gaps are replicated between the regional capital city of Rundu and the towns (e.g. Nkurenkuru), villages (e.g. Mpungu), and rural homesteads (e.g. Silikunga) that surround it. By another measure, our own fieldwork and past experience in the region suggests that it is not uncommon for young children in Rundu to speak better English and be more familiar with computers than teachers in the rural villages.

A number of technology-based development initiatives have been launched to redress this imbalance, many concentrated in the field of education (widely seen in Namibia and elsewhere as a primary means of effecting large-scale changes in technical and wider socioeconomic transformation). Many of these trace their roots to the SchoolNet program which began in 2000.[24] SchoolNet Namibia provided low-cost refurbished computers, open source operating software platforms, discounted access to the Internet where connectivity allowed, and the offer of technical support for repairs. It was recognized with the Africa Hafkin Communications Prize administered by the Association for Progressive Communication in 2002 before ultimately folding in 2008 due to a lack of donor support.

The lessons and approach of SchoolNet have given way to the much larger government initiative known as Tech/NA!. Tech/NA! was established in 2006 with the purpose of comprehensive deployment of education technologies across Namibia, including the Kavango region.[25] The scale of Tech/NA! is unprecedented for Namibia, with its proposed scope encompassing every school in the country by 2030. Interspersed in this timeline of ICTs and education development in Kavango have been various efforts by volunteer organizations and NGOs. These largely reflect more locally oriented projects and tend to

focus on bringing technology resources to a single community or school.

3.1 Maintenance and Repair in the Tech/NA! Initiative

Tech/NA! is the strategy to integrate ICTs across the national education system as part of the Namibian ICTs in Education Initiative. This project arose out of the Namibian Ministry of Education's *ICT Policy for Education* in 2005.[26] It is described as a "holistic, end-to-end approach that provides a comprehensive solution for all educational institutions progressing towards the goals of Vision 2030." The project's scope reaches across all of Namibia; however there are key items specific to the Kavango region. From 2006 through 2009, the Tech/NA! implementation plan called for the deployment of hardware specific computer labs in the Rundu College of Education and the four regional Teacher Resource Centres (TRCs). The Maintenance and Technical Support for ICTs component of the plan identifies three levels of support for the Tech/NA! labs and equipment: 1) Local maintenance support by the users of the technology through the expertise developed in a detailed training module. 2) A centralized national help center at the planned National Education Technology Service and Support Centre (NETSS Centre) located in Windhoek. 3) Regional support facilities by technicians experienced with the relevant platforms and network connectivity. As of July 2010, Tech/NA! labs have been deployed across the Kavango at the Rundu College of Education, two TRCs, and several senior secondary schools. Over this same time period, the government of Namibia estimates the cost of the program to be NAD210 million (~US$30.8 million).[25] The scale and vision of Tech/NA! make it an unprecedented technology based development project for Namibia. Although maintenance, repair, and upkeep considerations are included in the policy framework for the project, several glaring gaps have emerged in the four years since the project began.

3.1.1 Hardware and Software Concerns

The hardware setup of the standardized Tech/NA! lab is a modern solution of new components chosen specifically to match the needs of Namibian education institutions. The standard lab consists of a central server computer networked with around 15 thin client terminals. The thin client reads a master image off of the master server and thus has no need for permanent local storage or high-end components, limiting costs and maximizing the resources of the powerful server machine. Servers and thin clients are loaded with Microsoft Server 2003. This choice of operating system does provide familiarity to the most prevalent computing environments found in businesses in Namibia, however it overlooks a key maintenance concern. The Windows platform is characteristically more vulnerable to computer viruses than open-source options. The Tech/NA! servers are preloaded with all software in Windhoek before being transported to Kavango, however this does not include anti-virus programs. While affordable anti-virus solutions are available online, this option is impractical given the connectivity of most labs. In order to be effective, anti-virus software requires regular software updates from the Internet. While Tech/NA! policy ostensibly provides for an Internet connection at each lab, this is far from the reality in the Kavango, where access is available primarily through pre-paid GPRS cellular networks, leaving the cost of typically large anti-virus updates prohibitively expensive to schools. A computer lab coming to a Kavango school becomes not only an educational resource, but also a symbolic source of pride for the teachers, students, and local community as a whole. A typical school lab could have as many as 300-400 individual users in a week. This number of users, coupled with the prevalence of USB memory sticks, means that although the lab may not be connected to the Internet, it is incredibly vulnerable to the proliferation of crippling viruses.

When software errors occur in the lab, the server-thin client setup complicates the first level of the Tech/NA! maintenance policy. Given that training local school staff on basic computer repair is challenging enough given the expertise level of the typical Kavango teacher, effective training in an obscure server and network hardware environment is not feasible. The Kavango's shortage of experienced IT personal is exacerbated by the introduction of such an exotic system. Thus, the performance and efficiency gains of the thin-client setup are quickly neutralized by the slightest maintenance issue. Tech/NA! suffers from the tendency to assume that because hardware is new and expensive that it will somehow be immune to regular maintenance needs that should be expected in any educational computer lab.

The key component of the Tech/NA! maintenance and repair policy was the Namibia's National Education Technology Service and Support Centre (NETSS) in the capital city of Windhoek. This central technology nexus provides the distribution point as well as the maintenance and technical support for all education technology in Namibia. The maintenance policy for Tech/NA! is categorically centralized to be able to service the entire country. The repair policy of Tech/NA! states that any non-trivial hardware or software issue must be addressed by the technology professionals in Windhoek. This policy was developed according to past experiences that unqualified individuals attempting to fix computer problems in school labs end up creating more problems than they solve in the long run. Thus, repair must be centralized to a single location where quality control can be ensured and staff training maintained. However, this model presents a crucial weakness for timely and practical maintenance and repair. If any maintenance request is made to Tech/NA!, the device in question must be transported to Windhoek. The central repair hub has a current turn-around time of 2-3 months for any maintenance request. The server-thin client setup exacerbates this situation; if a lab's server needs the slightest repair then the entire lab will, be inoperable for the duration of service and transportation. The transportation realities of Kavango make the centralized maintenance and repair center ineffective for an education setting where computers are relied upon daily. The NETSS center is centrally located in Windhoek to accommodate the quality of living standards made by in-demand technology professionals. However, this clusters maintenance and repair expertise furthest geographically from where it is needed most; in disadvantaged regions such as the Kavango.

3.1.2 Training and Teaching

The Tech/NA! project seeks to not only provide useful technology devices for education, but to also incorporate comprehensive training for all teachers in the country. The project plans to provide training for all teachers towards the International Computer Driver's License (ICDL). The ICDL is the largest end-user computer skills certification program in the world, with almost 10 million candidates to date, utilized in 148 countries [27]. The ICDL training component for teachers in Tech/NA! has been out-sourced to a private computer training company based in

Windhoek. All teachers at schools with Tech/NA! labs take part in 2 hour training sessions each weekday for 3 months. These sessions are led by a training supervisor who lives on site during this time. The Ministry of Education awards teachers who successfully pass their ICDL training a free laptop. This training component represents a massive investment of resources on the part of the ministry, and time on the part of the teachers.

The ICDL testing modules are designed for a single client Windows XP machine – a fundamentally different set-up than the Tech/NA! configuration. Thus, teachers are being tested on competencies according to a rubric far removed from the platforms they are being trained on. Because of this difference, the maintenance and repair skills covered in ICDL certification are not transferable to the Tech/NA! lab configuration, undermining any local accumulation of expertise. While teacher training is reasonable for any IT project in Kavango, the ICDL program is not tailored for education specific skills, and thus does not correspond to improved learning in students. Nor are ICDL and broader Tech/NA! training activities well-integrated into local curricula: Kavango schools (including those with Tech/NA! labs), do not currently offer computer studies as a graded subject connected to grade level advancement. Instead, students are given time in the computer lab during a basic information science class period which occurs once per week. Class sizes in the region average around 40 students, thus the amount of time a given student has on a computer is roughly 40 minutes every 3 weeks. In our field observations of Tech/NA! labs, an average of 2 thin clients were not functional in any given lab, further diminishing the amount of available student machine time. Here again, insufficient attention to user needs and hard problems of maintenance and repair undermine the program's goals of broadened student access to computing.

3.1.3 Dangers of Neglected Maintenance Policy

By mandating maintenance take place only in Windhoek, the Tech/NA! program eliminates the opportunity for local technology repair expertise to develop according to the needs of a community. By ignoring the possibility of repair skills being transferred on site, a Tech/NA! lab is no longer a M&R learning space. The development of repair and maintenance skills in students is directly in line with the emerging demands of the region. Our observations show that local technology businesses in Rundu cite cell phone repairs as their single most profitable service. As the number of personal computers rises, repair skills become more valuable as means to employment. This is demonstrated by the story of a local youth in Nkurenkuru who is concentrating in computer studies at the University of Namibia. His father shared: "*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.*"

Maintenance and repair from a distance also perpetuates the technology hierarchy that finds Kavango disadvantaged compared to other regions. If emerging local sites of maintenance and repair power are bypassed to Windhoek, the technological ecosystem remains undermined. Without a practical implementation of locally based repair and maintenance policy attached to the Tech/NA! project, the very imbalance of technology expertise the program seeks to overcome is strengthened and perpetuated. Our fieldwork found several emergent informal businesses in Rundu focusing on technology repair. The story of one, the Rundu Institute of Computing, demonstrates the harm of bypassing local repair expertise. The center is currently profitable and the staff possesses excellent repair skills gained in an applied setting. However, the center's founder is unable to procure credit for expansion into computer repair due to the associated risk in this sector. It is known that although there is no shortage of broken computers in the region, the policy of the ministry of education mandates that Tech/NA! repairs take place in Windhoek, leaving this valuable repair market out of reach.

3.2 Maintenance and Repair in Volunteer-led Projects

The Tech/NA! project is an example of a technology for education initiative devised and supported through the Namibian government. However, a large number of the computers that are currently found in schools across the Kavango are the result of foreign volunteer, NGO, or non-profit organization. These systems arrived through a myriad of projects with no standard approach amongst them, however there are several noticeable trends that define the ultimate success or failure of such projects in regards to maintenance, repair, and ultimate sustainability. Typically these projects are of smaller scope and budget than large top-down initiatives such as Tech/NA! They often are concerned with a single school or community rather than providing a comprehensive technology solution for an entire country or region. The computing equipment is largely donated and often second-hand hardware that is being reclaimed for use for schools without the means to purchase brand new machines. In most cases, the computer systems are considered gifts to the host school, or supported through the gifts of individuals or organizations in developed countries. It is a standard practice to finds traces of these donors' presence from afar in badges on the sides of computers, or signs hanging in the computer lab. In the past 5 years, many volunteer led initiatives have moved away from the 'santa claus' style of donations, and now include an element of community investment to increase local sense of ownership and stake in the computers. However, given the extremely limited capital of most Kavango schools and communities, this usually amounts to the provision of the room which houses the machines.

In 2006, there were fewer than 50 computers in the Kavango region outside of Rundu. Site assessments made across the region now estimate this number to be several hundred,; having arrived through a combination of Tech/NA! and volunteer organization initiatives. However, this order of magnitude increase in computer hardware does not translate into sustainable practice without considerations of ongoing maintenance and repair issues. The most pressing challenge for volunteer led projects is the temporal nature of volunteer service. The Peace Corps-led Computers For Kavango project is a representative example ongoing in the region, and one of the focuses of our fieldwork observations. In addition, institutional partnerships can be found in Worldteach volunteer programs as well as faith-based examples such as the Evangelical Lutheran Church In Namibia (ELCIN), which is supported by Finnish mission work. These three organizations represent varied volunteer-led approaches to bringing computers to schools in the Kavango. However, in all cases sustainability is severely limited by the reliance on foreign technology experts who must procure, install, and train a

community in maintaining equally foreign equipment. Maintenance and repair concerns are almost entirely neglected in the face of such constraints. The key maintenance issues found in volunteer initiatives are similar to those found in the Tech/NA! program, but often for very different reasons. The comparison of these two approaches is essential for proper understanding of the maintenance and repair landscape and ultimately providing meaningful technology for education resources.

3.2.1 Hardware and Software Concerns

The typical volunteer sponsored computer lab project uses second hand equipment, often donated from schools, businesses, or organizations far away from the host community. This adds an extremely costly element to a project. Often the transportation costs for a computer lab far exceed the net worth of the hardware being installed. For example, a standard lab for one initiative at a site we visited consisted of 10 computers with CRT monitors, all second-hand hardware transported from the United States. Upon arrival via shipping container, half of the machines were not functional (thus a standard lab requires twice the shipping weight of hardware eventually in service). Moreover, second hand machines of the sort donated to Kavango, especially CRT monitors, have tended to be much heavier than newer components and too fragile for the long travel times and distances. New computer equipment is available in the Kavango, which is modern even by western standards. Following the success of cell phones, many technology related businesses have arisen in Rundu over the past 3 years. In addition, many initiatives through Namibian government agencies offer subsidized computer equipment prices for new hardware transported relatively easily from South Africa. By all indications, the motivation for using second-hand equipment from afar, despite questionable to negative cost savings, is driven largely by donor pressure: it seems that individuals would rather give their old and no longer used computer equipment to a Kavango school, than provide the equivalent amount of capital. In this way, the recycle and re-use concern of donors may undermine the sustainability of computer labs, as well as emerging local hardware markets in Rundu.

Another key weakness of using second-hand equipment is its expected life span once deployed in a school computer lab. Much of the computer equipment currently in place in Kavango schools was nearing the end of its operational life span when donated, leaving little chance of long-term impact. Machines that were headed for the scrap heap do not suddenly begin working properly once they are transported to Africa. In fact, the temperature and environment strains found in the Kavango further shorten functional life spans. The infrastructure that computers depend on may also be a limiting factor. The electrical grid is prone to dramatic dips and surges, which stresses aged power components. In interviews with the technology heads at the Teacher Resource Center, which handles all computer repairs for schools in the Kavango, it was found that apart from viruses, power supply failure is the largest contributing factor to computer breakdown in the region. The roads and vehicles available in the Kavango are not capable of reliably transporting delicate computer hardware to and from school sites to the repair center in Rundu. This challenge is exacerbated during the yearly rainy season, which often washes out roads during seasonal flooding. The storms also contribute greatly to electrical grid inconsistencies due to the large number of lightning strikes. These maintenance and repair realities are largely ignored in the design and implementation of volunteer initiatives as evidenced by the number of repair requests that now arrive at the regional repair center. Observations at this site found on average three donated second-hand machines per day brought in for repair. Many of these were 'repeat offenders' with a history of breakdown and component failure. These machines were referred to as *Skorokoro*, a vernacular term in the local language for something broken down and untrustworthy normally reserved for old taxi cabs. The transportation and replacement of broken components is only sometimes possible for a school to absorb, but not necessarily practical. In many instances, the second-hand computers end up becoming expensive problems for a host school rather than the dynamic learning tools envisioned by the volunteer. Often the only formal assessment of maintenance and repair in such projects is that the computers are functional at the moment the volunteer departs from their community, a measure which ensures no acceptable level of sustainability.

A third maintenance and repair issue in the volunteer-led initiatives pertains to software. Given the prohibitive cost of legal software licenses for operating systems and office suites for single schools or communities, two realities have emerged. The first is the installation of pirated software. Volunteers are often not professionally liable for any sort of repercussion for this action, and the likelihood of a Kavango school becoming a legal issue is low. However, the so-called 'cracking' of these software packages is a key means by which computer viruses are spread. The ad-hoc repair that arises once a volunteer leaves often relies on complete re-installation of a computer system due to the limited expertise of the local lab caretakers. Our interviews and site observations discovered that this leads to extensive physical sharing of pirated discs, often infected with viruses and malware, through the social networks of teachers.

A second option is found in the use of open-source software. While this option does eliminate the legal and virus caveats of using pirated software, it also strains the maintenance and repair resources of Kavango. Uniform hardware support in open-source operating systems is much more difficult to ensure. A typical volunteer founded lab is filled with different makes and models of computing equipment, thus the uniform computing environments needed for proper education is impossible. It is not uncommon to find a lab where one computer will not have audio capabilities because the sound card was not supported by the Linux version installed, while yet another machine has an entirely different version altogether due to its particular hardware setup. The fragmentation of open-source platforms undermines the education functionality of the computer lab as a classroom. It is impossible to teach students completely unfamiliar with computers in a lab with several variants of open-source operating systems or with varying degrees of supported hardware components. A computer lab only becomes a useful learning space when the teacher can be ensured that a single instruction or task given to a class is appropriate for all of the computers platforms present.

3.2.2 Training and Teaching

Small, locally oriented computer centers suffer from a number of disadvantages compared to national initiatives. While many volunteers receive training in grant writing or other fund-raising options, the ability to impart computer maintenance and repair skills is often underdeveloped. Even a volunteer with considerable technical expertise may find the teaching of such skills extremely difficult considering the myriad of cultural and language differences present between the Kavango and their home. The training required for proper maintenance and repair is extremely

difficult to pass on in the limited amount of time that a volunteer has within a host community. Even at the Ministry of Education regional repair center in Rundu, technical expertise is difficult to develop as the staff is typically overwhelmed by the sheer volume of regular maintenance needs in the immediate city area. In addition, knowledge of open-source platforms is typically limited, making problems more difficult to diagnose and rectify. Those key individuals in the Kavango tasked with maintenance and repair for education resources were trained almost exclusively on proprietary platforms as this is what the majority of employment opportunities require. In general, maintenance and repair concerns in volunteer initiatives are rarely formalized past the act of initial installation.

A limited number of volunteer projects have introduced formalized maintenance and repair measures; however the decentralized nature of such projects means that experiences are often not shared between such initiatives. Mistakes are prone to be repeated as NGO and volunteer organizations lack consistent institutional memory, both within and across organizations. One attempt at formalizing a repair component within a project was the creation of a lab assistant position. This person would be an out of work youth from the host community who would undergo training in basic computer repair. Upon the completion of the training course work, the assistant would accompany the computers to site and maintain the lab daily. Although the host schools often have little to no means to pay the assistant, the individual would have use of the lab as an income-generating platform. The experiences of this model are mixed one year on. Several labs are still waiting for electrical wiring in a classroom, and the assistant has likely moved on. The training of the assistants was shortened to one quarter of the planned course length when over half of the computers arrived from the United States damaged during shipping. In general, most of the assistants still maintaining their labs feel disconnected and powerless within the project. The lack of reliable income for the position means that most assistants are very limited in their ability to maintain the lab when hardware components fail. Assistants received a commendable initial training to act as a platform for further maintenance and repair learning. However this initial training was not adequate for the maintenance challenges they are facing one year in. The project provides no access to self-taught training resources or other reference manuals. Interviews of all lab assistants found a general 'start from scratch' approach to software problems, as demonstrated by the following quote: "*I do not have Internet here or materials to learn the problem, so all I can do is re-install Edubuntu. But now the sound does not work, but knowing how to re-install was the most important thing in training.*" This incomplete solution is merely a stopgap which does not uncover the root of problems. Being able to identify the root cause of failure is a key component of continuing the education of local emerging technology repair professionals. It is the development of these skills in local actors that will ultimately form sustainable technology ecosystems in the Kavango and eliminate the need to outsource these tasks to other regions.

3.2.3 Dangers of Neglected Maintenance Policy

Volunteer led initiatives in the Kavango offer a variety of approaches to maintenance and repair concerns in the education technology realm. As a site of innovation, a handful of projects have extended the school computer lab into an income generating business model. These include many various activities, such as printing photos, printing and typing documents for community members, burning music CDs, and conducting community computer training classes. By opening access surrounding the maintenance and repair of a school computer lab, broken or failing equipment can become a learning opportunity. However, there is a prevalent practice of locking broken equipment away to await the arrival of a repair professional or the return of the volunteer who devised the project initially. This stems from the fear that individuals with limited repair knowledge will further damage the computer beyond repair, despite the fact that it is already non-functional. This protective practice undermines the further education of emerging professionals and removes the school lab as a site of maintenance and repair empowerment

Decentralized projects also suffer from a lack of shared experiences, despite the presence of affordable cellular service by which they could be connected. Over the course of the fieldwork, nine volunteer led projects all suffered the same maintenance issue. Specifically, students would often remove or edit the basic appearance of the computer desktop by accidently manipulating the taskbar preferences. Thus, each computer's desktop would look completely different than any others; crippling to students attempting to follow a teacher's instructions. However, two lab assistants were able to independently discover the ability to lock the taskbar and solve this problem. By overlooking the affordance of the labs as sites of maintenance and repair learning, the project does not efficiently transfer experience among the key actors. This occurs despite the presence of a telecommunications infrastructure capable of cheaply and easily supporting this collaboration.

4. Conclusion

As new computer and mobile-based ICT resources have become more common in the Kavango, the principal challenges facing ICT initiatives in the region have shifted away from basic questions of access and infrastructure towards the no-less challenging problems of maintenance, repair, and sustainability. Through a combination of rapid growth in telecommunication coverage via mobile phones and the strengthening of national infrastructure, many countries in southern Africa find themselves with a relatively reliable technical platform from which to implement local development programs. Namibia's Kavango region represents such an emerging test-bed of ICTD projects, particularly in the education sector. Since 2000, many such technology-based programs have transpired with varying degrees of success. However, the Kavango, as well as development actors across the subcontinent, have often failed to adequately address key concerns surrounding maintenance and repair in their work.

Foregrounding maintenance and repair therefore promises important practical and theoretical gains. The diversity and resourcefulness found in local repair cultures may be a source of strength and learning for technology and community development practices both North and South. The frequent ingenuity of local repair practices may be a site of innovation producing new models and possibilities for technology practices, locally and elsewhere. Maintenance and repair may constitute or confound existing relations of power and dependency, granting local actors more and less autonomy to shape their developmental futures. And by supporting more sustainable and/or green IT models, maintenance and repair may support or undermine broader goals of social and environmental sustainability.

To support these ideas, the present paper has attempted an initial empirical comparison of maintenance and repair activities across a range of ICT for education projects active in the Kavango today. Drawing on original ethnographic fieldwork, we have explored the distinctive repair ecosystems surrounding technology for education initiatives and wider technology use in the region. Across the diversity of settings encountered, three prescriptive lessons stand out. First, both hardware and software platform choices must be taken with medium- to long-term maintenance and repair realities in mind (but rarely are). Second, training and maintenance policy must be aware of local emerging repair economies in order to avoid stifling development of local capacities for resilience and economic development (but rarely is). Lastly, maintenance and repair realities must be considered as prominent and potentially innovative sites within the sociotechnical space of a community: sites which produce barriers but may also offer opportunities for more sustainable local development in the long run.

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