Foundations and Trends® in
Human–Computer Interaction
Vol. 4, No. 1 (2010) 1–79
© 2010 K. Toyama
DOI: 10.1561/1100000021

now
the essence of knowledge

Human–Computer Interaction and Global Development

By Kentaro Toyama

Contents

Foundations and Trends® in
Human–Computer Interaction
Vol. 4, No. 1 (2010) 1–79
© 2010 K. Toyama
DOI: 10.1561/1100000021

now
the essence of knowledge

Human–Computer Interaction and Global Development

Kentaro Toyama

School of Information, University of California, Berkeley, USA,
kentaro_toyama@hotmail.com

Abstract

International development is concerned with making life better for the least privileged people of the world. Since the 1990s, HCI has engaged increasingly with development through an interdisciplinary field known as "information and communication technologies for development," or ICT4D. This article overviews the historical relationship between HCI and international development, compares their disciplinary approaches, and suggests that both sides would gain from ongoing interaction. International development could benefit from HCI's broad methodological tools, which include qualitative and quantitative research methods, design through iterative prototyping, and reflective inquiry. HCI could benefit from international development's exposure to a broader base of cultures, sectors, and concerns. These issues are discussed with specific examples from published papers and several well-known projects that apply HCI to development. Finally, future directions for an ongoing collaboration between HCI and development are also indicated.

1

Introduction

Imagine the following scene in Kibera, one of the world's largest urban slums, located in southwestern Nairobi[1]:

> A 32-year-old man who drives a *matatu* (an informally operated miniature bus) for a living deposits 5000 Kenyan shillings at the local mobile-phone shack. Although he normally visits the shop to add to his mobile talk-time (most mobile phone accounts in the developing world are pre-paid), in this instance, he requests that the money be added to his M-PESA account and provides the shopkeeper with his mobile phone number. She complies, and a few seconds later, he receives confirmation of the transaction via a single SMS text message.
>
> The man then performs a few manipulations on his mobile phone — a sequence that he learned a year ago

[1] This story is based, in part, on work by Morawczynski and co-workers [95, 96] and Ratan and co-workers [90].

> from a good friend — for which he receives another SMS confirmation: he has successfully sent 4000 Kenya shillings (Ksh) to his mother's mobile number. His mother lives in Nguni, a rural town about 70 kilometers away. Because she is illiterate and cannot distinguish between spam SMS and M-PESA notifications, he calls her immediately. They chat for a bit, and she tells him that she misses the time when he used to come see her more often. He responds that he wishes he could come home more often, too, but the roads seem to get less and less safe each month, even for an experienced matatu driver like him! At least, he can send her money safely now without having to worry that he'll get car-jacked and mugged on the way home. As he hangs up, he thinks about whether to spend or save the remaining Ksh. 1000.
>
> In Nguni, the man's mother sees that, in fact, the little square mark on her mobile has come on. So, she walks to the central petty shop in Nguni, hands the trader her mobile, and asks him for the cash. The trader reads the SMS and confirms the transaction, but says that he only has Ksh. 2000 in cash today, so she'll have to come back tomorrow for the rest. The mother takes the Ksh. 1960 (Ksh. 2000 less commission) and agrees to come back in a couple of days, not realizing that the trader, at her expense, will cheat her. He will take twice the commission he would have received if he paid her in one shot, as he is contractually obligated to do.

This is a typical usage scenario for M-PESA, a mobile payment service run by Safaricom that is wildly popular in Kenya. M-PESA transacted over US$1.7 billion in mobile payments since beginning in March 2007, and now has over 7 million customers [15].

For a designer or researcher interested in user experiences with technology, the service raises a rich array of interesting questions, ranging

from those that are specifically usability-focused to broader and more philosophical questions:

- Can mobile-phone interfaces be designed such that even illiterate users can use them?
- Do new research methodologies need to be devised to work with subjects who can't read?
- Who is "the user" when one person asks another to perform a device task?
- Are there patterns of device usage that are consistent across developing countries? And, can design recommendations be tailored to such patterns? Or, is there something special about Kenya that would suggest that similar services elsewhere would not necessarily succeed?
- Do designers carry an ethical burden in such circumstances, of ensuring just use of the technology?

These are the kinds of questions asked by a growing field called "information and technology for development," or ICT4D. ICT4D considers how technologies such as the personal computer, mobile phone, and the Internet can contribute to global socio-economic development of economically impoverished communities.

Many of the questions of ICT4D are those that people in human–computer interaction have been asking for decades in other contexts. In fact, HCI already figures prominently in ICT4D projects, though it is not always called "HCI." The Association for Computing Machinery's special interest group on computer-human interaction (ACM SIGCHI) defines human–computer interaction as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [54, 55]. By this definition, *all* of the questions enumerated above could be considered legitimate questions of HCI. In fact, in their foundational textbook on HCI, Schneiderman and Plaisant wrote, "As a profession, we will be remembered for how well we meet our users' needs. That's the ultimate goal: addressing the needs of all users" [124].

A key tenet of this article, therefore, is that HCI is central to ICT4D — it was so even before people who called themselves "HCI

researchers" were involved, and it will continue to be true, until the failure of the last gadget in the world's last non-profit organization. HCI has great potential to influence global development where computing technology is involved, and its methodology could be a model for development even without technology.

What about the converse? What can HCI gain from engaging with global development? Hopefully, this article will provide an adequate basis for readers to come to their own conclusions, but here are some possibilities.

First, global development presents largely unexplored territory for HCI research, terrain which will become increasingly relevant. In 2008, there were 1.2 billion PCs in use [23], and most of HCI so far has been focused on those 1.2 billion devices. This means that a much larger group of people, numbering over 5 billion, has not been addressed by the majority of HCI research — many of them live in cultures that may respond in new ways to modern technology, and in any case their experience with computing devices will be different from past users. While this latter population is largely unfamiliar with PCs, they are meanwhile becoming rapidly familiar with another powerful computing device — the mobile phone. There were 4.6 billion active mobile-phone accounts in the world in 2009 [63]; this is more than the total population of the world today who are over 20 years of age.[2] All this suggests that what ought to be considered the "typical user" and the "typical computing device" will shift from what have been the traditional concerns of HCI and computer science more broadly.

Beyond such quantitative trends, ICT4D also poses qualitatively new questions to the HCI community. For example, UNESCO estimates that in 2009 there were 774 million illiterate adults in the world [143], and this number is likely conservative. How should one design user interfaces for non-literate users? And, even if you can read in your own language, software is written primarily for the world's dominant languages. Many languages are spoken only by small communities, for which it is cost-prohibitive to localize software. Are there

[2] These statistics do not necessarily mean that every adult on the planet owns a compute-intensive mobile phone, as many countries have penetration rates above 100%, and individual phone ownership in the world's very poorest communities still remains rare.

ways to extend software reach without all-out language localization? Or, consider that there are cases when the cost of an SMS text message becomes a barrier for services that save lives [128]. How should user decisions based on pricing of products and services be incorporated into HCI methodology? Many people in low-income communities are intimidated by new technology, or have little experience answering hypothetical questions. What new methodologies can be devised to overcome such experimental challenges? These are just a few examples of questions that emerge in ICT4D contexts which expand HCI's borders.

Engaging with different populations can also temper overgeneralization in HCI. It is frequently lamented that undergraduate students are not a representative sample of the human population, and yet a good portion of psychology and HCI studies are conducted almost entirely with such biased samples. An implicit assumption of generalizations drawn from these studies is that undergraduate students in developed countries are reasonable representatives of modern PC users, at least with respect to traits that matter for HCI. Not all such claims, however, will extend to people from very different groups, such as those who are preoccupied with the source of their next meal, or those who keep track of critical business contacts entirely in their head. Thus, HCI in developing-country contexts may help add greater precision to existing claims.

At a personal level, involvement with HCI can bring great rewards to the researcher. Many HCI researchers go into "the field" out of a concern for people and a desire to support them in their interactions with technology. Certainly, there is satisfaction in discovering the critical set-top box feature that consumers seek out, or the UI nugget which helps an office worker use spreadsheets 10% more efficiently. Imagine, though, if that attention were directed not just at increasing convenience in suburban homes or efficiency of office work, but at easing suffering and alleviating poverty? If the design of a computer system could help a rural healthcare system deliver vaccines 5% more effectively, that would likely be at least as satisfying as making an online social networking site 5% easier to navigate.

Finally, as discussed further in Section 3, ICT4D tends to emphasize participatory approaches, and this is perhaps where HCI for global

development exerts its strongest pull. Researchers work closely with partners and collaborators in the field — whether it is in the slums of Nairobi or in the arid desert of Rajasthan. Work in such environments often comes with significant challenges, but the emotional returns can be dramatic. Few things are as rewarding as witnessing the moment when a child who has barely interacted with books, first interacts with a PC. Or, when a smallholder farmer who is featured in a how-to video, first sees himself "on TV". Or, when a slum resident discovers to her surprise that she can find relevant jobs via her mobile phone. These are common experiences for the researcher working in ICT for global development.

This article will provide background to ICT for global development (Section 2), discuss the methodological and historical interplay of HCI with ICT4D (Section 3), provide examples of HCI projects in global development (Section 4), pull out recurring themes and lessons (Section 5), and conclude with some thoughts on future directions.

This article is by no means an exhaustive survey or a thorough history of the field. Despite its youth, ICT4D has covered wide ground, touching just about every domain of global development and many geographies. Instead of attempting a comprehensive overview, a compromise between breadth and depth has been attempted. Moreover, the focus of this article is on the most mature class of ICT4D research — that in which beneficiaries of development efforts directly interact with technology. Other ICT4D possibilities, such as the use of ICT in the operations of development organizations, ICT for networking among development professionals, or ICT for policy-making, are not given as much attention, in part because these applications of ICT have not yet received as much attention among researchers. Perhaps a future issue of this series will provide introductions to these other flavors of ICT4D.

In any case, it is hoped that the contents will provide a point of departure for those in HCI who are new to global development, as well as provocation and ongoing discussion for those who are already involved.

2

"Information and Communication Technologies and Development"[1]

2.1 The "D" in ICT4D

"Development" is international development or global development. There is no formal consensus on exactly what development is, yet a useful approximation to start with is the following: global development involves deliberate attempts to lessen or eliminate economic poverty and the undesirable states correlated with it — poor health, low levels of education, lack of political power, greater unhappiness, and so on. It is an international activity that focuses primarily on the economically poor countries of the world (also labeled "third world countries," "developing countries," or "low-income countries"), but it could also include attempts to improve the quality of life of poorer populations in wealthy countries.

For some, development is strictly about economic growth; others believe it is about political empowerment; still others suggest it should focus on happiness or subjective well-being. Yet, while there is no agreement about the exact goals, there is approximate coherence to the concept of development, perhaps defined best by what it is

[1] Some of this material is adapted from Ref. [137].

not: development theorists and practitioners are rarely concerned with further improving the well-being of the relatively rich and powerful, except as an side effect.

Global development is a relatively recent activity, with a history not much longer than half a century. In part, this is because the huge gaps between rich and poor countries are themselves a new phenomenon in the long span of human civilization. Economist Jeffrey Sachs notes in his book, *The End of Poverty*, that even in 1820, there was little difference among countries in their per-capita GNP [115]. Beautiful visualizations of these and other facts can be generated with Gapminder — an instance of HCI information visualization tools applied to global development statistics [41] — where twiddling with a few knobs shows that no country earned a per capita GNP[2] greater than $4000 per year until around 1860, and few had life expectancies above 40 years. In 1940, a handful had per capita GNP above $10,000. As a result, prior to the middle of the 20th century, countries, if they were consciously focused on "development" at all, were focused on developing themselves.

Then, with the ending of World War II, the seeds were planted for explicit global development. The International Monetary Fund and the World Bank were conceived in July, 1944 at Bretton Woods [61, 148], and also around that time, the United Nations was also proposed — it was eventually founded in October, 1945 [144]. At their inception, these organizations concentrated on post-war reconstruction and the prevention of another Great Depression, and a new field of "development economics" was born. Economists began with the reconstruction of countries devastated by the war, but they quickly shifted their attention to developing countries, reasoning inductively that policies that helped rebuild countries could help grow poorer countries, as well. And so, the charters of the UN, the IMF, and the World Bank rapidly expanded to include assistance for the development of economically poor countries. Development efforts gained momentum with the Cold War, when the United States, the Soviet Union, and their allies intensified aid to Third-World countries in an effort to curry ideological favor [51]. Over

[2] Adjusted to 2005 purchase-price parity dollars, as set by the World Bank's International Comparison Program, a group that collects and analyzes comparative price data across countries.

the decades, global development has formed an autonomous identity of its own (though it remains strongly influenced by international politics) and involves a growing number of governments, multilateral entities, non-profit organizations, and for-profit corporations.

What makes global development of increasing interest to HCI is that recently, the international development community has begun to seek out electronic technology as a way to further the development agenda.

2.2 The "ICT" in ICT4D

This is not to say that technology has never played a part in global development; in fact, it has from the beginning. The earliest equations of macroeconomic growth hypothesized that more, or newer, technology was the key to a country's growth, though they tended to conceive of technology as industrial machinery that amplified human labor [35].

Electronic technology was not far behind, however. Televisions, for example, were common in US households by the mid-1950s, and by the 1960s, researchers and development specialists were pushing them for global development. Wilbur Schramm, often considered the founder of communication studies as a field of research, wrote in 1964:

> . . . television has never been used to its full capacity in support of economic development. It may be financially impossible to use it in this way. But still the possibility is tantalizing: What is the full power and vividness if television teaching were to be used to help the schools develop a country's new educational pattern? What if the full persuasive and instructional power of television were to be used in support of community development and the modernization of farming? Where would the break-even point come? Where would the saving in rate of change catch up with the increased cost? [119].

This excitement around commodity analog hardware carried through into the 1970s, but appears to have waned by the 1980s, perhaps because despite the increasing penetration of the radio and TV, evidence of impact on poverty was not significant [78].

Beginning in the mid-1990s, efforts to apply electronic technology to development were revived with the commoditization of digital technologies. The personal computer (PC) kicked off this recent wave of technology for development, and early work considered how PCs could help non-profits and other development-focused organizations streamline their operations. This application of PCs, of course, is not very different from the use of PCs in offices, and so few people with interests in innovation took notice.

By the late 1990s, however, a new phenomenon was beginning, ushering in what could be considered the first big wave of ICT4D: the telecenter. Though burdened with many names — "PC kiosks," "rural kiosks," "village knowledge centers" — and many different shades of meaning, a reasonable definition is that telecenters are physical centers "which exist primarily to provide the general public access to computing and/or the Internet with the explicit intent to serve a developmental purpose." They are related to, but "different from public phone booths, from computer classrooms, from rural data-entry centres, from computerized post offices, and from Internet cafes" [138].

Because of their developmental focus, telecenters are typically placed in or near poor neighborhoods, both rural and urban, and seek out clientele from economically poor backgrounds. This difference in locus turns out to have a dramatic impact on usage styles and statistics. As early telecenter implementers quickly discovered, this reality prompted a range of questions that would make any HCI researcher shiver with excitement: what kind of client is most likely to use a telecenter [139]? How do clients respond to user interfaces in languages they are not fluent in [58]? What sort of social interaction occurs if you allow distant telecenters to communicate via video teleconference [65]? How can clients be encouraged to partake of telecenter services [10]? Does the placement and orientation of the PC influence usage paradigms [132]?

Telecenters as a whole are difficult to operate [121], and so the success of any single telecenter is often crucially dependent on the answer to these kinds of questions. These days, it is rare to read reports and case studies of telecenters without finding a section that reads much like a tutorial on doing HCI: Identify a real problem. Involve the user

in the design process. Keep things simple. Consider factors beyond the technology. Understand *all* the stakeholders.[3] These challenges stretch the boundaries of HCI by going well beyond typical usability concerns, but remaining within a broad notion of human–computer interaction.

Telecenters continue to be promoted in development circles, but the early hype has waned. Research thus far, which has largely been of a qualitative nature, suggests that telecenters are not easy to sustain economically (and otherwise), and that the developmental impacts are difficult to achieve [8, 121]. Researchers themselves appear to have tired of the topic, and each year witnesses fewer publications on telecenters.

ICT4D is much broader than the telecenter, however, and parallel efforts have considered how other recent technologies could be relevant to development. Novel wireless technology has been used to provide data connections to remote rural areas that are otherwise unconnected [7, 108, 112]. Personal digital assistants have assisted rural healthcare workers [25, 117]. Video has seen a revival, now that end-to-end video production systems can be bought for a few hundred US dollars [40]. And customized gadgets are being built, taking advantage of the miracles of Chinese manufacturing [21, 130].

A recognition of the importance of lower-tech media, such as print or audio by itself, has also spawned renewed interest in technology that mediates the interface between digital and physical [104, 114]. Older technologies might not strictly fall into contemporary notions of ICT, but they nevertheless remain a critical component of end-to-end systems, just as paper never went away in the developed world despite predictions of a paperless office. In any case, HCI questions abound, because for every technology, there is a user, and in ICT4D, the user is more often than not, someone very different from the typical user imagined by HCI researchers.

Without doubt, however, the most visible ICT4D technology is the mobile phone. Its startling global penetration roused even the most jaded researchers. While North Americans were still wondering what

[3] See, for example, Ref. [48]. In addition, *Telecentre Magazine* provides a wealth of such articles.

"texting" was, mobile phones reached into nooks and corners all over the planet.[4] The social value of mobile phones is not unsurprising [27, 28], but prominent research with mobile phones has even identified immediate economic gains — something which has eluded research on telecentres, for example. Econometric analysis suggests that for penetration of mobile phones in the general population accounts for additional GDP growth [147]. A more methodologically solid study by Robert Jensen shows strong evidence that south-Indian fishermen and their customers each saw measurable economic benefits due to the introduction of the mobile phone — mobiles allowed fishermen to make intelligent decisions on which coastal market to haul their catch to, thus eliminating price variation and inefficiencies across markets [64]. And, a project called the Grameen Village Phone allowed over 300,000 women in rural Bangladesh to boost their incomes by becoming door-to-door phone booths for their otherwise unconnected villages [133].

Mobile phones, of course, had already opened a new playground for HCI (Europe's MobileHCI conference was started in 1998 [94]), and with their wide adoption even in developing countries, much of the HCI research in ICT4D shifted platforms. In the research community, Tapan Parikh led the charge with CAM, a toolkit for developing data-entry tools that used camera phones as barcode readers [105], with in-field experimentation in microfinance.

As of this writing, ICT4D remains enthralled with the mobile phone. Research has expanded in multiple directions at once, each with its own HCI questions. Some avenues explore what can be done with a simple phone, restricting communication to voice [75, 80], SMS text messages [28, 145], or the less well-known Unstructured Supplementary Service Data (USSD) channel [135]. This technical restriction, however, occurs only on the client side — the server side may involve call centers operated by live people, interactive voice-response (IVR) systems, automated speech recognition (ASR) servers, and so on.

[4] However, despite the astronomical rate of growth, plenty of households in poor rural areas are still without a mobile phone, and sparsely populated areas remain out of cellular reach. Poor, disempowered women living in remote areas remain disproportionately without access to phone service.

Others view higher-end mobile phones as PDAs with connectivity. In fact, much of the early work with mobiles in ICT4D came from development practitioners, who saw their PDAs being superseded by mobile phones. Organizations that equipped rural healthcare workers with PDAs, for example, have shifted to mobile phones [117]. Still others anticipate the rise of "mobile-only Internet" [30], where increasing numbers of users, particularly in the developing world, experience the Internet for the first time on a mobile phone.

Researchers, of course, are not the only people to innovate, and some of the most inspiring stories in ICT4D happen when users adapt mobile phones to suit their own circumstances. Jan Chipchase, an ethnographer and designer earlier at Nokia, has made a career out of discovering such adaptations [19]. In Uganda, for example, entrepreneurs provide "cash out" services (for a fee) for mobile talk time, effectively turning exchangeable phone credits into a viable currency [20]. Some credit this gray market activity as the inspiration for M-PESA [1]. Elsewhere, microentrepreneurs charge car batteries in urban areas, transport them to rural areas without electricity, and offer mobile-charging services. Other researchers have written about other adaptations — Nithya Sambasivan and colleagues [116] discuss the role of intermediaries who operate technology on behalf of someone else.

In any case, as physical access to mobile phones becomes all but universal, HCI has an opportunity to engage not just with the 1+ billion people who regularly consort with PCs, but with the remaining several billion inhabitants of the planet.

2.3 Larger Context of ICT4D

ICT4D is, therefore, an activity with truly global potential. But, it is also one that requires an international perspective involving global teams. For HCI, this means yet another opportunity — to engage with researchers all over the world whose perspectives will undoubtedly enrich and inform current practice. ICT4D could broaden the HCI community along at least three dimensions.

First, ICT4D work occurs in countries outside of the normal range of HCI research — in Africa, South Asia, Latin America, the Caribbean,

Oceania, and so forth. Even within rich countries such as the United States, ICT4D enters poor communities that are rarely considered by HCI [83].

A second aspect of ICT4D is its multi-sectoral nature. Typical HCI research is an activity that focuses on academia and industry. Occasional work might consider the special needs of another sector, and those who are inclined towards policy might have some interaction with a government. ICT4D, however, is inextricably tied not only to academia and industry, but also to governments, multilateral entities (such as the UN or the World Bank), as well as civil society and non-profit organizations.

Third, academic ICT4D is expansively interdisciplinary, perhaps even more so than HCI. The earliest research in ICT4D was done in departments of information systems, communications research, and science and technology. These groups were observing technology trends in developing countries before the first computer scientists arrived [52]. Engineers, designers, computer scientists, and HCI researchers came relatively late to the game — this is not unexpected, given that few engineering PhD programs involve travel to a third-world country. Like HCI, ICT4D also brings in anthropologists and sociologists; but it also works with economists, geographers, political scientists, and those in development studies. The latter researchers tend to have a foot firmly in their home fields, while also contributing to ICT4D. A ICT4D research community is just beginning to coalesce, with conferences such as the IEEE/ACM International Conference on Information and Communication Technologies and Development (ICTD) striving to harmonize a diverse chorus while maintaining the pitch and quality of each voice.

As with any field with a broad constituency, interdisciplinarity can be a curse as much as a blessing. Fierce debates have broken out regarding what might and might not be ICT4D, as well as the standards by which good ICT4D research can be judged [13]. HCI as a field can bring a lot to these discussions based on its own history of integrating anthropology, human factors, cognitive psychology, and computer science.

It should be noted that these debates have not been settled, any more in ICT4D than in HCI, nor is it likely that they will ever be

settled once and for all. Often times, the debates seem to be based more on temperament as in the case, for example, between those who find generalizable technology interesting versus those who find unique individual or cultural reactions to technology interesting. The reality is that neither side has the full view, and both are needed for a complete picture to emerge. For some, the debates themselves make the fields more intellectually vibrant. Nevertheless, HCI has had more experience than ICT4D in asking these questions, identifying pockets of consensus, and proceeding practically despite disagreements. Thus, there are likely things which ICT4D can learn from HCI, whether it is the structure of philosophical debates within HCI [32], or the practical wisdom around how to review papers [18]. Such experience could serve as meaningful guidance for navigating ICT4D's future evolution.

3

HCI and ICT4D

HCI thus appears to have much in common with aspects of ICT4D. This section explores these points in greater detail.

3.1 Methodological Overlap

Over the years, HCI research has converged on a set of methodologies that are widely agreed upon, if not in the details of execution, at least at a high level in terms of their value. Broadly speaking, these might be categorized into (1) qualitative methods and user studies, (2) design and iterative prototyping, and (3) evaluation [26].[1] In addition, HCI brings to computer science the fourth activity of reflection — researchers stepping back from the technical details of their work and considering the larger social implications of their research. These classes of activities are also common in ICT4D work, and though ICT4D tends to draw from an even larger set of methodologies and disciplines

[1] These activities frequently occur one after the other, but they may also occur in other configurations. Some research projects focus on one aspect, applying only a single methodology; others cycle through multiple methodologies in quick succession; still others may overlap and fuse methodologies.

(e.g., agriculture, economics, or public health) HCI is unequaled in its methodological scope and overlap with ICT4D.

3.1.1 Qualitative Research and User Studies

Qualitative research methodologies were among the first methodologies used in ICT4D research, as ethnographers studied the adoption of modern technologies in developing countries. Qualitative methods include those methodologies most often attributed to anthropology and qualitative sociology, though they are increasingly used by a variety of fields. For data collection, researchers rely on participant observation, in-depth interviews (structured and open), focus groups, and other non-quantitative methods, in which depth and richness are sought over quantity or representative sampling. Raw data might then be formally coded or summarized, and the data is analyzed, using discourse analysis, content analysis, analytic induction, and so forth.

Much of this work is informally called "ethnography" although formally trained ethnographers complain that few people in either HCI or ICT4D spend the time or the breadth of engagement with communities that would merit that label. More often than not, researchers are engaged in something more akin to HCI's qualitative user studies, with the differences that the focus is on subjects' real or potential interaction with either technology or development-focused mechanisms, and that subjects may not be yet be actual users of technology.

The goals of qualitative methods are deep understanding and "thick description," in the sense of Clifford Geertz [42]. In-depth analysis of meaning, motivation, and overall context of human behavior is sought, often revealing profound causes for differences in culture. In the context of global development, a major category of difference is that which accompanies disparities in wealth. Many of the more intriguing research questions arise when socio-economic constraints lead to cultural differences that take on a life of their own. For example, limited economic means encourages a culture of sharing — observers have noted that PCs are not strictly "personal" in many schools [102], and that mobile phones, which are highly personal in the developed world, are aggressively shared in developing countries [116]. Habits born of resource

constraints lead to cultural phenomena which take on a life of their own, which explains in part why patterns of mobile-phone usage differ so much from country to country.

Both in HCI and ICT4D, this kind of in-depth understanding is often seen as the basis for invention and intervention. Some ICT4D practitioners would go so far as to argue that knowledge that does not lead to design of interventions is not worth pursuing. What is the point of knowing that people share phones unless it leads to impact that helps alleviate their poverty? Others, however, raise a debate often heard in HCI circles: that qualitative research ought to be a first-class endeavor that need not necessarily lead to concrete application to be worthwhile. This perspective is perhaps best articulated in the HCI community by Paul Dourish [32]; many in ICT4D would subscribe. Even the label, "ICT4D," itself is suspect; "4" implies application, for which some explicitly substitute "and," with the less application-focused abbreviation, ICTD.[2]

A conciliatory viewpoint suggests that a little mutual respect goes a long way. On the one hand, it is, in fact, very rare for good qualitative research not to have potential application. It is difficult to imagine interesting qualitative results that could not somehow be relevant to an ICT4D intervention — any new knowledge about people provides additional input for the engineer or the designer. In any case, it seems valuable to encourage all research around people's interaction with technology, unfettered by an artificially imposed intent to drive interventions. The path from knowledge to application is not always obvious at first. At the same time, the interventionists in development are, in fact, primarily interested in knowledge for the sake of application, so conclusions drawn in such a way that others could apply them have additional value beyond less interventionist findings.

On the other hand, some practitioners have learned a healthy skepticism for the so-called "needs assessment," in which flimsy processes for identifying actual needs on the ground are presumed to result in a good understanding of people's needs and desires. Invariably in ICT4D,

[2] Indeed, this is the very reasoning behind the choice of the name of one of ICT4D's premier academic conferences: the International Conference on Information and Communication Technologies and Development (ICTD).

needs assessments reveal that people need better healthcare, education, clean water, job opportunities, ability to fight injustice, and so on. In short, nothing surprising. It's not that needs' assessments aren't necessary — they are vital — but, rather that following a process for a needs assessment is no guarantee that interesting needs will be discovered, any more than writing a good business plan makes one a successful entrepreneur. Far more important is to spend sufficient time with the community with open eyes, ears, and mind, and to try to absorb people's sensitivities and cultural inclinations. If making life better, easier, or happier is an objective, then a thorough intuition for the potential user lays the foundation for design.

3.1.2 Design and Iterative Prototyping

Good design is an elusive beast. It could perhaps be described as a parsimonious satisfying of constraints in an aesthetically pleasing manner, but this only begs the question of defining "parsimonious" and "aesthetically pleasing." Luckily, both HCI and ICT4D have practical ends in mind, and tend to set aside the mystical side of design and focus on the more pragmatic. HCI asks of its designs, "How does it simply life for the user?" "Do users prefer X to Y?" "What is more easily learned or more quickly executed?" The analogous questions in ICT4D might be, "How does it improve life for the user?" "Does the community prefer X to Y?" "What is more readily learned or more cost-effectively executed?"

These questions can be put directly to users, if they have a chance to interact with prototypes. Thus, the best projects in both HCI and ICT4D typically involve a process of iterative prototyping and testing that adapts and modifies an initial design. This process is even more critical to good design in ICT4D because those driving the design have such different frames of reference from potential users. In HCI, for example, it's common for computer users to design interfaces for other computer users — the designer can lay claim to some minimal intuition about the target user (although, even then, the field is full of poor intuitions and misguided designs). In ICT4D, well-off graduates of engineering schools might take on the design of a low-cost PDA for use by rural farmers. Even after thorough qualitative research, it is difficult

for the former to gain accurate intuition for the subjective lives of the latter. Prototyping and testing is thus all but necessary to ensure that an initial guess in design does in fact fit with the intended user.

ICT4D research is filled with stories of grand ideas on paper being shredded to confetti in the first minutes of prototype testing [29]. Conversely, some of the best ICT4D projects have come from months of iterative design, as was the case with Digital Green, where Rikin Gandhi, the lead researcher on the project spent six months trying various different things with video in a rural village to see what would most appeal to local farmers [40].

3.1.3 Evaluation

HCI inherits evaluation methodologies from several fields, and these have also been passed onto ICT4D through HCI researchers working in ICT4D. Among the more dominant methodologies are those that come from cognitive psychology, qualitative methods, and computer science. For example, to get at questions of user preference, users might be asked to fill out questionnaires (with, e.g., questions posed on Likert scales), or to perform tasks while reaction time is measured. Interviews can reveal user preferences, as well as a variety of other information, though such data is often subject to self-reporting biases. Qualitative research stresses in-depth interviews, participant observation, and careful analysis of subjective meaning that people ascribe to newly introduced technology. Computer science brings with it a tradition of instrumentation, in which the user's every action is digitally logged for more objective, if semantically limited, data.

ICT4D, drawing as it does from a broad spectrum of disciplines, augments these methodologies with others, as well. The sociology community, for example, is adept at hybrid methodologies that mix elements of qualitative and quantitative work. Examples include Q-sorts, in which ranked qualitative preferences can be clustered for quantitative analysis, as well as quantitative evaluation of qualitatively gathered data. Recent work in the economics community with randomized control trials has also introduced empirical scientific methodology to the development community, even beyond public health [34].

There is some gnashing of teeth in both the HCI and ICT4D communities, concerning the use of qualitative versus quantitative methods for evaluation. However, in both communities, it's clear that the fields benefit from a broader perspective that comes from having both ends of the spectrum involved. It cannot be one or the other alone. Statistically significant quantitative evaluations are necessary to ensure internal validity — that findings aren't due to the whims of chance. To the extent possible, potentially important results should be verified through large-scale randomized trials of the user population for whom the conclusions are being drawn. For budget and logistical reasons, such experiments are not always easy to do in an idealized form, but the closer to the ideal, the more reliable the outcome. On the other hand, it's also clear that studies conducted at large-scale inevitably miss many of the interesting details and nuanced responses of users. Thick description is a foil to oversimplified explanations that may arise from analysis of quantitative data, and it is often a fount of new ideas, causal explanations, and technical possibilities that rarely emerge from surveys and multiple-choice questionnaires. Here, again, the strength of HCI is that it has dealt with these issues of interdisciplinarity, and has for the most part, been able to respect the unique strengths of different methodologies.

One thing that global development emphasizes in evaluation is an eye on the end goal. So, for example, if the goal is education, it's not enough for a new technology to delight students (however that might be assessed) — some concrete benefit to learning must be demonstrated, whether through test scores, self-confidence instruments, or perhaps increased income opportunity. Similarly, it's not quite enough to show that a UI improves task completion time by 40% in an application for rural healthcare workers; it's further necessary to show that that 40% does in fact lead to more patients visited or, even more conclusive, better health for the population. Indeed, one informal critique of HCI that is commonly heard among ICT4D practitioners is that HCI researchers often seem happy to have demonstrated that a handful of users expressed joy in using a technology, without showing a concrete development outcome. (In all fairness, however, it should be mentioned

that even development specialists struggle to evaluate projects against their desired outcomes, and with the exception of public health and agriculture, the trend towards rigorous examination is a recent phenomenon in global development.)

3.1.4 Reflection

One of the great strengths of both the HCI and ICT4D communities is their capacity for reflection and self-critique. Borrowing the traditions of qualitative research and critical theory, members of both communities have raised questions both about their fields overall, as well as specific practices or trends in the communities.

Paul Dourish, in a paper eloquently outlining of the main issues faced by ethnographers in HCI, provides a perfect example of this reflexive capacity [32]. This paper stands out because the content is composed entirely of an analysis of the field of HCI itself — how it situates and views ethnographic work. These questions are foundational for the anthropologists and qualitative researchers in HCI, and important for the computer scientists who interact with them.

Similarly, international development imposes questions on practitioners — the question of development goals simply cannot be escaped, since any attempt to make the world a better place implies some definition of "better." For instance, although economic development in terms of per capita Gross National Product (GNP) or Gross Domestic Product (GDP) reigns in discussions of international development, many scholars have questioned the use of these figures as measures of "development." Among the most recognized critics is Amartya Sen, the Nobel-prize winning economist, who argues that increased freedom and capability, rather than increased income, should be the focal point of development [120], and these debates have trickled into ICT4D work, as well [71]. Ratan and Bailur [113], for example, consider the decision faced by development organizations in supporting projects where the objectives of the funders conflict with what beneficiaries want out of the project. For anyone hoping to do evaluations of their HCI work in development, these kinds of questions precede the technical details.

3.2 Methodological Differences

Thus, there are a range of similarities between HCI and ICT4D. Of course, the two fields are not identical. There are a number of differences between HCI and ICT4D that are also worth calling out.

3.2.1 Practicality versus Technological Dazzle

Perhaps among the most prominent differences between HCI and ICT4D is ICT4D's strong emphasis on practicality and potential for genuine impact. In mainstream HCI, it's perfectly okay, even encouraged, to consider wild ideas and technological fireworks that stretch the imagination. HCI research, in particular, is hungry for new technical ideas that provoke and dazzle. "How is this new?" is a question that paper reviewers have in mind when judging a research article.

In ICT4D, however, there is a strong emphasis on pragmatism. Despite a tendency for technocrats to look for problems to be solved by the latest technology, the field as a whole tends to frown on technology for its own sake. Much of the research in ICT4D, therefore, focuses on what is actually possible in a remote rural village, and what real barriers face a technology in an urban slum. Where HCI is happy with user studies conducted in usability labs, ICT4D wants to see the technology taken out into the field, where real conditions differ greatly from those in a lab.

One prominent way in which this difference impacts HCI is that in work for development, cost-benefit considerations and economic analyses of projects are critical. Since ICT4D takes place in the context of scarce resources, costs cannot be ignored. In making a case for ICT4D work by computer scientists, Brewer et al. [12] call out cost considerations as one of the defining characteristics of ICT4D work. A later paper by a subset of the same authors, presents a nice framework for considering economic sustainability of ICT4D projects: It suggests that initial capital costs can be underwritten by development grants and donations, but a project must at least be able to cover its own operational costs to be financially viable [134].

In any case, ICT4D is almost always concerned with the costs of owning and operating technologies successfully — a project that

expects farmers earning a dollar a day to invest in a $1000 device would be subject to derision, and heated debate might ensue around the viability of the same project at $100 or $10. Such discussions often lead to questions about the choice of device, with cost being a large part of the consideration. One camp might argue for a PC-based telecenter, while another recommends mobile phones [70], and a third raises the possibility of PDAs. Where money is scarce, cost, and not usability, may be the deciding factor.

This is a difference that is likely to persist between the two fields, and the differences are healthy for each field. HCI as a whole should consider far-out technologies that might take decades to be affordable, if at all; and ICT4D should be concerned with costs to the extent that it is an issue.

3.2.2 Route to Scale

Most researchers would like to see wide-scale application of their work. The typical HCI researcher is most likely to imagine that this will happen through commercialization of their artifacts or industry adoption of recommended practices. Furthermore, they can be somewhat cavalier about how exactly this might happen: Perhaps engineers in large corporations will find out about their published work, and then complete the engineering required to make interesting ideas happen. A few researchers will patent their ideas or found start-up companies around their ideas, but most are content to contribute to the ongoing academic dialogue.

In ICT4D, researchers are more likely to expect any large-scale impact to happen through government policies or by convincing multilateral organizations like the United Nations or the World Bank to recommend them as "best practices" to civil society. And, for reasons that are not entirely understood, ICT4D researchers appear more vested in the eventual implementation of their work [146]. ICT4D research itself, thus, appears more concerned with what is practically achievable, and how a project might scale. Researchers in ICT4D are as likely to obsess about what will make an idea work in the real world, as the organizations who are actually implementing projects.

And, because these concerns go well beyond finances, to social, cultural, infrastructural, and political challenges, ICT4D researchers are wont to extend their research itself to a wider range of topics.

There is a danger to ICT4D's multidisciplinary reach, though. In the desire to solve problems end-to-end, focus can blur, and research can become diluted. It's often not clear where rigorous research ends and one-off problem solving begins. Here, the experience of HCI in extracting clear research problems out of complex human–machine systems is certain to help. For example, Ben Schneiderman is famous for his dictum, "Overview first, zoom and filter, then details-on-demand" [123]. Such generalizable research conclusions don't come from solving a single problem. Schneiderman himself repeats the statement ten times in one paper, claiming each instance represents one project in which he rediscovered it.

3.2.3 In Situ Research

As a result of the broader range of issues faced in ICT4D, there is also a greater emphasis placed on in-situ prototyping and evaluation. In developed-world HCI, it's perfectly okay to tinker and tweak in the research lab, and to seat undergraduate students behind half-silvered mirrors to conduct usability studies of technologies meant for office workers. In development-focused ICT projects, however, the tinkering frequently needs to happen on location, and evaluation must eventually happen with subjects drawn from the population intended for benefit. This is simply a statement about the vast and unpredictable gulf between the cultural background of undergraduate students — relatively wealthy, educated, and confident on any scale that includes the world's poorest people — and the groups that development works with.

Poor residents of slums may be intimidated by shiny corporate offices or imposing academic buildings, further heightening any trepidation they might have about being asked to use unfamiliar technologies. It's not hard to imagine that subjects in such circumstances will second-guess answers to researcher questions, such as, "Would you use System X, if it were freely available to you?"

And, a technology that works perfectly well in an air-conditioned office supported by a competent IT support team might fare less well in the dusty heat of a remote village where voltage spikes of 1000 V are not unusual [134]. Consider, too, the difference between watching a video in the privacy and comfort of a sound-proof room and doing so in a one-room home shared by seven family members and visiting neighbors, all clamoring for a view.

Therefore, in ICT4D, researchers place repeat importance on in-situ experimentation and evaluation. Researchers often bemoan the extra effort and unforeseen surprises awaiting researchers hoping to test a new technology [5], and this leads to two critiques, both worthy of consideration. On the one hand, whatever moral value there might be in ICT4D work (due to its intended impact or difficult implementation), doesn't excuse poorly executed research methodology, any more than charitable work grants a license to crime. On the other hand, the research is challenging, and a rigid expectation that complex systems be built on location and tested in a controlled manner needs to be tempered with the value of trying new things in less-than-ideal conditions. HCI appears to be wrestling with similar issues — how to weight the relative value of tightly controlled experiment against in-situ system building — as a recent lament from James Landay [81] suggests.

With increased interaction between the two fields, these differences are likely to contribute to the dynamic interchange between HCI and ICT4D.

3.3 HCI in Technology for Development

With so much overlap in methodology and philosophical background between HCI and development, there's bound to be some history. Although formal activity that is called HCI has only been a recent entry to global development, related activities have occurred for some time.

3.3.1 Appropriate Technology

"Appropriate technology," sometimes also called "intermediate technology," is the name given to a concept that was popularized in the

1970s and 1980s, that focused on designing technology that met the constraints of the local populations it was meant for. By then, international development had seen technology with good intentions misapplied in environments that couldn't use them: Electronic medical equipment gathered dust in clinics without electricity, and oversized tractors rusted unused in remote villages with farms too small to use them.

Thus, technologists sought solutions that worked within infrastructural, material, and human-capacity constraints. One description notes that appropriate technology uses "engineering techniques, physical structures, and machinery that meet a need defined by a community, and utilize the material at hand or readily available. It can be built, operated and maintained by the local people with very limited outside assistance (e.g., technical, material, or financial). It is usually related to an economic goal" [37].

Appropriate technology goes further to look at the human interface to technology, as well, presaging modern human-computer interaction which it preceded by at least a decade. The movement is concerned with "the social structures, human interactive processes, and motivation techniques" [37]. But, even beyond topical commonalities, there are agreements about the methodologies by which new designs were generated: Appropriate technology "is the structure and process for social participation and action by individuals and groups in analyzing situations, making choices and engaging in choice-implementing behaviors that bring about change" [37]. The parallels are uncanny, and appropriate technology could be counted as a precursor of HCI.

Of course, there are differences, too, even apart from a focus on mechanical versus electronic technology. They echo the differences between ICT4D and HCI: Appropriate technology almost always focuses on cost-effective solutions with benefits for impoverished or marginalized populations.

Interestingly, although appropriate technology has traditionally stayed away from complex electronics because they are rarely easy to manufacture or service in developing countries, the recent surge of mobile phones has ignited an interest in ICT4D among appropriate technology enthusiasts. Amy Smith, celebrated for her D-Lab series of

courses at MIT has begun an ICT4D module for students interested in identifying appropriate electronic technology [126]. History thus comes full circle, and we may see a convergence of HCI with appropriate design in global development.

3.3.2 Early HCI for Development

Although there were one-off instances of HCI dipping its toes in global development in the 1980s — for example, an effort in France sought to design personal computers for developing countries, with a clear HCI bent [36] — steady HCI involvement in global development really only began in the late 1990s, a time that coincides with the development community's increasing interest in PCs to support non-profit activity.

For instance, Matt Huenerfauth wrote a prescient masters thesis on designing interfaces for illiterate users [57]. During this time, Tapan Parikh, who was likely the first to be granted a PhD by a computer science department for work that was clearly HCI for development, began much of his initial exploration with technology for microfinance [104]. Meanwhile, several researchers in South Africa began applying HCI to work relevant to developing communities: A group led by Edwin Blake considered software applications relevant to rural areas [17]. Gary Marsden joined Blake at the University of Cape Town and began work with mobile phones [66]. And, Paula Kotzé looked at HCI issues in developing country research and education [73]. In India, Dinesh Katre at the Centre for Development of Advanced Computing also began publishing work on interfaces for illiterate users [69].

Much of what became a steady stream of introspection, analysis, and perhaps some emotional venting, also began during this time, as HCI researchers reflected on their experiences working in impoverished contexts. Cecelia Merkel and colleagues were among the first to write in this genre, and their subtitle is telling: "Tales from the field" [93]. Jacques Hugo mentioned the need for sensitivity to different cultural factors in HCI, particularly as it pertained to developing countries [59]. Jason Pascoe et al. brought attention the UI issues as they impact fieldwork itself [106].

This period also saw the entry of industry-driven HCI through the portal of "emerging markets," which became hot as the new frontier for global businesses. Human Factors International, which is well-known for its usability consulting practice entered the fray [104], as did Dray & Associates, the Center for Knowledge Studies, and so forth.

For those wanting to know more about the history of HCI in development, a nice historical overview of HCI in development has been written by Melissa Ho et al. [55], from which much of the above history has been drawn.

3.3.3 Increasing Attention at Conferences

Since then, HCI efforts in development have become an increasing presence at HCI's most prestigious conferences and journals, among them the Participatory Design Conference, MobileHCI, HCI International, and so forth. Other conferences, such as the iConference (sponsored by Schools of Information) also include considerable HCI work in development. Space does not permit a comprehensive review, but as a way to get a sense for the growth and the trends in HCI research for development, below, we look at the stream of full papers that have appeared at HCI's most prominent publication venue: ACM's *SIGCHI Conference on Human Factors in Computing Systems (CHI)*.

Parikh's thesis work was represented in a CHI paper on CAM, a toolkit that allowed barcodes on paper forms to be read by mid-tier mobile phones, which in turn issued voice instructions and collected data in digital form [105]. This appears to be the first paper published at CHI that explicitly applied HCI for global development.[3]

The next year, a young researcher, Udai Pawar, evaluated the use of multiple mice with PCs as a way to drill English vocabulary for resource-constrained Indian schools [109]. This was an application of an idea that dates back to at least 1991 in the HCI community [11] which itself gave rise to the coinage "Single Display Groupware," [131]. But, SDG had not met with a compelling application until qualitative research of government schools in India by Joyojeet Pal revealed a

[3] Based on an examination of paper titles and abstracts for CHI proceedings beginning in 2001 in the ACM Digital Library.

tendency for students to cluster around single PCs [102]. Pawar showed that for elementary learning tasks, students could learn just as much in a 5-to-1 configuration of students (and mice) to PCs, as in a 1-to-1 setting. Though neither technically new, nor better in terms of impact for each student, it was a dramatic gain in terms of cost-per-student for the value of PCs in education — educational administrators from developing countries (and some from developed countries) immediately understand its value in helping them with the arithmetic of matching $X budget to Y students. Neema Moraveji later extended the multiple mouse concept to an entire classroom, where 20 or 30 students could all have mice manipulating cursors on a single projected screen in a classroom [95].

Also in 2007, Matthew Kam and Divya Ramachandran, both working with John Canny, published preliminary papers of their explorations in India. Both papers examined the design process of working in developing communities. The fruits of Kam's work appear in CHI 2009, where careful designs of instructional games on mobile phones are used to enhance education in schools in India. Ramchandran's work appears later in CHI 2010, where providing rural healthcare workers with mobile phones and video clips appears to provide some support for their efforts.

Some work at CHI has focused specifically on the needs of non-literate users. Indrani Medhi compared several options for UIs on a mobile phone with respect to its usability for illiterate users. She found that there is a tradeoff between rich multimedia UIs that combine voice and images, and those that work primarily through interactive voice response — the former sees shorter times for task completion, but the latter is more likely to reach task completion with fewer human prompts [89]. Leah Findlater considered whether semi-literate users, who can make out letters, but are not fluent readers, would benefit from text in UIs, and found that they become both quicker readers of frequently viewed text, and also become quicker at manipulating UI tasks [38].

Chris Le Dantec and Keith Edwards opened a new horizon for HCI in development by considering the homeless in a wealthy country — the United States [83]. They have considered social services as they're delivered in America, as well [84].

CHI 2008 was the first year in which an entire session was devoted to HCI for development. Titled "Healthcare in the Developing World," the session featured three papers led by Rowena Luk, Brian DeRenzi, and Karen Cheng. Luk et al. leveraged the power of social networks to develop an asynchronous system for medical consultation in Ghana [85]. DeRenzi et al. [25] trialed a PDA-based system that allowed rural healthcare workers in Tanzania to run a UNICEF protocol for childhood illnesses digitally. And, Cheng et al. [16] tested PDA's as an instrument for collecting sensitive medical data in Angola.

By 2009, there were eight relevant papers, and not all will be described here, as they include themes already discussed above. However, one line of interesting work concerns the use of technology in war-torn countries. Gloria Mark et al. interviewed 45 Iraqi citizens and their use of technology during the Iraq war [86]. They found that PC-based Internet, mobile phones, and digital cameras were all used in an organic process to maintain social and logistical networks even as buildings and infrastructure were systematically targeted.

In addition to the innovations listed above, CHI has recently also seen a number of qualitative papers that observe and analyze the interaction between technology and poorer populations in developing countries. For example, Nithya Sambasivan, found repeat instances of intermediated technology use, where the person benefiting from a technology and the person who manipulated the technology are not always the same person [116]. A surrogate, for example, might look up information on the Internet, on behalf of a relative who might never interact with the Internet directly herself — this observation challenges the very notion of a monolithic "user," since the technical user of a device is different from the user who benefits from the device.

Meanwhile, Thomas Smyth uncovered the grey market of mobile-phone multimedia exchange in urban India, where gigabytes of video and music are traded routinely without the involvement of corporations or other formal organizations (and with little regard for copyright law). Smyth et al. [127] note that unlike many intentional projects in HCI for development, this natural ecology of video exchange overcomes major HCI obstacles through the sheer will of the participants. They attribute it to a powerful motivation that appears frivolous unless viewed with

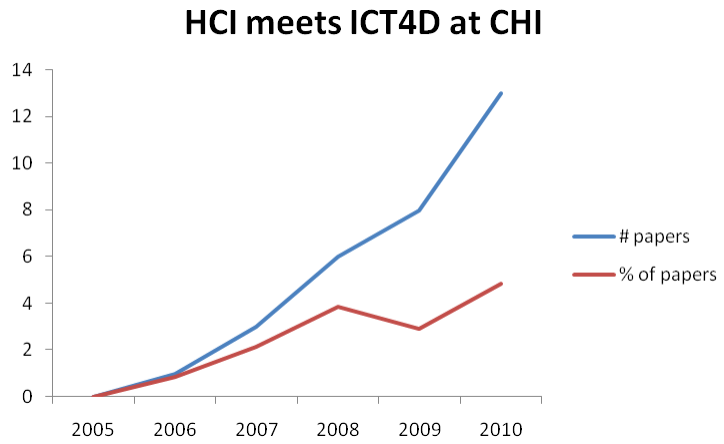

Fig. 3.1 Number of papers relevant to ICT4D presented at ACMs. International Conference on Human Factors in Computing Systems (CHI).

a deeper understanding of poor users of technology, who at heart, are not so different from rich users in their seeking of entertainment and leisure activity.

Apart from the papers, CHI has also hosted a series of workshops on HCI and development, beginning in 2007 and running through 2009 (with workshop names vacillating among various labels for the activity of HCI for development: "User Center Design and International Development" [141], "HCI for Community and International Development" [50], and "Human-Centered Computing in International Development" [49]). In 2010, CHI hosted a panel on global development that features some of the researchers who established this line of work [67].

Thus, the first decade of the twenty-first century saw HCI involvement in global development start with a few one-off projects and grow into an enterprise that the HCI community has adopted as one of its consistent areas of work. Figure 3.1 shows that the number of papers has increasing at CHI over the years, both in absolute numbers and as a fraction of total published.

4

Examples of HCI in Global Development

To get a sense for HCI work in global development, we now examine in more detail several ongoing avenues of research and development. As with much HCI work, prominent activity occurs both in academic research labs, as well as in commercial product development. We look at examples from both streams in this section.

4.1 Research

Research in HCI for global development has a particular flavor: It tends to emphasize realism and practicality over expansive vision and technological novelty. Below, we look at two streams of research which emphasize this inclination. In Text-Free User Interfaces, the goal is to arrive at a set of guidelines for designing device user interfaces that can be used by non-literate users. In the Telecom Web, voice and mobile phones replace the HTTP protocol and PC clients, as a way to extend Internet-like capabilities to those who aren't regular users of PCs or the Internet.

4.1.1 Text-Free User Interfaces

Illiteracy is an obvious barrier to computer usage, and it was among the first problems to be considered by researchers working in ICT4D.

The barrier is also squarely about the interface, and so the required research falls specifically in the domain of HCI.

4.1.1.1 Early Work

Perhaps the earliest mention of a computer interface for illiterate users occurs in a 1997 document by Canada's International Development Research Centre [60]. They saw correspondences between blindness and illiteracy, and this led to the recognition that software designed for the visually impaired could be immediate applicable to the illiterate user. The document focuses on text-to-speech and speech-recognition technologies as a way to make text as it appears on websites directly accessible to illiterate users. Similarly, Chris Law and Gregg Vanderheiden designed a government service website catered to the visually impaired user, but also suggested that it would allow illiterate users access [82].

In the early 2000s, a second wave of research considered special interfaces that went beyond re-application of accessibility tools for blind users — this line of work acknowledged that the blind-illiterate correspondence went only so far, and that in particular, illiterate users could still perceive and understand imagery. Thus, Youll [149] proposed a visual interface for e-mail and social networks. Goetze and Strothottle [46] considered variations of replacing or augmenting text with images.

Then in 2002–2003, two sets of researchers independently set the stage for a more systematic approach to illiterate users. In a wide-ranging masters thesis aptly titled, "Developing design recommendations for computer interfaces accessible to illiterate users," Matt Huenerfauth systematically considers the various ways in which UIs could be adapted for illiterate users [57].[1] The analysis is based only on hypothetical scenarios (no empirical research is conducted with illiterate users), but an extensive set of recommendations is provided, with some of the key ideas presaging future work: Use of voice annotations, choice of graphical elements, provision of user assistance, etc. Huenerfauth also keenly notes issues beyond illiteracy, per se, such as the fact

[1] Huenerfauth, incidentally, provides a nice review of the relevant literature in UIs for illiterate users until 2002.

that illiterate users, who are unlikely to be technology adepts, may also feel intimidated by computers, as do many other first-time users of PCs.

Ghosh et al. [43] pioneered work with actual illiterate users, by conducting work in rural India. This line of work revealed insights that would not be easily available without in-situ studies. For example, in working with microfinance lending groups, they found that many illiterate women in India were nevertheless able to read, write, and manipulate numbers.

The "Text-Free UI" work described in the remainder of this section builds on these earlier attempts. Like Huenerfauth, it attempts to provide a systematic framework for designing UIs for illiterate users; and, like Ghosh et al., the concepts are iteratively designed in collaboration with groups of illiterate users.

4.1.1.2 The Process

The problem of designing UIs for illiterate users transcends culture, language, economics, and application. Yet, to test ideas concretely, a specific group of potential users and a specific application had to be chosen. Indrani Medhi et al. were based in Bangalore, India, but while there are plenty of illiterate people in the city, they were not in touch with large groups of illiterate people whom they could work with. Thus, they began by looking up and meeting with a number of local non-profit organizations (also called "non-governmental organizations" or NGOs).

Medhi et al. built what became a long-term partnership with Stree Jagruti Samiti ("Organization for Women's Empowerment"), a local non-profit with a presence in several slums around Bangalore. SJS's own goals were in political and economic empowerment of the women living in the slums (most of whom were illiterate), and education for their children. They felt that computing technology could be of value in advancing their cause, though it was not understood at the outset how that might be achieved. Both as a goodwill gesture, and also to understand how SJS worked, the researchers began by attending SJS meetings offering a computer literacy class for some SJS children, and even helping to run a weekend basketball program run by another SJS partner.

This initial period of interaction over several months established rapport between SJS and the researchers and formed the foundation for future work. Between 2005 and 2009, the two organizations worked together on a number of projects that involved both research elements and practical value, such as nutrition classes recorded and disseminated on video CDs, an employment-matching program investigating the feasibility of an automated system to match women with employers, and of course, Text-Free User Interfaces (It's worth noting that during this time, the researchers occasionally made small donations in cash and in kind to SJS, as tokens of their appreciation for the relationship; these helped to acknowledge the researchers' debt to SJS for their time and effort in projects which, though they fulfilled research goals, did not always contribute to SJS's goals.)

To pick a concrete application, Medhi (the lead researcher on the Text-Free research), spent an initial period of several weeks doing unstructured interviews and participant observation among the women in the community. She found that the women worked primarily as informal labor doing domestic chores for middle-class households — cleaning, cooking, and so forth. These jobs were not consistently available, nor were they necessarily convenient for the women in terms of schedule and location, and so there was demand for information about available jobs. Normally, the women heard this information by word of mouth, and while they could think of no other way to accomplish it, they wanted more complete and more timely information. In their first research project, therefore, Medhi et al. [91] decided to design a Text-Free UI for a job-matching website.

Over a period of several months, new prototypes were designed and tested with women in the slum communities. Testing was conducted in "the field," either in the SJS offices or in the households of the subjects, for a variety of reasons — the complex logistics of transporting many women to the lab; the potential for the women to feel intimidated in a corporate office; the desire for some women to stay at home due to family pressures; etc.

Once iterative prototyping was completed, the project moved to an evaluation phase in which a more formal process was relayed to potential subjects at an SJS meeting. Over several weeks, evaluation studies

were scheduled adjacent to SJS meetings to ensure maximum participation. The rigor required for evaluation was not always easy to achieve, and the experiments took perhaps twice as much time as was initially planned. Subjects would not show up at scheduled times or would leave mid-experiment for unexpected reasons; they would speak to each other about the experiment despite instructions not to do so; and due to difficulties of creating a sound-proof space for testing, subjects would often interfere in others' evaluation sessions.

At the completion of the study, subjects were presented a formal certificate of appreciation, and small gifts on the order of US$2 each.[2] All told, Medhi spent approximately 300 hours in the slum communities, field-testing and evaluating versions of the application.

A similar process was followed for most of the research described in this section, although because much of it was conducted with SJS, Medhi et al. did not have to build new relationships for each new research project.

4.1.1.3 Results

The Text-Free UI research agenda resulted in a number of findings which have been published in both ICT4D and HCI proceedings and journals [87, 88, 91, 92].

Many of the suggestions by Huenerfauth were verified in evaluations with illiterate subjects: Voice annotations, graphical representations, a help function offering spoken assistance were all appreciated by subjects, and allowed them to manipulate UIs whose text versions were incomprehensible to them [87, 91]. The claims by Ghosh et al., that numbers are recognized by many illiterate people, was also confirmed, though in the subjects studied by Medhi et al., some participants were prone to confusing digits with similar appearances (e.g., 2 and 5).

Medhi et al. further discovered that particular forms of graphical representations were more effective than others. Specifically, semi-abstracted cartoon drawings were more easily understood as representations of generic classes of objects, than either photographs (which

[2] Although the developing world presents many severe challenges to the field researcher, one key advantage is the lower cost of many research expenses.

were easily mistaken for the actual instance of the thing photographed) or simplified icons (which were not always accurately identified, even when iteratively designed with members of the same community) [87]. Cartoon animations could also be helpful, although the value of animation over static imagery was small.

As Huenerfauth hinted, illiterate users had significant challenges beyond simple illiteracy [91]. Echoing findings for literate first-time users of PCs, subjects expressed discomfort handling computing equipment, citing that they were afraid to break an expensive piece of machinery. Among those who overcame such anxiety and were able to comprehend and manipulate the UI were some who were unable to understand what value such activity had — how did selecting icons on a graphical display help to find information about jobs? One solution to this problem was tested in a follow-up research project called "Full-Context Video" in which a looped video dramatizing the application's mechanics and usage scenario was found to be effective at both diminishing fears of technology and providing a cognitive model for how the application worked [92].

Other extensions of the Text-Free UIs research considered such things as the trade-off between voice-based interfaces and a rich text-free UI on mobile phones [88], as well as authoring tools for Text-Free UIs that take advantage of "tooning" features that allow a user to easily convert photographs into drawings [87].

A number of qualitative observations arising from the Text-Free work lights the way for further research: Drawings with moving parts (e.g., flowing water, emitted smoke) were more likely to be interpreted as verbs[3] [91]; some subjects with very little education appeared to be confused by bimodal displays (e.g., image *and* voice annotation) [87]; illiterate subjects appear to have a strong preference for narrative explanations over deductive or analytical explanations [88]; and so on.

4.1.1.4 Limitations

The strongest critique of the body of Text-Free UI research would be that most of it has been undertaken in no more than a handful of

[3] Professional cartoonists and illustrators utilize this phenomenon in their work.

communities, and thus it's not clear how much the results generalize to other cultures. In order to establish greater external validity, similar research would need to be conducted in other geographies.

The authors themselves note that the design of graphical elements in any Text-Free UI must be tested with the intended user community. They found, for example, that women looking for jobs in the city were confused by a graphic of a sloped-roof house to indicate a family, since they were expecting to work in flat-roofed apartments [91]. Even such things as the directionality of a display (left-to-right or right-to-left?) appear to be dependent on script — Muslim subjects were prone to "reading" right-to-left (even if they can't read, they're influenced by the fact that the Arabic script reads from right to left), while Hindu subjects read left-to-right. Otherwise, there are communities where people are unable to read numbers any more than letters and words, and at least one researcher who tried Full-Context Videos in Liberia found that they did little to lower barriers to technology use [9].

So, the Text-Free UI research to-date is perhaps best seen as a starting point and a strawman for further research. Over time, with more work conducted in different domains and geographies, a fuller picture may emerge in which the universal and context-dependent elements of Text-Free UIs are better understood.

Finally, a word on the implementations of actual text-free systems: Medhi et al. have made attempts to implement real systems using text-free designs. These ran into challenges that are all too typical for ICT4D projects. They tried two routes to implementing a digital job-matching site using text-free principles. In one case, a start-up venture called Babajob, which was already working in the space of job-matching online, agreed to create a text-free set of pages for use by potentially illiterate users [44]. In another, SJS, who was interested in exactly such a capability, agreed to a phased implementation in which an initial paper pilot without computers would be used to test the overall flow of a job-matching system and then upgraded to a digital database later on [88]. In both cases, the projects have run into the implementation challenges of maintaining a fresh set of job announcements (desired by workers but only inconsistently offered by employees), providing an assurance of quality control (desired by employees but difficult to

enforce among workers), and doing these both at scale. The SJS effort was stopped after two years for these reasons. Babajob, has been more successful at scaling its system, as it has dedicated staff whose incomes rest on the success of the entity; on the other hand, demand for the text-free pages is non-existent, as illiterate users rarely access the websites themselves — interactions are intermediated by literate acquaintances. These cases suggest that ICT4D projects require much more than carefully designed UIs to work, in much the same way that a profitable software business requires much more than good software to function. It could also be a lesson for HCI researchers in ICT4D: to be truly effective, design efforts must go well beyond a narrowly defined notion of the human–computer interface.

4.1.1.5 Other Work

Jahanzeb Sherwani et al. connect exploration of UIs for non-literate users to the ideas of Walter Ong, a cultural historian, who posited the notion of *orality* — which casts cultures without a writing tradition to be qualitatively different than those with a literate tradition [122]. Ong notes, for example, that oral cultures emphasize narrative over deductive thinking, real examples over abstraction, and interactive engagement over static representation [101]. It's not clear how much of this view is a romanticization of illiteracy, and Sherwani's paper struggles to maintain Ong's grace in casting illiteracy not as a deficiency but merely a difference. Nevertheless, Ong's observations lead to design directions that deserve further research.

Much of the work with non-literacy puts illiterate and semi-literate people into a single bucket, although there is a continuous range of illiteracy from those who cannot recognize individual letters, to those who can identify certain words on sight, and may be able to pronounce words phonetically with effort. Leah Findlater et al. [38], however, focused on some of the differences within less literate users, and found that semi-literate users, who know their alphabets, can both improve their reading ability and learn to accomplish UI tasks more quickly, if they are given both text and audio markers to UI elements on a display. Completely illiterate users, on the other hand, showed none of this learning or

improvement, indicating that there are qualitative differences in what can be gained from certain UI designs along the spectrum of literacy. Brij Kothari's studies with "same-language subtitling" in which television shows are subtitled in the same language as that of the audio track have displayed similar phenomena [72].

The Medhi team has also pushed forward with text-free interfaces for mobile phones. With the increasing interest in money transfer, they investigated several UIs on mid-tier mobile phones that would allow non-literate users to perform mobile banking [89]. Results suggest that there are tradeoffs between UIs, with combinations of graphics and voice annotation leading to quicker transactions but more overall confusion, while voice interfaces alone were perceived to be easier to use, but seemed to take longer. The pace of work for non-literate users on mobile phones seems set to increase, as witnessed by more recent publications in this area [45, 68].

4.1.2 The Telecom Web and *Avaaj Otalo*

In 2007, researchers at IBM Research Labs in India proposed the *Telecom Web*: The idea was to enable many of the functionalities of the regular Internet, but entirely through phones, with voice as the medium [76]. The core insight was that fundamental operations of HTTP "put" and "get" could be replaced by the receiving and transmitting capabilities of phones [2]. Servers would still accumulate, store, index, process, and serve content, but instead of serving text, images, and movies, the content would be limited to audio content. Similarly, users could post audio content. This idea has spawned several streams of work (as well as project names), and this section will also discuss one of the more recent streams, *Avaaj Otalo* (or "voice stoop").

The description below is drawn from several papers by the Telecom Web and Avaaj Otalo teams, as well as from informal communication with the researchers in person and over e-mail [2, 3, 4, 75, 76, 77].

4.1.2.1 Early Work

The technical ideas for the Telecom Web preceded any significant fieldwork [2], but soon after conceiving the idea, the researchers conducted

qualitative field work among 26 urban, low-income laborers and micro-entrepreneurs, and 25 customers of these laborers in the Delhi area [75]. The workers included plumbers, carpenter, and other skilled laborers.

Kumar et al. found that many workers spent as much as 60% of their work day idle, presumably hoping for more business. At other times, requests for multiple jobs might come in, and they would have to negotiate alternate appointments between conflicts. Additionally, as in many big cities, Delhi traffic presents a sufficiently high barrier to travel between points in the city, that many workers would refuse work that came from too far away.

Their potential customers, meanwhile, seemed eager for a service that would allow them to find laborers as needed, with 23 out of 25 respondents desiring such a service, and nearly 60% willing to pay for such a service.

Additional interviews found that while there were a number of yellow-page-like services in urban Delhi (including a call-center-based search service called Just Dial that is to the phone what search engines are to the Internet), most customers were reluctant to hire laborers without some references through their social network. Laborers, for their part, would self-organize into somewhat more formal businesses, but many found themselves exploited by such groups.

Further qualitative research with auto-rickshaw drivers (drivers of three-wheeled motorized cabs) in three Indian cities uncovered similar issues as those that the laborers faced. In short, everyone experienced too much idle time and wanted more business. Any service that would help them fill more of their workday was welcome.

Kumar et al. then mocked up a system for skilled laborers that could be used to match laborers with customers, and tested the system with workers and customers for user interface issues. They found that laborers, for the most part were able to use a voice-based system to answer a few questions that would allow them to "post" their capabilities and availability on the system. Similarly, customers were able to recover information that was posted.

Although a complete working system was not initially implemented, feedback from this exercise revealed that simple prompts were

desired by laborers, and that two-thirds of the customers struggled to understand the accents of the laborers who posted jobs. The latter effect was likely due to the fact that many laborers came from regions outside of Delhi, where spoken Hindi can take on diverse accents different from that spoken in the capital.

4.1.2.2 The Process

Encouraged by their preliminary trials, the IBM team went on to test two separate systems in rural villages of Andhra Pradesh and Gujarat, India [3, 107]. In these pilot projects, an audio bulletin board was set up for the sake of local residents, micro-entrepreneurs, and/or farmers, and the goal was to understand broad usage patterns as well as usability issues. The second pilot ran as a new project called Avaaj Otalo, and the team was joined by Neil Patel and Tapan Parikh, respectively at Stanford University and the University of California, Berkeley.

In the first pilot, *VoiKiosk*, an audio bulletin board was set up in one rural community in Andhra Pradesh, India. The team worked through a non-profit organization, the Byrraju Foundation, that ran a variety of development-focused efforts in rural Andhra Pradesh. The second pilot, *Avaaj Otalo*, catered to a farming community in Gujarat, India, and was run collaboratively with Development Support Center, an agricultural non-profit, which works through partner farmers scattered across hundreds of villages in that state.

The Telecom Web team spent time visiting four villages in Andhra Pradesh ranging in population from 2000 to 5000, introduced by Byrraju Foundation staff and volunteers in each village. Many of them were members of the local community, so they were able to get insight into the local use of phones and people's needs for information. They found conditions that today are common, if not ubiquitous, in rural areas across the developing world — more than 50% of the households owned mobile phones, and sharing of mobiles was a common phenomenon. Cell-phone signals are widespread, and in the villages the team visited, they were ever-present. They also surveyed the kind of information that villagers might want, and found the usual suspects: agriculture information, employment opportunities,

health information, notices by local businesses, and so forth. They also verified local user interest in a phone-based bulletin board, and found confirmation.

On the technical front, a voice bulletin board server was set up, with various features such as the ability to log and store calls, an interactive voice-response menu that would provide spoken menus and instruct users in how to respond. Four categories of users were given differential permissions to add, edit, and listen to content. This prototype was then deployed in one of the villages visited by the team, in Juvvalapalam, Andhra Pradesh, a village with 4000 people and 70% mobile-phone penetration by household. A group of about 30 initial users were told about the system, instructed in its use, and then run for a period of four months during which time, two minor modifications were made to the system in response to usage. Throughout, usage statistics were collected, and the nature of the calls were analyzed to understand exactly how villagers interacted with the system. No interviews, however, were conducted with users after the deployment of the prototype.

In Avaaj Otalo, the team could build on its earlier experience, but since the experiment was run in a different region of India, Patel spent additional time interacting with DSC and the local farmers. Ultimately, the findings on local needs were similar, but there were small differences in the technology, as well as in the preferences of DSC. In setting up the server, the service offered three different options: (1) a question and answer forum, in which farmers could ask questions, answer others' questions, or hear existing Q&A; (2) an announcement board used by DSC for broadcasting information; and (3) a radio archive, which allowed users to listen to past radio programs broadcast by DSC as part of its work. Then, in addition to logs of system usage and transcripts of audio input, interviews were conducted with 36 Avaaj Otalo users and 40 non-users.

The Avaaj Otalo pilot was also more comprehensive in understanding UI issues of a voice bulletin board. It sought to understand whether users preferred an automated speech recognition system or a touch-tone system for input, and it also collected data about errors in usage.

The projects were run one after the other, so researchers had time to digest the results of the first pilot and adapt the system for the second

pilot. In Avaaj Otalo, additional researchers joined as collaborators, both of whom had more experience with ICT for agriculture as well as formal HCI: the lead researcher for Avaaj Otalo was Patel, a Stanford PhD student who had worked previously in HCI and on local models for organic agriculture. Patel was also joined by Parikh, one of his PhD advisors, who had done work with coffee growers in Central America, and is otherwise familiar with development in India.

4.1.2.3 Results

The overarching findings of the experiments with VoiKiosk and Avaaj Otalo were that there was consistent usage of audio bulletin boards by village residents and farmers, and that even illiterate users were able to use the system. The most compelling use of both systems seemed to be the functionality of the bulletin board, which permits semi-broadcast of various types of information as well as Q&A.

VoiKiosk eventually logged over 100,000 calls over a nine-month period, totaling 2135 hours on the system; there were 6509 unique users. Though there was some initial spike in usage due to novelty, usage continued to grow over nine months, and by the end, there were a consistent stream of users. All of this happened with the seeding of some 30 initial users, who propagated news of the system by word of mouth.

Avaaj Otalo logged nearly 7000 calls over a seven month period. Avaaj Otalo did not log as many users or calls, and this was due to a number of intentional and unintentional differences with VoiKiosk: first, Patel and Parikh were intent on finding a system that would support farmers, and so they felt an open experiment like VoiKiosk could inhibit discussion of the farming-related dialogue they hoped to foster. Second, there were structural differences in the community Avaaj Otalo catered to: DSC's most active clients are a handful of farmers from many villages, and so the "community" of these farmers is virtual to begin with. Diffusion through direct word of mouth is less likely for both geographic and social-network constraints. Finally, DSC itself felt that the pilot should be run with a select group of their most active constituents, rather than with the community at large.

With regards to usage, VoiKiosk's most popular feature was a bulletin board. Callers found a variety of uses for this feature that went beyond the initial productivity-oriented notions of the researchers. Although some microentrepreneurs advertised their services, there were many other postings having to do with wedding announcements, political campaigns, and so forth. In some cases, the system appears to have been used as a person-to-person voicemail, as when one family posted a child's greeting to her grandparents. Apparently, due to a glitch in the prototype, there were several weeks when the system forced users to listen to all previous posts before being offered the chance to record their own. Users appeared to be willing to sit through the announcements, and the researchers note that with 87% of the users never posting, the vast majority of the usage was to hear other people's postings.

Avaaj Otalo's most popular feature was the Q&A forum, but it should be noted that this forum was also used very much like a bulletin board, though DSC and the researchers' agricultural intent was largely preserved. Users posted questions and answers, but also commentary on questions and answers, as well as requests for announcements, radio archives, and additional information. Several clever entrepreneurs even responded to questions by describing and then advertising solutions they had devised themselves.

The Avaaj Otalo pilot also collected evidence of user preferences. For example, consistently over 80% of the users preferred touchtone input for selecting among menu options, though an equally consistent 5% or more seemed to prefer speech recognition. Speech, however, ran into frequent misrecognition problems, requiring a hang-up and re-dial by the user, since the system did not include a loop-back mechanism common in commercial IVR systems.

Patel et al. also note that user errors during menu navigation were a persistent feature and did not seem to abate even after several months' experience by the most common users. On the other hand, none of those interviewed indicated any dissatisfaction with the menu-based system, and all seemed happy with a topic-wise organization of content.

Among the most interesting findings were the various social interactions that evolved in both systems. In VoiKiosk, individuals converged on posting what were effectively classified ads and personal notices,

which others consumed as if they were reading the local newspaper. Avaaj Otalo witnessed several more nuanced forms of communication. For example, callers routinely introduced themselves by name, village, and phone number before proceeding to their main content — and the other farmers seemed to value this introduction as a way to locate the caller. Community moderation also instituted itself, as some posters reprimanded others for rambling messages or incorrect information. Finally, the interviews revealed that some users asked questions on behalf of friends who were less confident in their ability to either use the system or articulate questions well.

In short, both the VoiKiosk and Avaaj Otalo experiments show considerable promise for a voice-based bulletin board system that can serve many of the purposes that might be served by a community online bulletin board.

4.1.2.4 Limitations

Thus far, none of the studies associated with the Telecom Web have charged users for their time with the system. Although not strictly an HCI issue, this is a central ICT4D issue, as cost can often be a show-stopper for development projects. At this point, it is not yet clear that Avaaj Otalo would find the same levels of success if farmers were charged even for the low voice rates offered by India's telecoms. For example, researchers associated with the Jameel Poverty Action Lab, a renowned center that conducts randomized controlled trials of development interventions (with and without technology) finds consistently that people respond to "free" in a very different way from even the smallest token costs [110], and there are studies that suggest that even token costs applied to development projects dramatically inhibit take up [74]. This issue points directly at one of the key differences between HCI and ICT4D traditions — whether or not to consider issues of cost for users as part of research — and it is certain to remain a topic of discussion as the two communities interact.

4.1.2.5 Other Work

The Telecom Web inherits from two streams of previous work. One set includes efforts to build similar systems that parallel the Internet,

but through communication channels that are more readily available in developing countries. Perhaps the most dominant are efforts to do this over Short Message System (SMS) text-messaging. Ken Banks released a widely used platform called Frontline SMS that allows one to quickly turn laptops and PCs into SMS servers that can receive, process, broadcast, and otherwise serve text messages for various purposes [6]. Anyone with a SMS-enabled phone can then interact with the server, by sending requests for information and receiving information, in much the same way that one would request webpages online. Of course, the information sent and received in this way is limited to the 140-character restrictions on SMS, and in many countries, high SMS costs prohibit extensive use of such systems, but the concept is potentially far-reaching, as demonstrated by Twitter (established in 2006, well after Frontline SMS), effectively a blog-and-broadcast site that works through SMS.

The other line of work relevant for the Telecom Web are past efforts in the developed world to allow browsing of content by voice. Within agriculture, there are a number of such systems [39], but the history of such work goes back to efforts to create dialogue systems for phones in the 1970s. Since then, recent work in this area considers the use of speech recognition to understand spoken input [14, 47].

4.2 Industry: The Mobile Phone

While researchers have focused on needs-based designs and careful evaluations, corporations have gone ahead with their own UI innovations for the developing world. As with commercial products in the developed world, commercial innovations for the developing world typically forego the academic experimentation that researchers undertake. What they lack in academic rigor, however, they make up for with market experiments, some of which go onto become wild commercial successes.

In 2009, there were 4.5 billion active mobile phone accounts in the world [63], comfortably exceeding the number of adults in the world 20 years of age and over. The majority of these phones are now in developing countries, and without doubt, the mobile phone is the single

most widely penetrating ICT in the developing world. (In contrast, there were only 1.4 billion televisions in the world in 2003, and 2.4 billion radios in the world in 1997 [98].

Numerous studies extol the virtues of the mobile phone for economic growth. Leonard Waverman et al. calculate that a country's year-on-year GDP growth benefits by an additional 0.6% for every 10% penetration of phones in the country [147]. Jensen [64] found that mobile phones in the coastal state of Kerala, India, benefited both fishermen and consumers, by eliminating inefficiencies in markets.

In 2003, Nokia introduced its model 1100 mobile phone, perhaps the first phone to be specifically designed for developing countries and emerging markets [99]. In its press release, it noted that the low-cost phone featured "anti-slip sides to provide a better grip as well as reduce the risk of dust and rain damage," a "display... and keypad layout [that] makes the phone intuitive and easy-to-use," a flashlight, and a "long lasting battery [that] gives users a talk time of up to 2 hrs to 4 hrs 30 mins and a standby time of up to 400 hours," the latter presumably for environments in which reliable electricity is not a given. In India, one of the two sites where the phone debuted, the phone was marketed as "made for India." It went on to a wildly successful run of over 200 million units sold, earning a world record as the best-selling consumer electronic device ever [97]. Well aware of users' preference for expressing themselves via their phones, Nokia also made sure that "Users can personalize their Nokia 1100 phone with a wide range of interchangeable Xpress-on covers, as well as a variety of ring tones, operator logos and picture messages" [99].

Nokia has since discontinued the 1100 in favor of even lower cost models with more features, but the legacy of the 1100 remains: It gave birth to an entire industry of low-cost phones, which for the most part are not seen in developed countries. Developing countries have recently witnessed waves of new phones balancing cost and feature-richness, from big-name handset makers such as Motorola, to lesser-known manufacturers in China.

Low-cost mobile phones are a singular success within technology and the developing world. They are the perfect example of C. K. Prahalad's

claim that there is a "fortune at the bottom of the pyramid" [111]. Prahalad himself struggled to find examples of his own thesis — that corporations could provide for the poor and make huge profits at the same time, as long as they were willing to find creative, affordable solutions for poor markets — and despite his popularity in the business world, his book is notoriously filled with examples that don't quite fulfill his own claims. Yet, Nokia's 1100 could be the poster child for Prahalad: it was a runaway success that worked exactly because it took a function that human beings everywhere appreciate, and then designed it to be affordable and appropriate for a heretofore unaddressed customer.

4.3 Methodological Innovations

The interaction of HCI and ICT4D has resulted in a number of methodological innovations. Three such innovations are described below: Researcher immersion as a technology-focused poor man's ethnography; partnerships with development organizations; and the "Bollywood method" of interviewing subjects.

4.3.1 Researcher Immersion

HCI researchers frequently spend time with their target users in the users' "natural" environment. Studies over the years have followed knowledge workers in their office environment, for example. Yet, as the genuine ethnographers in the CHI community are eager to point out, very little of this kind of work qualifies as real ethnography, at least of the kind that is typically conducted by trained anthropologists. Researchers rarely spend more than a few days or a few weeks in an environment, and the deep methodological insertion of the researcher into the environment rarely happens. Most usability studies occur in the somewhat sterile conditions of the usability lab.

In ICT4D, immersion is the hallmark of some of the strongest projects. Rikin Gandhi, for example, the lead researcher in a widely hailed ICT4D project called Digital Green [40], spent a half year living in a rural village in the state of Karnataka, India, both to understand

the culture and daily life of farmers in that region, and also to try out various ways of using video to teach farmers sustainable agriculture practices. Gandhi had no formal ethnographic training, nor would he call what he did ethnography. But, the immersion in the actual environment he hoped to impact was a critical aspect of the research that led to Digital Green. It led to a deep intuition for what was likely to work — the kind of intuition that great product designers have about their consumers. And, it allowed for extensive prototyping and testing at a level that is difficult to do when any distance is placed between researcher and subjects. Gandhi returned from his experience with a working knowledge of the local language (Kannada), a good understanding of the prevailing agricultural practices, and a sense for the best way to apply video in those communities. He later demonstrated experimentally that the particular system he designed was 10 times more cost-effective than classical means of agriculture extension in persuading farmers to take up new practices.

Similarly, between the Telecom Web and Avaaj Otalo, the researchers involved took many visits to their sites to meet with villagers and workers, and Medhi's Text-Free UI work was also conducted through several hundred hours spent with non-literate women in Bangalore slums.

It's useful to note how this form of immersion differs from formal ethnography. First, its aim is unapologetically design-focused, and it de-emphasizes the theory-building and abstraction that is demanded in ethnographies; the goal is very much to arrive at meaningful problems to address as well as workable designs of solutions, through a process of intensive prototyping and testing. Second, and as a result, it focuses much more on the mechanics and economics of the processes of interest — exactly how do farmers procure their tools, what are the costs and revenues they see in a crop cycle, etc. (Ethnographers may also investigate these details, of course, but their interest will be tempered by interest in a host of other questions.) Finally, it can be conducted by anyone with a curious mind and a sensitive heart. Designers, engineers, and computer scientists without formal training in ethnography can engage (though such training can certainly help), and anecdotal evidence suggests that they *should* engage as part of the

design team. There is no substitute for field experience in gaining the intuition required for good design.

4.3.2 Partnerships with Development Organizations

One methodological tool that is particularly useful in researcher immersion and otherwise, is partnership with development-focused organizations, be they governments, non-profit organizations, or community groups.

Such partnerships can dramatically reduce the time needed to gain the trust and rapport needed to work with a poor community. A foreign researcher — and, anyone not from the local community is likely to be viewed as foreign, even if they come from the same country — coming in with a fancy gadget and unheard-of ideas is not likely to make much progress with residents whose reactions may include hostility, skepticism, indifference, or polite but unproductive hospitality. An organization that already has the trust of a local community can provide quick access to willing subjects and informants.

Local organizations that share a development goal can also be a fantastic source for understanding the politics and cultural forces that may impact a project. They often know whom to approach in a family (as well as whom not to approach), what kinds of gifts might be appropriate in return for time with subjects, whose buy-in is needed to avoid community clashes down the line, and so on. Having even a rough sense for such cultural parameters can prevent social faux pas and even unexpected violence.

On the other hand, anecdotal experience among ICT4D researchers suggests that partner organizations are not necessarily the best sources for new ideas or design suggestions. Their views of technology can be naïve, neither understanding the limits or potentials of a technology. They may not necessarily see challenges where outsiders see immediate problems. Often times, a conscious or unconscious attempt to project competence translates to an inability or unwillingness to acknowledge problems. So, there is very much a place for the professional HCI researcher, who understands technology, and has made a habit of identifying pain points in everyday activity.

4.3.3 The "Bollywood Method" and Other Adaptations

Conducting user studies with people new to technology as well as processes as formal as good usability tests can be a challenge. For one thing, it's often neither practical nor advisable to pull subjects from slums or rural villages into usability labs in security-ridden office buildings gleaming with new technology. Yet, the quadruple shock of being in a foreign culture, navigating a foreign infrastructure, hearing a foreign language, and interacting with subjects who are foreign to technology, presents HCI researchers new to development with a range of unexpected difficulties. Just for example, laptops may deliver electrical shocks, interpreters can be unreliable, and subjects might second-guess the experimenter — a good portion of the literature of HCI for development is written by graduate-student airing their horror stories and attempting to formulate generalizable lessons from their experiences.

Among the common problems is the challenge of administering surveys and structured interviews with subjects whose previous experience with formal question-and-answer sessions were often intimidating to them. For some village residents, vivid memories of negative experiences with authority lift visible emotions to the surface. They remember strict or ineffective teachers who physically beat them for school transgressions, or government bureaucrats who are abusive or corrupt. It's no wonder that a lifetime of such experiences might predispose someone towards suspicion for anything like an HCI questionnaire.

In addition, subjects with very little formal education often, though not always, appear to exhibit both intellectual and emotional difficulties with counterfactuals.[4] Questions of the type, "If you were without a job, what methods would you use to find one?" can elicit either confusion or fear. Some respond with, "What do you mean? I have two jobs. Why

[4] Some readers may feel compelled to question claims that the poor suffer any cognitive deficiencies. These feelings often originate from a desire to believe that the poor are just as good as anyone, or that we shouldn't blame the victim. But, we don't have to blame the victim to note that the cognitive abilities of the poor might suffer along with their incomes, due to circumstances beyond their control. Poverty leaves people malnourished or undereducated, which in turn leads to less developed mental capacities. The converse belief leads directly to a conclusion that good nutrition and education provide no cognitive advantages, which devalues the work of people investing in good nutrition and good education.

should I look for another one?" Others might ask with trepidation: "Do you know something I don't know? I just went to work yesterday and everything seemed fine!"

Particularly for this latter problem, Apala Lahiri Chavan of Human Factors International devised a technique she calls the "Bollywood technique" of inquiry, in which the point is to deflect some of these challenges by situating survey questions in the context of a non-threatening story [118]. In the case of the question above, the researcher might construct a little movie script, in which Raj, the hero, has just lost his job. Seema, his friend (and perhaps romantic interest) wants to help him. At this point, the subject might be asked, "What could Seema do to help Raj find a job?"

Asking questions in this manner places distance between the subject and the content of the question, thus diffusing any direct threat they may feel about the situation if it were to occur in their own life. Yet, at the same time, it gets at the heart of the issue. The Bollywood technique also imagines a medium — the movies — that many people are familiar with, even in very poor communities. Of course, there are remote places where people are not familiar even with 2D illustrations,[5] to say nothing of movies, but these are increasingly rare in our global world.

[5] The Me'en tribe in Ethiopia, for example, were unable to recognize animals they were intimately familiar with when shown black-and-white illustrations of the animals on paper [24]. Cognitive science research confirms that those with less formal schooling have more difficulty understanding 2D imagery.

5

Recurring Themes

So, HCI in global development is still in its early stages, with active research happening only for the last decade. Already, however, we can discern a number of recurring themes: the challenge of hardware and infrastructure constraints; differences in culture, language, and literacy; sharing and intermediated use of technology; and, the need to attend to a rich aura surrounding technology — social, economic, and political. These issues repeatedly arise in the literature, and they represent themes which will undoubtedly keep HCI researchers busy for some time to come.

5.1 Hardware and Infrastructure Constraints

Among the most visible challenges in doing ICT4D work are physical resource constraints, whether it is inability to afford certain kinds of hardware or poor infrastructure.

Cost constraints on hardware, of course, are obvious, but few people recognize just how severe these constraints can be. Government spending on education per child per year in India, for example, doesn't exceed $200 [142]. With such budgets, even a hundred-dollar laptop ceases to be impractical as a per-child expenditure.

Meanwhile, infrastructural limitations add another layer of challenges. Electrical power, for example, can be missing altogether, available only for several hours a day, or poorly stabilized — one study observed voltage surges of 1000 volts in rural India [134]. And, connectivity, though increasingly eased by the provision of GPRS data services over mobile networks, remains an ongoing challenge — affordable broadband availability, for example, remains scarce in developing communities.

Other infrastructural deficits can also impact ICT4D efforts. The availability and quality of roads, buildings, plumbing, and so on, frequently impinge on the success of ICT projects. E-commerce requires low-cost, reliable shipping, and projectors may be overwhelmed by ambient light in classrooms where poor ventilation and overcrowding prevent shutting of windows.

These kinds of challenges plague ICT4D projects, and many fail due to an inability to find effective solutions. Though these problems are daunting, there are at least a couple of ways in which HCI research can provide input, without solving national infrastructure problems or taking on cost-benefit analyses. Stark conditions make things difficult, but rarely impossible; instead, they force a decision among trade-offs, and HCI could supply meaningful input into the comparative advantages of different options.

For example, consider again the issue of electrical power. Solutions might involve the use of alternative energy sources (e.g., solar panels, hand-crank generators), batteries ferrying power from urban areas, low-power devices, or even processes in which the use of electronic technology is constrained to occur in locations where power is reliable. Each such solution comes with a monetary cost as well as pros and cons for users, and HCI methodologies are appropriate for assessing the latter.

Perhaps the greatest potential for HCI to impact this class of ICT4D challenges, however, is to bring in points of view beyond the technological. Many such problems cannot be easily mitigated by electronic technology alone, and that means they will require support of people and organizations. Considering how technology works in tandem with

existing organizations, therefore, is often a practical way to address infrastructural challenges obliquely.

5.2 Cultural, Linguistic, and Non-Linguistic Adaptation

Another set of traits of developing communities are those of cultural and linguistic differences from the developed world. There are a host of interesting challenges in matching the content and capabilities of technology with the linguistic and cultural preferences of local populations. One set of questions is around the "translation" of documents existing in one language into a form that is comprehensible by someone who speaks another language, or by someone who cannot read at all. Other questions are raised by the office-centric metaphors used by modern computer systems, including notions of files, folders, desktop, and so on. Still other questions come from many groups' lack of familiarity with electronic technologies altogether.

As is often cited, the Internet is dominated by English, with some estimates putting English at 85% of all Internet traffic [100]. Thus, anyone who doesn't read and write English will be at a disadvantage online, unable to access the vast stores of information readily available to readers of this article. Part of this issue may involve HCI contributions.

For example, it is often suggested that language-translation tools can be brought to bear, but state-of-the-art machine translation depends on large corpora of data to build their translation engines, in the range of millions of parallel sentences between two languages [79]. This kind of data is hard enough to come by for the world's most popular languages, but it is all but impossible to gather for languages spoken by smaller populations. Thus, there are questions as to whether partial or imperfect translations are meaningful, and if so, how best they can be integrated into a user interface.

Similar problems plague the development of speech recognition systems, although speech is often considered ideal as a form of input for those who are non-literate. Additional challenges exist that echo many of the early findings with speech technologies in the developed world: How should speech systems represent themselves, given that they are

never as responsive as human operators? What is the right trade-off between reducing recognition error and permitting a wider class of responses? And, so on.

Finally, there are unique problems around the metaphors of modern computers. The fundamental units of GUI manipulation are files, pages, and buttons, and yet these trappings of air-conditioned offices are often absent in the object vocabulary of communities where global development works. Perhaps the entire GUI needs to be re-thought for different cultures. On the other hand, a class of response that might replace files with seeds and folders with buckets is even more problematic. The real questions here are much deeper: Is it possible that limited formal education leads to less facility handling hierarchical structures? Maybe it's okay to leave files as files and folders as folders — when is it that, with a little training, users will simply adapt? When users unfamiliar with physical files and folders manipulate them on a PC, what is their mental model for these objects? Etc.

5.3 Technology Sharing and Intermediation

Two common features of technology in the developing world are those of shared usage and intermediated usage.

In shared usage, a single device is used by multiple people, either simultaneously or one after the other. For instance, Internet cafés are a common sight in developing countries, often existing right alongside petty shops selling everything from car parts to fertilizer. Estimates of Internet cafés range in the tens of thousands to hundreds of thousands in both China and India, although accurate numbers are difficult to assess. Simultaneous shared usage of PCs is also frequent, particularly in schools, where the ratio of students to PCs radically outpaces budgets for technology in schools [102].

Perhaps the device more deserving of the adjective, "personal," is the mobile phone, which in developed societies is felt to be intensely personal and private — many consider it at least as personal an item as their wallet or purse. Yet, in the developing world, sharing of mobile phones is a common practice. Even wealthier middle-class households in India often share one or two mobile phones among the entire family

[29, 31]. When one family member goes out, she takes one of the phones with her, with the understanding that she will need to take messages on behalf of other family members. In what might be called "approxi-calling," friends often receive phone calls for their phoneless peers: "Is Harsha with you? Could I talk to him?" [129].

A related, but different, phenomenon is that of intermediate technology usage. Here the notion of a single technology "user" splits into two or more people fulfilling roles as either technology *beneficiaries* or technology *manipulators*. The manipulator direct handles the device, whether it's to type in queries or dial numbers, while the beneficiary provides the motive for device usage.

Researchers have noted the different ways in which this can happen. Parikh & Ghosh, note how in a situation where the technology infrastructure is managed by an organization on behalf of clients, the organization often manipulates the device with the client looking on [103]. Sambasivan et al. find in urban Bangalore slums that there are technology *surrogates*, who handle almost all of the device manipulation on behalf of their beneficiary peers, such as when one person looks up information online on behalf of a beneficiary; *proximates*, who perform device-input manipulations, such as dialing a number on a mobile phone, before handing the device off to the beneficiary; and *translators*, who might help a beneficiary navigate a device they are already using, such as when going through a DVD player menu [116]. Gitau and Donner observe that in South African slums, a local expert called a "fundi" becomes the go-to person for advanced mobile-phone functionality [30].

In all of the above cases, the prototypical notion of a single user working with a single device is replaced by other configurations where multiple people interact with a single device. HCI, of course, has considered such situations in the developed world, but these are often fringe instances: Some have considered, for example, the shoulder-to-shoulder usage of PCs [33]. In the developing world, shared usage is arguably a mainstream activity, and this, in turn opens the door for additional research.

Shared use of a single PC in the form of thin clients or multiple terminals has clear economic value, but researchers have also considered

shared usage of a single PC with only one display. In MultiPoint, Pawar et al. allow multiple users to use a single PC via multiple mice, and apply it to developing-world schools as a way to cheaply provide increased interaction with PCs to schoolchildren [109]. This is an HCI concept with a history going back as far as 1991 ([11], only seven years after the mainstream use of the mouse through the Apple Macintosh), but while earlier the use of multiple mice struggled to make a case for itself as a tool for collaborative education [62, 131, 140], in the developing world, resource constraints give it dramatic relevance.

The case for new HCI is even stronger for mobile phones, since these devices are typically designed for individual use. What happens when they're shared? How should address books, SMS text messages, and contacts work if more than one person uses a phone? What are the privacy issues that need to be addressed? Is there value in a split multimodal experience, where shared use of the phone provides audio cues to one "user" while the other depends on the visible display? Etc.

5.4 Technology Alone is Not Enough

One of the oft- recurring lessons in ICT4D is that technology alone is almost never enough to make an impact. Success in ICT4D is often based on a project's "sustainability" — whether it can survive beyond an initial pilot and continue to have impact, even after project initiators have left the scene, and sustainability is known to have many dimensions, of which technology is often just one. Richard Heeks, a long-time commentator on ICT4D, cites financial sustainability, political sustainability, social sustainability, and so on [53], and studies of defunct projects consistently point to a failure to address the many factors outside of technology.

The point that underlies this phenomenon is that technology itself requires a platform of physical infrastructure and human organization simply to operate, to say nothing of whether the technology then has meaningful impact. Even in developed-world contexts, the information systems literature is full of caution about the total costs of ownership of technology: One study cites that the IT costs for a modern corporation can be on the order of US$7000 per employee per year [22]. The Maine

Technology Learning Initiative, one of the few rigorously studied cases of providing a laptop per student in the developed world, allocates only a portion of its budget to technology; the rest goes to maintenance, curriculum development, and teacher training [56, 125].

Partly because much of the challenge in ICT4D is extra-technological, many successful ICT4D projects run with little new technology: the technical innovations, if required, are often straightforward adaptations of technology that is already well-understood. This fact frequently comes as a disappointment to technology-happy engineers, but for HCI researchers, it is a rich opportunity. HCI regularly engages with the extra-technological issues surrounding user and machine, and ICT4D encourages a further broadening of the problem horizon.

For example, in the widely hailed Grameen Village Phone project, the mobile phone is used as is, with no technological adaptations. All of the innovation is in the way in which the devise is used: an entrepreneur becomes a walking phone booth, and a single phone is shared by an entire village [133]. Although this model presents little new for the technical engineer, it is of deep interest to those with an HCI inclination — Who dials the number when the phone is used — the entrepreneur or the caller? How do entrepreneurs reveal call costs to callers, especially when callers are illiterate? And, as is frequently the case with HCI, such questions lead to further questions that require technical adaptation: How should mobile phone interfaces work, if it is assumed that one phone is used by multiple people?

More recently, critics have begun to ask whether there are some circumstances in global development, in which deep problems of human capacity or society must be solved prior to technology being useful [136]. As technology meta-questions, these are again, lines of questioning that are part and parcel of interdisciplinary HCI and ICT4D.

6

The Future of HCI in Global Development

6.1 Summary

Although there have been glimpses of HCI ideas in global development even before computing was mainstream, it's only been in the last decade that global development has witnessed conscious application of HCI. Beginning as it did with significant conceptual and methodological overlap, it's not surprising that the fields of HCI and global development have found much to share.

Both are intensely interdisciplinary fields, comprising disparate factions that not infrequently clash over deep, epistemological differences. Yet, participants in both fields also share common goals, whether it is to make life better for technology users or to support the aspirations of the impoverished. There are methodological similarities between the larger fields of HCI and ICT4D, arising from a need to solve problems end-to-end, and to verify that they have been solved. Both fields place a strong emphasis on qualitative research to uncover the unique contexts of their human subjects. Both fields seek to design novel solutions, and to refine them through a process of iterative prototyping. And, both fields seek to evaluate their solutions, to confirm their efficacy. Then,

when the poor also become users or beneficiaries of technology, "HCI for development" emerges.

As examples, this article described the methodologies and findings of three ongoing projects: Text-Free UI is a research effort to design UIs that could be useful to illiterate users. The Telecom Web and its pilots examine how an audio bulletin board accessed by mobile phones is received by farmers and microentrepreneurs in poor communities. And, Nokia's 1100 line of mobile phone, highlighted the potential demand for a technology designed specifically for a global market of relatively poor but eager consumers.

Several themes emerge consistently in the work of the last decade. Two were predicted by early researchers in ICT4D: (1) the fact of significant hardware and infrastructure constraints, and the need to work around them, or invent beyond them; (2) the culture, language, and literacy differences between HCI professionals from wealthy backgrounds and the intended beneficiaries of global development. Two were more surprising, but repeat as themes in much of the research: (3) the degree to which developing communities share technology and make use of intermediation by friends and family; (4) the complexity of problems, where rarely is a technological solution on its own enough, however good the UI: There are social, political, economic, and cultural phenomena that require as much attention as the technological and cognitive.

So, these themes will continue in future work in HCI for development, because the challenges are far from overcome. And, they'll be joined by additional themes that are just beginning to emerge....

6.2 Impact-Focused Evaluation

Although HCI on the whole values evaluation of technology and usability, it tends to limit its purview to UI issues. For example, after prototyping a new interface or a new tool, HCI evaluation will typically measure such figures as task error rates or time to task completion, while surveying or interviewing for user preference or user opinions. A UI might be designed to ultimately impact worker productivity, but it's rare that productivity itself is measured: There are few, if any, studies of corporate or national productivity that result from the use

of one technology or UI over another. Instead, HCI research generally assumes, for example, that if you can cut 10% of the task completion time in something that everyone spends 2 hours doing daily, you'd have saved 12 minutes per day per person, which is assumed to translate to greater productivity. Whether these are valid assumptions or not is rarely questioned, but they are accepted.[1]

At some point in the future, global development may come to a similar understanding, but at present, development experts are all too aware that making task completion 10% quicker is no guarantee of positive impact. Workers may use the saved time in a variety of ways that don't result in healthier children, better educated teens, or wealthier families. Thus, it's important that when measuring the impact of HCI-for-development projects, to observe or measure the outcomes that are ultimately desired. If, for example, a new tool for healthcare workers is designed to improve the overall system, an ideal evaluation would look at the healthcare outcomes that result.

This kind of end-impact evaluation is still missing on the whole from ICT4D projects. Indeed, early ICT4D rarely performed evaluations of any kind, and so, HCI's focus on evaluation is welcome. It would be nice to see this emphasis extended to ultimate impacts.

The issue applies equally well to qualitative and quantitative research. In qualitative research, it's one thing to observe users actually using a system, to interview them at length, and so forth, but it's another to focus on end impact. A researcher might draw subjects from the eventual beneficiaries of the system, who may not necessarily be direct technology users. For example, when a healthcare worker starts using a new technology, how do the patients respond? Do they perceive any difference in the healthcare workers? Do they themselves interact with the technology? And, so forth. Brian De Renzi et al. note, for example, that when healthcare workers carry PDAs rather than paper forms, the patients themselves feel greater respect for the healthcare workers [25].

[1] Actually, these assumptions deserve to be questioned even in mainstream HCI. In an office environment, 12 minutes saved daily may translate to 12 minutes more time to read online news or 12 minutes less time at the office.

In quantitative research, there is a rich tradition in medicine that performs clinical trials with statistically meaningful patient samples, and this has extended into global development through the field of public health. Metrics such as disability adjusted life years (DALY), are widely used as a way to measure overall impact of programs. Some development economists, such as those associated with the Jameel Poverty Action Lab, Innovations for Poverty Action, and the Center for Evaluation of Global Action, have also begun to use randomized trials, as a way to measure program effectiveness at a large scale, and they strive to measure ultimate outcomes whenever possible. The methodology of the controlled experiment is well understood by HCI researchers, so all this takes is a shift to measuring final outcomes, along with intermediate ones of usability.

6.3 Beyond Computing

Finally, one exciting possibility, as the arenas of HCI and global development intersect, is the possibility of HCI's methodology increasingly diffusing into global development. Global development, dominated as it is by social scientists, tends to excel at observation, evaluation, critique, and even policy, but innovation and invention is not its primary strength. Even when new ideas are considered, the methodology could be called "trial by evaluation," where an idea is tried at a large scale; society is treated as a black box; and the outcome is observed at coarse granularity to decide whether the idea has merit. At the very least, this kind of methodology has a practical problem in that it could take decades and even centuries to decide the optimal parameters for a new system. (To be sure, there are exceptions to this claim, including appropriate technology advocates, some innovative NGOs, entrepreneurs, and so on, but their voices are muted in policy circles.)

In contrast, HCI comprises a unique, complete theory of problem solving: From contextual observation and problem assessment, to design and iterative prototyping, to rigorous evaluation. In addition, HCI draws from the tradition of qualitative social sciences that constantly questions the goals of the fields, as well as the kind of impact

delivered to users. Few other fields are concerned with all of these stages of problem solving, and rarely are they as methodologically rigorous in each. This is one of the great strengths of HCI as a field. And, while the details may differ from problem to problem, and from domain to domain, these problem-solving steps have great value in facing an array of challenges.

Worldwide, technologists seem increasingly interested in contributing to global development, as witnessed by the growing field of ICT4D. This trend provides the perfect entrance for HCI. With more interaction between HCI professionals and global development practitioners, we can look forward to a future for HCI that extends to greater and more meaningful impact — not only in solving the problems of technological user interfaces, but perhaps also in addressing the big challenges of global development.

Acknowledgments

The author is grateful to Arun Kumar, Olga Morawczynski, Tapan Parikh, and Neil Patel for reading through sections of the paper for accuracy. Kumar, in particular, provided much-needed corrections in the section on the Telecom Web. In addition, two anonymous reviewers provided excellent suggestions, without overwhelming the author with additional things that could have been added. There are many more topics and references that could have been included in an overview article of this nature, and the author wishes to thank readers for their forbearance with the article's shortcomings.

References

[1] African Economic Outlook, "Pro-development innovative applications," URL: http:// www.africaneconomicoutlook.org/en/in-depth/innovation-and-ict-in-africa/pro-development-innovative-applications/, March 14 2010.

[2] S. K. Agarwal, D. Chakraborty, A. Kumar, A. A. Nanavati, and N. Rajput, "HSTP: Hyperspeech transfer protocol," in *Proceedings of the Eighteenth International ACM Conference on Hypertext and Hypermedia* (Hypertext 2007), Manchester, UK, September 10–12th 2007.

[3] S. K. Agarwal, A. Kumar, A. A. Nanavati, and N. Rajput, "Content creation and dissemination by-and-for users in rural areas," in *Proceedings of 3rd IEEE/ACM International Conference on Information and Communication Technologies and Development (ICTD2009)*, Doha, Qatar, 17–19 April 2009.

[4] S. K. Agarwal, A. Kumar, A. A. Nanavati, and N. Rajput, "User-generated content creation and dissemination in rural areas," *Information Technologies and International Development*, 2010.

[5] Y. Anokwa, T. N. Smyth, D. Ramachandran, J. Sherwani, Y. Schwartzman, R. Luk, M. Ho, N. Moraveji, and B. DeRenzi, "Stories from the field: Reflections on HCI4D experiences," *Information Technologies and International Development*, vol. 5, no. 4, 2009.

[6] K. Banks, "Reaching out through mobile technology with the humble SMS," *Didactics World*, pp. 21–24, April 2008.

[7] Y. Ben-David, "Welcome to Air Jaldi," URL: http://resources.airjaldi.com/wp-content/uploads/2006/11/yahel-ben-david-opening_remarks.pdf (March 2, 2010), 2006.

[8] P. Benjamin, "African Experience with Telecenters," On the Internet, November–December 2000.
[9] M. Best Private communication, 2008.
[10] M. L. Best, D. Thakur, and B. E. Kolko, "The contribution of user-based subsidies to the impact and sustainability of telecenters - the eCenter project in Kyrgyzstan," in *Proceedings of the 3rd International Conference on Information and Communication Technologies and Development* (ICTD2009), 2009.
[11] E. A. Bier and S. Freeman, "MMM: A user interface architecture for shared editors on a single screen," in *Proceedings of the 4th Annual ACM Symposium on User interface Software and Technology* (Hilton Head, South Carolina, United States, November 11–13, 1991), UIST '91, pp. 79–86, New York, NY: ACM, 1991.
[12] E. Brewer, M. Demmer, B. Du, M. Ho, M. Kam, S. Nedevschi, J. Pal, R. Patra, S. Surana, and K. Fall, "The case for technology in developing regions," *Computer*, vol. 38, no. 6, pp. 25–38, June 2005.
[13] J. Burrell and K. Toyama, "What constitutes good ICTD research?," *Information Technology and International Development*, vol. 5, no. 3, pp. 82–94, 2009.
[14] I. Ceaparu, *Telephone-based Access to the Web–Speech Recognition*. University of Maryland, April 2001. URL: http://otal.umd.edu/uupractice/phone/ (March 16, 2010).
[15] CGAP (Consultative Group to Assist the Poor), "M-PESA: Connecting urban and rural communities," URL: http://www.cgap.org/p/site/c/template.rc/1.26.11223/ (March 2, 2010), August 12 2009.
[16] K. G. Cheng, F. Ernesto, and K. N. Truong, "Participant and interviewer attitudes toward handheld computers in the context of HIV/AIDS programs in sub-Saharan Africa," in *Proceedings of the 26th Annual SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy, April 05–10, 2008). CHI '08, pp. 763–766, New York, NY: ACM, 2008.
[17] M. Chetty, W. Tucker, and E. Blake, "Developing locally relevant software applications for rural areas: A South African example," in *Proceedings of the Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on IT Research in Developing Countries*, pp. 239–243, 2004.
[18] CHI, "CHI reviewing: A guide and examples," URL: http://www.chi2005.org/cfp/reviewing.html (March 14, 2010), 2005.
[19] J. Chipchase, "Future perfect blog," URL: http://www.janchipchase.com/ (March 14, 2010), 2005–2009.
[20] J. Chipchase, "Shared phone use. Future perfect blog," URL: http://www.janchipchase.com/sharedphoneuse (March 14, 2010), 2006.
[21] G. Chu, S. Satpathy, K. Toyama, R. Gandhi, R. Balakrishnan, and S. R. Menon, "Featherweight multimedia for information dissemination," April 2009.
[22] Computer Economics, *IT Spending and Staffing Benchmarks 2009/2010*. 2009. URL: http://www.computereconomics.com/page.cfm?name=IT% 20Spending%20and%20Staffing%20Study (March 20, 2010).

[23] Computer Industry Almanac, "PCs in-use reached nearly 1.2B in 2008," URL: http://www.c-i-a.com/pr0109.htm (March 20, 2010), 2009.

[24] J. B. Deregowski, *Illusions, Patterns and Pictures: A Cross-Cultural Perspective*. Academic Press, 1980.

[25] B. DeRenzi, N. Lesh, T. Parikh, C. Sims, W. Maokla, M. Chemba, Y. Hamisi, D. Shellenberg, M. Mitchell, and G. Borriello, "E-imci: Improving pediatric health care in low-income countries," in *Proceedings of the 26th Annual SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy, April 05–10, 2008). CHI '08, pp. 753–762, New York, NY: ACM, 2008.

[26] A. Dix, J. E. Finlay, G. D. Abowd, and R. Beale, *Human-Computer Interaction*. Prentice Hall, 3rd ed., 2003.

[27] J. Donner, "Blurring livelihoods and lives: The social uses of mobile phones and socioeconomic development," *Innovations: Technology, Governance, Globalization*, vol. 4, no. 1, pp. 91–101, 2009.

[28] J. Donner, "Mobile media on low-cost handsets: The resiliency of text messaging among small enterprises in India (and beyond)," in *Mobile Technologies: From Telecommunications to Media*, (G. Goggin and L. Hjorth, eds.), pp. 93–104, New York: Routledge, 2009.

[29] J. Donner, R. Gandhi, P. Javid, I. Medhi, R. Aishwarya, K. Toyama, and R. Veeraraghavan, "Stages of design in technology for global development," *Computer*, vol. 41, no. 6, pp. 34–41, June 2008.

[30] J. Donner and S. Gitau, "Four frames of social software use by mobile-centric internet users," Paper presented at the GLOBICOMP Workshop: A preconference workshop of UBICOMP2009, Orlando, 2009.

[31] J. Donner, N. Rangaswamy, M. W. Steenson, and C. Wei, ""Express yourself"/"Stay together": Tensions surrounding mobile communication in the middle-class Indian family," in *Handbook of Mobile Communication Studies*, (J. Katz, ed.), pp. 325–337, Cambridge, MA: MIT Press, 2008.

[32] P. Dourish, "Implications for design," in *Proceedings ACM Conference on Human Factors in Computing Systems CHI 2006*, pp. 541–550, Montreal, Canada, 2006.

[33] S. M. Drucker, T. Regan, A. Roseway, and M. Lofstrom, "The visual decision maker: A recommendation system for collocated users," in *Proceedings of the 2005 Conference on Designing For User Experience* (San Francisco, California, November 03–05, 2005), p. 21 Designing For User Experiences, vol. 135, New York, NY: AIGA: American Institute of Graphic Arts, 2005.

[34] E. Duflo, R. Glennerster, and M. Kremer, "Using randomization in development economics research: A toolkit," in *Handbook of Development Economics* , vol. 4, pp. 3895–3962, Elsevier, 2008.

[35] W. Easterly, *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*. MIT Press, 2003.

[36] J. N. Eastmond Jr. and R. Mosenthal, "The world center for computing's pilot videodisc project for French language instruction," *CALICO Journal*, vol. 2, pp. 8–12, 1985.

[37] A. O. Faulkner and M. L. Albertson, "Tandem use of hard and soft technology: An evolving model for third world village development," *International Journal of Applied Engineering Education*, vol. 2, no. 2, pp. 127–137, 1986.

[38] L. Findlater, R. Balakrishnan, and K. Toyama, "Comparing semiliterate and illiterate users' ability to transition from audio+text to text-only interaction," in *Proceedings of SIGCHI Conference on Human Factors in Computing Systems (CHI 2009)*, pp. 1751–1760, 2009.

[39] M. Gakuru, K. Winters, and F. Stepman, "Inventory of innovative farmer advisory services using ICTs," Technical report, The Forum for Agricultural Research in Africa, 2009.

[40] R. Gandhi, R. Veeraraghavan, K. Toyama, and V. Ramprasad, "Digital green: Participatory video for agricultural extension," *Information Technology and International Development*, vol. 5, no. 1, pp. 1–15, 2009.

[41] Gapminder, URL: http://www.gapminder.org/world (March 2, 2010), 2010.

[42] C. Geertz, "Thick description: Toward an interpretive theory of culture," in *The Interpretation of Cultures: Selected Essays*, pp. 3–30, New York: Basic Books, 1973.

[43] K. Ghosh, T. S. Parikh, and A. L. Chavan, "Design considerations for a financial management system for rural, semi-literate users," in *CHI '03 Extended Abstracts on Human Factors in Computing Systems* (Ft. Lauderdale, Florida, USA, April 05–10, 2003). CHI '03, pp. 824–825, New York, NY: ACM, 2003.

[44] A. Giridharadas, *In India, Poverty Inspires Technology Workers to Altruism*. New York Times, October 30 2007.

[45] T. Giridher, A. Bulchandani, R. Kim, P. Naik, A. Wasilewska, and J. L. Wong, "Social mobile applications," *Applications and Technology Conference (LISAT), 2010 Long Island Systems*, pp. 1–6, doi: 10.1109/LISAT.2010.5478281, URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5478281&isnumber=5478264, 7 May 2010.

[46] M. Goetze and T. Strothottle, "An approach to help functionally illiterate people with graphical reading aids," *Smart Graphics Symposium UK*, March 21–23, Hawthorne, NY, USA 2001.

[47] J. Haas, F. Gallwitz, A. Horndasch, R. Huber, and V. Warnke, "Telephone-based speech dialog systems," *Lecture Notes in Computer Science*, vol. 3663/2005, 2005.

[48] M. Hasan, "Mission2011: Building inclusive ICT based knowledge system," *Telecentre Magazine*, June 2009.

[49] HCC4ID, "Workshop on human-centered computing in international development," URL: http://www.ics.uci.edu/∼nsambasi/hcc4id/, 2009.

[50] HCI4CID, "Workshop on HCI for community and international development," URL: http://mikeb.inta.gatech.edu/HCI4CID/, 2008.

[51] J. W. Head, *Losing the Global Development War: A Contemporary Critique of the IMF*. Leiden, Nijhoff: The World Bank, and the WTO, 2008.

[52] R. Heeks, "Technology policy making as a social and political process: Liberalizing India's software policy," *Technology Analysis and Strategic Management*, vol. 2, no. 3, pp. 275–291, 1990.

[53] R. Heeks, "Information and communication technologies, poverty and development," *Institute for Development Policy and Management*, 1999.

[54] T. Hewett, R. Baecker, S. Card, T. Carey, J. Gasen, M. Maneti, G. Perlman, G. Strong, and W. Verplank, *ACM SIGCHI Curricula for Human-Computer Interaction*. New York: ACM Press, 1992.

[55] M. Ho, T. Smyth, M. Kam, and A. Dearden, "Human–computer interaction for development: The past, present, and future," *Information Technologies & International Development*, vol. 5, no. 4, URL: http://itidjournal.org/itid/article/view/420/188, 2009.

[56] L. Holcomb, "Lessons learned from 1:1 laptop initiatives: A collective review," *TechTrends*, vol. 53, no. 6, pp. 49–55, Springer, 2009.

[57] M. Huenerfauth, "Developing design recommendations for computer interfaces accessible to illiterate users," Master's thesis, University College Dublin, 2002.

[58] E. Huerta and R. Sandoval-Almazán, "Digital literacy: Problems faced by telecenter users in Mexico," *Information Technology for Development*, vol. 13, no. 3, pp. 217–232, 2007.

[59] J. Hugo, "HCI and multiculturalism in southern Africa," in *Proceedings of the CHI 2002 Development Consortium*, 2002.

[60] IDRC Study/Acacia Initiative, "Exploring a basic illiterate web access system," Prepared by m-powa, Midrand, South Africa. February, URL: http://www.idrc.ca/en/ev-9515-201-1-DO_TOPIC.html, 1997.

[61] IMF (International Monetary Fund), "Cooperation and reconstruction," URL: http://www.imf.org/external/about/histcoop.htm (March 2, 2010), 1944–1971.

[62] K. Inkpen, K. S. Booth, M. Klawe, and R. Upitis, "Playing together beats playing apart, especially for girls," in *The First International Conference on Computer Support for Collaborative Learning*, pp. 177–181, Indiana Univ., Bloomington, Indiana, October 1995.

[63] ITU (International Telecommunications Union), "ITU sees 5 billion mobile subscriptions globally in 2010," URL: http://www.itu.int/net/pressoffice/press_releases/2010/06.aspx (March 2, 2010), February 15 2010.

[64] R. Jensen, "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector," *Quarterly Journal of Economics*, vol. 122, no. 3, pp. 879–924, 2007.

[65] A. Jhunjhunwala, A. Ramachandran, and A. Bandyopadhyay, "n-Logue: The story of a rural service provider in India," *Journal of Community Informatics*, vol. 1, no. 1, pp. 30–38, 2004.

[66] M. Jones and G. Marsden, *Mobile Interaction Design*. Chichester, UK: Wiley, 2006.

[67] M. Kam, S. Dray, K. Toyama, and G. Marsden, "Computing technology in international development: Who, what, where, when, why and how?," *Panel presented at CHI 2010,* Atlanta, GA, 2010.

[68] D. Katre, R. Orngreen, P. Yammiyavar, T. Clemmensen, and P. Kate, "Developing a mobile phone based GUI for users in the construction industry: A case study," in *Human Work Interaction Design: Usability in Social, Cultural and Organizational Contexts. IFIP Advances in Information and Communication Technology*, 2010. URL http://dx.doi.org/10.1007/978-3-642-11762-6_17.

[69] D. S. Katre, "Using mnemonics as part of pictorial interface for self identification of illiterate villagers," in *Proceedings of International Conference on Human-Computer Interaction (I-HCI 2004)*, 2004.

[70] K. Keniston, K. Toyama, R. Samarajiva, and S. Mpagi, "Telecentre debates: the PC is the best vehicle for providing e-Services to the rural areas," *Telecentre Magazine*, pp. 29–32, April–June 2009.

[71] D. Kleine, "ICT4What? — Using the choice framework to operationlise the capability approach to development," in *Proceedings of IEEE/ACM International Conference on Information and Communication Technologies and Development*, 2009.

[72] B. Kothari, A. Pandey, and A. R. Chudgar, "Reading out of the "idiot box": Same-language subtitling on television in India," *Information Technologies and International Development*, vol. 2, no. 1, pp. 23–44, 2004.

[73] P. Kotzé, "Directions in HCI education, research, and practice in Southern Africa," *Extended abstracts on human factors in computing systems*, pp. 524–525, 2002.

[74] M. Kremer and E. Miguel, "The illusion of sustainability," *Quarterly Journal of Economics*, vol. 122, no. 3, August 2007.

[75] A. Kumar, N. Rajput, S. K. Agarwal, D. Chakraborty, and A. A. Nanavati, "Organizing the unorganized — employing IT to empower the Under-privileged," in *ACM International World Wide Web Conference (WWW)*, Beijing, China, 21–25 April 2008. Preprint available as IBM Research Report No. RI07007, October 2007.

[76] A. Kumar, N. Rajput, D. Chakraborty, S. K. Agarwal, and A. A. Nanavati, "VOISERV: Creation and delivery of converged services through voice in emerging economies," in *Proceedings of 8th IEEE International Symposium on World of Wireless, Mobile and Multimedia Networks (WoWMoM)*, Helsinki, Finland, June 21–25 2007.

[77] A. Kumar, N. Rajput, D. Chakraborty, S. K. Agarwal, and A. A. Nanavati, "WWTW: The World Wide Telecom Web," in *Proceedings of ACM SIGCOMM Workshop on Networked Systems for Developing Regions (NSDR)*, Kyoto, Japan, August 2007.

[78] P. Kumar, *Television Industry in India: Market Structure, Conduct, and Performance*. New Delhi: Deep & Deep Publications, 1988.

[79] A. Kumaran, K. Saravanan, and S. Maurice, "WikiBABEL: Community creation of multilingual data," in *the WikiSYM 2008 Conference, Porto, Portugal*, Association for Computing Machinery, Inc., September 2008.

[80] A. Lall and S. Sahi, "Taking ICTs to the grassroots: A case study of the lifelines india initiative," *Information Technology in Developing Countries Newsletter. IFIP WG 9.4*, vol. 19, no. 1, pp. 13–15, 2009.

[81] J. Landay, "I give up on CHI/UIST. Dub for the Future blog," URL: http://dubfuture.blogspot.com/2009/11/i-give-up-on-chiuist.html (March 14, 2010), 2009.

[82] C. Law and G. Vanderheiden, "The development of a simple, low cost set of universal access features for electronic devices," in *CUU2000: ACM Conference on Universal Usability*, Arlington, VA, November 16–17 2000.

[83] C. A. Le Dantec and W. K. Edwards, "Designs on dignity: perceptions of technology among the homeless," in *Proceedings of the 26th Annual SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy, April 05–10, 2008). CHI '08, pp. 627–636, New York, NY: ACM, 2008.

[84] C. A. Le Dantec and W. K. Edwards, "Across boundaries of influence and accountability: The multiple scales of public sector information systems," in *Proceedings of the 26th Annual SIGCHI Conference on Human Factors in Computing Systems (2010)*. CHI 2010, 2010.

[85] R. Luk, M. Ho, and P. M. Aoki, "Asynchronous remote medical consultation for Ghana," in *Proceedings of the 26th Annual SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy, April 05–10, 2008). CHI '08, pp. 743–752, New York, NY: ACM, 2008.

[86] G. J. Mark, B. Al-Ani, and B. Semaan, "Resilience through technology adoption: merging the old and the new in Iraq," in *Proceedings of the 27th International Conference on Human Factors in Computing Systems* (Boston, MA, USA, April 04–09, 2009). CHI '09, pp. 689–698, New York, NY: ACM, 2009.

[87] I. Medhi and R. Kuriyan, "Text-free UI: Prospects for social inclusion," *International Conference on Social Implications of Computers in Developing countries,* Brazil, May 2007.

[88] I. Medhi, G. Menon, and K. Toyama, "Challenges of Computerized Job-Search in the Developing World," in *Proceedings of the ACM Conference on Computer Human Interaction*, Florence, Italy, 2008.

[89] I. Medhi, G. S. N. Nagasena, and K. A. Toyama, "Comparison of mobile money-transfer UIs for non-literate and semi-literate users," in *Proceedings of ACM Conference on Computer Human Interaction*, Boston, USA, 2009.

[90] I. Medhi, A. Ratan, and K. Toyama, "Mobile-banking adoption and usage by low-literate, low-income users in the developing world," in *Proceedings of Human Computer Interaction International*, San Diego, USA, 2009.

[91] I. Medhi, A. Sagar, and K. Toyama, "Text-free user interfaces for illiterate and semi-literate users," *IEEE/ACM International Conference on Information and Communication Technologies and Development, Berkeley, USA*, 2006.

[92] I. Medhi and K. Toyama, "Full-context videos for first-time, non-literate PC users," *IEEE/ACM International Conference on Information and Communication Technologies and Development,* Bangalore, India, 2007.

[93] C. B. Merkel, L. Xiao, U. Farooq, C. H. Ganoe, R. Lee, and J. M. Carroll et al., "Participatory design in community computing contexts: Tales from the field," in *Proceedings of the Conference on Participatory Design*, pp. 1–10, 2004.

[94] MobileHCI, "Human computer interaction with mobile devices," URL: http://www.dcs.gla.ac.uk/∼johnson/workshops_old/mobile.html (March 2, 2010), 1998.

[95] N. Moraveji, T. Kim, J. Ge, U. S. Pawar, K. Mulcahy, and K. Inkpen, "Mischief: Supporting remote teaching in developing regions," in *Proceedings of the 26th Annual SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy, April 05–10, 2008). CHI '08, pp. 353–362, New York, NY: ACM, 2008.

[96] O. Morawczynski, "Examining the usage and impact of transformational M-banking in Kenya," *HCI*, vol. 14, pp. 495–504, 2009.

[97] D. Murph, "Nokia's 1100 handset: Over 200 million served," *Engadget*, URL: http://www.engadget.com/2007/05/07/nokias-1100-handset-over-200-million-served/, May 7 2007.

[98] Nationmaster, Radio receivers (per capita) (most recent) by country. http://www.nationmaster.com/graph/med_rad_rec_percap-media-radio-receivers-per-capita, November 4 2010.

[99] Nokia Press Release, "Nokia 1100 phone offers reliable and affordable mobile communications for new growth markets," URL: http://www.nokia.com/NOKIA_COM_1/About_Nokia/Press/Press_Events/zz_New_Potential/Nokia 1100_release.pdf, August 27 2003.

[100] G. Nunberg, "Languages in the wired world," Presented at Conference on "The Politics of Language and the Building of Modern Nations," Institut d'Etudes Politiques de Paris, URL: http://people.ischool.berkeley.edu/∼nunberg/WebPaper.html, October 2 1998.

[101] W. Ong, *Orality and Literacy: The Technologizing of the Word*. London: Routledge, 1982.

[102] J. Pal, U. S. Pawar, E. A. Brewer, and K. Toyama, "The case for multi-user design for computer aided learning in developing regions," in *Proceedings of the 15th International Conference on World Wide Web* (Edinburgh, Scotland, May 23–26, 2006). WWW '06, pp. 781–789, New York, NY: ACM, 2006.

[103] T. Parikh and K. Ghosh, "Understanding and designing for intermediated information tasks in India," *IEEE Pervasive Computing*, vol. 5, no. 2, pp. 32–39, 2006.

[104] T. Parikh, K. Ghosh, and A. Chavan, "Design considerations for a financial management system for rural, semi-literate users," *ACM Conference on Computer-Human Interaction*, 2003.

[105] T. S. Parikh, P. Javid, K. Sasikumar, K. Ghosh, and K. Toyama, "Mobile phones and paper documents: Evaluating a new approach for capturing microfinance data in rural India," *ACM Conference on Computer-Human Interaction (CHI)*, Montreal, Canada, April 24–27 2006.

[106] J. Pascoe, N. Ryan, and D. Morse, "Using while moving: HCI issues in fieldwork environments," *Transactions on Computer-Human Interaction*, vol. 7, no. 3, pp. 417–437, 2000.

[107] N. Patel, D. Chittamuru, A. Jain, P. Dave, T. S. Parikh, and A. Otalo, "A field study of an interactive voice forum for small farmers in rural India," in *Proceedings of ACM Conference on Human Factors in Computing Systems* (CHI 2010), 2010.

[108] R. Patra, S. Nedevschi, S. Surana, A. Sheth, L. Subramanian, and E. Brewer, "WiLDNet: Design and implementation of high performance WiFi based long distance networks," USENIX NSDI, April 2007.

[109] U. S. Pawar, J. Pal, R. Gupta, and K. Toyama, "Multiple mice for retention tasks in disadvantaged schools," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1581–1590, 2007.

[110] Poverty Action Lab, Scientific evidence to guide policy on MDGs, URL: http://povertyactionlab.org/MDG/ (March 16, 2010), 2010.

[111] C. K. Prahalad, *The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits*. Wharton School Publishing, 2004.

[112] B. Raman and K. Chebrolu, "Experiences in using WiFi for rural internet in India," *IEEE Communications Magazine*, Special Issue on New Directions In Networking Technologies In Emerging Economies, January 2007.

[113] A. Ratan and S. Bailur, "Welfare, agency, and ICT for development," in *Proceedings of the IEEE/ACM International Conference on Information and Communication Technologies and Development*, pp. 119–130, Bangalore, India, 2007.

[114] A. Ratan, S. Chakraborty, K. Toyama, P. Chitnis, K. S. Ppo, M. Phiong, and M. Koenig, "Managing microfinance with paper, pen and digital slate," in *International Conference on Information and Communication Technologies and Development*, London, 2010.

[115] J. Sachs, *The End of Poverty: Economic Possibilities for Our Time*. Penguin Press, 2005.

[116] N. Sambasivan, E. Cutrell, K. Toyama, and B. Nardi, "Intermediated technology use in developing communities," in *Proceedings of CHI 2010, Human Factors in Computing Systems* (Atlanta), ACM press, 2010.

[117] Satellife, "Handhelds for health : SATELLIFE's experiences in Africa and Asia," URL: https://idl-bnc.idrc.ca/dspace/handle/123456789/28142 (March 14, 2010), 2005.

[118] E. Schaeffer, *Institutionalization of Usability: A Step-by-step Guide*. Addison-Wesley.

[119] W. Schramm, *Mass Media and National Development: The Role of Information in the Developing Countries*. Stanford University Press, 1964.

[120] A. Sen, Development as freedom, 1999.

[121] A. Sey, "Public access to ICTs: A review of the literature," Research Working Paper Series. Center for Information & Society, University of Washington, 2008.

[122] J. Sherwani, N. Ali, C. Rose, and R. Rosenfeld, "Orality-grounded HCID: Understanding the oral user," in *Information Technologies & International Development, Special Issue on Human Computer Interaction and Development*, December 2009.

[123] B. Shneiderman, "The eyes have it: A task by data type taxonomy for information visualizations," in *Proceedings of the 1996 IEEE Symposium on Visual Languages* (September 03–06, 1996). VL, p. 336, Washington, DC: IEEE Computer Society, 1996.

[124] B. Shneiderman and C. Plaisant, *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. Addison-Wesley, 4th ed., 2004.

[125] D. L. Silvernail and D. M. M. Lane, *The Impact of Maine's One-to-One Laptop Program on Middle School Teachers and Students*. Maine Education Policy Research Institute, February 2004. URL: http://maine.gov/mlti/articles/research/MLTIPhaseOneEvaluationReport2004.pdf (March 20, 2010).

[126] A. Smith, *Lecture Notes for D-Lab: Development, Dialogue and Delivery*. MIT. URL: http://ocw.mit.edu/OcwWeb/Special-Programs/SP-721Fall-2004/ LectureNotes/ (March 14, 2010).

[127] T. N. Smyth, S. Kumar, I. Medhi, and K. Toyama, "Where There's a Will There's a Way: Mobile Media Sharing in Urban India," in *Proceedings of*

SIGCHI Conference on Human Factors in Computing Systems (CHI 2010), 2010.

[128] S. Song, "Nathan and the mobile operators," URL: http://manypossibilities.net/2009/03/nathan-and-the-mobile-operators/ (March 2, 2010), March 20 2009.

[129] M. Steenson and J. Donner, "Beyond the personal and private: Modes of mobile phone sharing in urban India," in *The Reconstruction of Space and Time: Mobile Communication Practices,* vol. 1, pp. 231–250, Transaction Publishers, 2009.

[130] S. R. Sterling, J. O'Brien, and J. K. Bennett, "Advancement through interactive radio," *Information Systems Frontiers*, vol. 11, no. 2, pp. 145–154, April 2009.

[131] J. Stewart, B. B. Bederson, and A. Druin, *Single Display Groupware: A Model for Co-present Collaboration*. New York, NY, USA: ACM Press, 1999.

[132] A. Sukumaran, S. Ramlal, E. Ophir, V. R. Kumar, G. Mishra, V. Evers, V. Balaji, and C. Nass, "Intermediated technology interaction in rural contexts," in *CHI Spotlight on Works in Progress*, ACM, 2009.

[133] N. P. Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy*. Jossey-Bass, 2007.

[134] S. Surana, R. Patra, S. Nedevschi, and E. Brewer, "Deploying a rural wireless telemedicine system: Experiences in sustainability," *Computer*, vol. 41, no. 6, pp. 48–56, June 2008.

[135] S. Swamy, "Inclusive banking via cellphones," *The Economic Times*, p. 11, 05 January 2010.

[136] K. Toyama, *The Crux of Daedalus*. Boston Review, Nov/Dec, to appear 2010.

[137] K. Toyama and M. B. Dias, "Information and communication technologies for development," *IEEE Computer*, vol. 41, no. 6, pp. 22–25, 2008.

[138] K. Toyama and K. Keniston, "Telecentre debates," *Telecentre Magazine*, URL: http://www.telecentremagazine.net/articles/article-details.asp?Title=Telecentre-debates&articleid=72&typ=Telecentre Debates (March 2, 2010), March 2008.

[139] K. Toyama, K. Kiri, D. Menon, J. Pal, S. Sethi, and J. Srinivasan, "PC Kiosk trends in rural India," *Policy Options and Models for Bridging Digital Divides* (Tampere, Finland), April 2005.

[140] E. Tse and S. Greenberg, "Rapidly prototyping single display groupware through the SDGToolkit," in *Proceedings of the 5th Conference on Australasian User Interface*, pp. 101–110, Dunedin, New Zealand, January 01 2004.

[141] UCDID, "Workshop on user centred design and international development," URL: http://mikeb.inta.gatech.edu/UCDandIDWorkshop/, 2007.

[142] UIS, *GLOBAL EDUCATION DIGEST 2007: Comparing Education Statistics Across the World*. UNESCO Institute for Statistics, URL: http://www.uis.unesco.org/ev.php?ID=7167_201&ID2=DO_TOPIC (March 20, 2010), 2007.

[143] UIS (UNESCO Institute for Statistics), "According to the most recent UIS data, there are an estimated 774 million illiterate adults in the

world, about 64% of whom are women," URL: http://www.uis.unesco.org/ev_en.php?ID=6401_201&ID2=DO_TOPIC (March 2, 2010), October 8 2009.

[144] UN (United Nations), "About the United Nations/History," URL: http://www.un.org/aboutun/history.htm (March 2, 2010), 2000.

[145] R. Veeraraghavan and K. Toyama, "Warana unwired: Mobile phones replacing PCs in a rural sugarcane cooperative," *Information Technologies for International Development*, vol. 5, no. 1, pp. 81–95, 2009.

[146] R. Walton, "Private communication," November 2009.

[147] L. Waverman, M. Meschi, and M. Fuss, "The impact of telecoms on economic growth in developing nations," URL: http://www.vodafone.com/etc/medialib/attachments/cr_downloads.Par.78351.File.tmp/GPP_SIM_paper_3.pdf, 2005.

[148] World Bank, "World Bank History," URL: http://go.worldbank.org/2GIYUD9KB0 (March 2, 2010), 2010.

[149] J. Youll, "World dialog: Video/voice messaging for developing regions," *Preliminary Research Proposal*, MIT Media Lab. URL: http://web.media.mit.edu/∼jim/projects/world/world.pdf (February 4, 2000), 2000.