Research Article

Human-Computer Interaction for Development: The Past, Present, and Future

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Abstract

Recent years have seen a burgeoning interest in research into the use of information and communication technologies (ICTs) in the context of developing regions, particularly into how such ICTs might be appropriately designed to meet the unique user and infrastructural requirements that we encounter in these cross-cultural environments. This emerging field, known to some as HCI4D, is the product of a diverse set of origins. As such, it can often be difficult to navigate prior work, and/or to piece together a broad picture of what the field looks like as a whole. In this paper, we aim to contextualize HCI4D—to give it some historical background, to review its existing literature spanning a number of research traditions, to discuss some of its key issues arising from the work done so far, and to suggest some major research objectives for the future.

Introduction

Recent years have seen a growing research interest in both the design and use of information and communication technologies (ICTs) in the context of developing regions, and the impact that technology adoption has on economic and social development. A broad area of study has grown up that encompasses "development informatics," "social implications of computers in developing countries," "Information Technologies and International Development" (ITID), and "ICT and Development" (ICTD). Within this broad area, there is now a growing body of work examining questions of how interactive products, applications, and systems can be appropriately designed to both address the distinctive needs of users in developing regions, and to cope with the difficult infrastructural contexts where these technologies must work. This area can be termed "Human-Computer Interaction for Development" (HCI4D).

What does it mean to be doing HCI research "for development"? Firstly, let us start with a definition of human-computer interaction from the Association for Computing Machinery (ACM):

> Human-computer interaction is 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. (Hewett, Baecker, Card, Carey, Gasen et al., 1992, p. 5)

Development is a "major phenomenon," as is the rapid proliferation of ICT throughout the developing world. Thus, HCI can never be complete without study of interactive computer systems in developing regions.

Arriving at a definition for development is far more contentious, and

the field of development studies includes a very wide range of positions. Some approaches focus on economic growth; some on the millennium development goals (MDGs); some concentrate on people's livelihoods (DfID, 2001); some on development as freedom or capabilities (Sen, 1999); and there are many more possible positions. Indeed, the discourse within development studies is so diverse (Kleine & Unwin, 2009), and unavoidably political, that it is beyond the scope of this paper to examine this issue in depth.

While we often make claims that our research can broadly contribute to "development," it is often difficult to measure the wider impacts of our contributions within the short timeframes of our (often) 3- to 5-year research projects. The question of what entails research done "for development" is also difficult to define. Therefore, for the purposes of this paper, we scope "HCI4D" broadly, as any HCI research that addresses the needs or aspirations of people in developing regions, or that addresses specific social, cultural, and/or infrastructural challenges of developing regions.

We use the initials ICTD (information communications technology *and* development) to refer to the broad field of study involving ICT in developing regions. This includes studies of the social impacts of ICTs in developing countries (e.g., Bhatnagar & Odera, 1992); studies of particular usages of ICT, such as Horst and Miller's study of cell phone usage in Jamaica (2006), Bell's study of middle class computer usage in South Asia (2006b), or Burrell's study of Internet café usage in Ghana (2009); and studies of the social and economic impacts of particular projects or programs. Within this broader field of study, we use the term ICT *for* development (ICT4D) to describe research that deals with the challenges of designing, developing, and sustaining ICT systems that are suitable for the conditions in developing regions. For example, Surana, Patra, Nedevschi, Ramos, Subramanian et al. (2008) describe some of the challenges faced in maintaining rural wireless networks.

The term HCI4D, then, indicates a subfield of ICT4D that focuses on understanding how people and computers interact in developing regions, and on designing systems and products specifically for these contexts. Thus, the initials "ICT4D" and "HCI4D," as our community has adopted them, carry a level of intent and purpose. As a community, we do not seek merely to understand how humans and ICTs interact in developing regions, but to apply this understanding to adapt the interactive behavior of ICTs in these contexts, to shape new and more appropriate forms of ICTs, and to devise human-centered approaches to designing ICTs that can be used by people to improve lives, livelihoods, and freedoms. We contend that appropriate, human-centered designing and contextually sensitive designs of digital ICTs are *necessary,* although clearly, these have not been sufficient conditions to enable effective use of ICT to support development outcomes. Kleine and Unwin (2009) have recently raised concerns that the discourse in ICT4D (and more widely, in ICTD as we have defined it above) is paying too little attention to the role of previous generations of information and communication technologies, such as writing, printing, telephony, radio, and TV. Because of its concern with properly understanding contexts before designing ICT interventions, HCI4D research (when done well) pays careful attention to existing information and communication technologies and practices. Thus, ICTD has much to gain from dialogue with HCI, and vice-versa. HCI4D provides a focus for that interdisciplinary dialogue.

This article is a review of the past, present, and future of HCI4D. In it, our aims are to do the following:

- Articulate some of the histories that inform this particular community of researchers.
- Provide an overview of existing work in HCI4D spanning numerous venues and research traditions.
- Discuss several of what we believe to be the most pertinent issues in the discipline.
- Suggest a set of grand challenges for the field over the next 5 to 10 years.

Inevitably, this article is biased toward work published in the English-language HCI community and based in the home countries of the authors (the United States and United Kingdom). However, we have sought to consult with researchers on all six continents in an effort to alleviate that bias.

A Brief History

It is difficult to identify the beginnings of a field or an area of research. For many, HCI4D started to gain acceptance around 2006, with the ICTD 2006 con-

ference and the HCI4D workshop at CHI 2007. However, as early as 2003, Susan Dray and others edited a special issue of *interactions* on "HCI in the developing world," (Dray, Siegel, & Kotzé, 2003) reporting on work in China, South Africa, India, and Brazil.

The earliest HCI4D effort that we have identified occurred in 1982, with the establishment of the World Center for Computer Science and Human Resources in France, which was specifically intended to design personal computers for developing countries. The group planned to develop computer-based education projects in Senegal, Kuwait, Ghana, and the Philippines. While the program faltered shortly thereafter (Eastmond & Mosenthal, 1985), it is apparent that this experience was not without influence and seems to have revived itself as the One Laptop Per Child (OLPC) project (Camfield, 2007). Several researchers from Apple did a study in 1995 using the Newton as a record-keeping device for auxiliary nurse midwives in India, the results of which were published at the CHI conference in 1997 (Grisedale, Graves, & Grunsteidl, 1997).

From the early 1990s onward, the Health Information Systems Project (www.hisp.org) designed and deployed district health information systems in South Africa. The software has now been extended and deployed to many countries, including Mozambique, Tanzania (Zanzibar), India, Ethiopia, Sierra Leone, and Cuba. Reports are published in venues such as the Participatory Design Conference (Braa, 1996), WITFOR (Braa & Blobel, 2003), and the Information Society (Braa & Hedberg, 2002).

In the late 1990s, Liebenberg and Blake reported on CyberTracker, a field computer system designed to support scientific data collection from expert animal trackers who were not textually literate (Leibenberg, Blake, Steventon, Benadie, & Minye, 1998; Blake, 2002). Also in the late 1990s, Gary Marsden went to the University of Cape Town in South Africa to join Edwin Blake specifically to work on mobile computing for development. Efforts to engage the HCI community around research oriented toward development eventually led to ACM SIGCHI supporting a Development Consortium meeting for South Africa in 2002. Reporting the outcomes of this meeting, Hugo (2002) observes that:

> In multicultural environments it is even more important [to] consider how our understanding of the complex dialectic between culture, economy and technological innovation influences our ability to empower our people. (p. 4)

The consortium participants suggested that software should be adapted for communal users rather than for individual preferences ("communitization"). Patra and Pal reached a similar conclusion when studying computer-aided learning in India (Patra, Pal, Nedevschi, Plauché, & Pawar, 2007). Another concrete outcome of this consortium was the aforementioned special issue of *interactions* in 2003.

The situation in South Africa may be a special case, with early commitment of the country's political leaders to the application of ICTs for social development. This commitment is reflected in the creation of the Meraka Institute, with its mission to "facilitate national economic and social development through human capital development and needs-based research and innovation, leading to products and services based on Information and Communication Technology" (Meraka Institute, 2009). This has created an academic environment where research on ICT and development is more highly valued than in many other countries. Certainly, the South African SAICSIT conference series, which regularly addresses the challenges of using ICT in developing regions, has many HCI contributions each year.

Brazil's HCI community has been gathering since 1997 (Prates, 2007), with a "for development" project described in the 2003 special issue of *interactions* (de Souza, Prates, & Barbosa, 2003). In 2005, the Brazilian Computer Society (SBC) issued a series of "Grand Challenges," including "Universal and Participatory Access to Knowledge for all Brazilian Citizens." Like South Africa, Brazil is a country where academic infrastructure and political leadership cooperate to facilitate understanding of how ICTs can be used to improve development.

Since the early 1990s, international aid donors and government agencies have directed funding specifically toward exploration of the potential of ICT in development, enabling a number of projects, conferences, and workshops. In 1999, the Fiankoma project (www.fiankoma.org) set up a partnership project between schools in Ghana and the UK to share digital stories, and to help youngsters in both countries recognize both how much they had in common and how their lives differed. A similar project, established in 2004, focuses on Muslim girls in

London and Ghana (www.divoproject.org). Since 2006, the European Union and UNESCO have sponsored annual e-Learning Africa conferences. From 2002–2005, the Indo-European Systems Usability Partnership worked to develop capabilities in HCI in India, resulting in the first India HCI conference in 2004. A similar partnership model is currently being used in the Sino-European Systems Usability Network to develop HCI capacity in China (Smith, Joshi, Liu, Bannon, Gullicksen et al., 2008).

During this time, many United States–based universities sought funding and started to establish information technology for developing regions as a research domain. MIT and the government of India established Media Lab Asia in 2001, a collaborative venture with a mission of "innovating for digital inclusion" (Media Lab Asia, 2009). In 2003, researchers at the University of California, Berkeley were funded by the U.S. National Science Foundation (NSF) for a large multidisciplinary project of social scientists and computer scientists designing and evaluating novel information technologies "for billions." UC Berkeley offered a live, video-conferenced class on the topic, jointly taught by staff at UC Berkeley and Carnegie Mellon. Tapan Parikh, a University of Washington graduate student, received a best paper award at the ACM Conference on Universal Usability (CUU) in 2003 for his work with micro-credit agencies in India (Parikh, Ghosh, & Chavan, 2003). As more University of Washington students rallied behind the idea of using their technical skills to improve the lives of the underserved, students and faculty members formed a group now known as Change. Work by the MIT Media Lab and Georgia Tech introduced novel interfaces for communications in the Dominican Republic (Escobedo & Best, 2003; Sin, Escobedo, & Best, 2004). Best went on to found the Technologies and International Development Lab at Georgia Tech, while Carnegie Mellon created TechBridgeWorld (Dias, Mills-Tettey, & Mertz, 2005), an experiential program for students interested in developing regions.

In 2005, the UK Engineering & Physical Sciences Research Council began an initiative on "Bridging the Global Digital Divide" (www.bgdd.org). This initiative brought together an interdisciplinary group of leading researchers to set new research directions in ICT and development. The four projects created by this initiative each had strong elements of human-computer interaction. Each project had at least one researcher with a track record in HCI, and each project team committed to using participatory design methods. Drawing on this commitment, a workshop at the Participatory Design Conference in 2006 was planned to examine relations between participatory IT design and participatory development practice. Although this workshop was cancelled due to insufficient registration, the idea was revised, and a workshop was held at CHI 2007 (Dearden, Light, Dray, Thomas, Best et al., 2007). A valuable contributing factor to this workshop was funding from the U.S. National Science Foundation and ACM SIGCHI to support the attendance of a small number of researchers and practitioners from developing countries. This workshop was followed by similar workshops at HCI 2007, DIS 2008, CHI 2008, PDC 2008, the Pan Commonwealth Forum on open and distance learning (PCF 5), CHI 2009, and INTERACT 2009, as well as panels and discussions at HCI International 2007 and Interact 2007. In 2008, IFIP Technical Committee 13 (Human-Computer Interaction) approved the establishment of a new special interest group on Interaction Design and International Development, thus providing an international umbrella under which our field can organize.

As researchers and students within these various programs began to do more work, it became possible to establish peer-reviewed forums in which the work could be evaluated—for both its technical merit and its usefulness in its intended context. Over the course of the last few years, we have seen both publications in major international English language academic conferences, as well as publications in workshops attached to such conferences. In addition to the workshops at CHI, HCI, PDC and INTERACT, the WWW conference from 2006 onward has featured a developing regions track. In addition, ICTD 2006 (Berkeley), ICTD 2007 (Bangalore), and ICTD 2009 (Doha) have all featured a blend of social science and technical contributions.

Survey of HCI4D Literature

It is difficult to specify a precise scope for a review of this fast-growing literature, given the varying and diverse locations where this work has been published: internationally recognized English-language HCI conferences, workshops at these conferences specifically discussing HCI4D, workshops and conferences on HCI that have been held in developing re-

gions, and various journals and conferences that are not specifically HCI-focused.

Instead, the review below aims to emphasize works that are representative of major trends and topics identified in the various workshops at CHI, HCI, Interact, PDC, and DIS, as well as by ongoing discussions within the IFIP Special Interest Group. We relate them to one another to provide the reader with a conceptual roadmap for making sense of this emerging literature.

Cross-cultural HCI

The field that deserves to be first mentioned is *cross-cultural HCI,* which investigates how culture relates to user interface design, research, and practice. This line of work grew out of efforts in the early 1990s to develop systematic methods for adapting commercial software for markets other than those originally intended (Nielsen, 1990; Fernandes, 1995; del Galdo & Nielsen, 1996). International Workshops on Internationalization of Products and Systems (www.iwips.org) have taken place regularly since 1999. Evers (1998) investigates the role of metaphors in interface design, while Bourges-Waldegg and Scrivener (1998) propose a new HCI approach to understand culturally determined usability problems. Other work investigates the cross-cultural usability of specific technologies, such as cell phones (Katre, 2006), Automatic Teller Machines (de Angeli, Athavankar, Joshi, Coventry, & Johnson, 2004), and digital libraries (Duncker, 2002).

Cross-cultural HCI focuses on *differences* in culture—that is, how user interface designs and principles can be translated from one culture to another, or how interfaces can be designed so as to be as neutral as possible to cultural differences. The users of interest are often the urban middle class in industrialized nations who have different cultural characteristics from the marginalized communities on which HCI4D research focuses. International development is almost never a goal in cross-cultural HCI.

On one hand, lessons from cross-cultural HCI are applicable to HCI4D, since both areas frequently involve researchers and users from disparate cultures. On the other hand, unlike cross-cultural HCI, HCI4D often involves user communities with limited textual literacy (Bidwell, 2009). It is therefore important that HCI4D researchers study the characteristics of local communities and understand how orality should inform technology and information design (ibid.).

Unique Needs

But how is designing for and with underserved communities different from interaction design with reasonably affluent users in the industrialized world? Some early reviews describe the emerging state of HCI education, research, and practice in emerging economies, such as China (Wang, 2003), South Africa (Kotzé, 2002), and to a smaller extent, India (Henry, 2003). In this context, some articles (Dray et al., 2003; Brewer, Demmer, Du, Ho, Kam et al., 2005; Brewer, Demmer, Ho, Honicky, Pal et al., 2006) which attempt to provide a more comprehensive review of early HCI4D activities identify some key challenges as the following: poor electricity, little exposure to computing technologies, low literacy or linguistic knowledge restricted to local languages, and differences in sociocultural practices responsible for differences in mental models between Western and non-Western users.

Projects that take the above constraints of developing regions into account have sprung up around application domains such as education (Furtado, Falco, Gomes, Eduardo, Rodrigues et al., 2008; Kam, Ramachandran, Devanathan, Tewari, & Canny, 2007; Moraveji, Kim, Ge, Pawar, Mulcahy et al., 2008; Pal, Pawar, Brewer, & Toyama, 2006), healthcare (Braa, Titlestad, & Sæbø, 2004; DeRenzi, Lesh, Parikh, Sims, Maokla et al., 2008; Grisedalel, et al., 1997; Ho, & Aoki, 2008), microfinance (Parikh, Javid, Ghosh, Sasikumar, & Toyama, 2006), mobile banking (Medhi, Gautama, & Toyama, 2009), rural supply-chain management (Javid & Parikh, 2007), agriculture (Gandhi, Veeraraghavan, Toyama, & Ramprasad, 2007; Parikh, Patel, & Schwartzman, 2007), embroidery (Sharma, Sharma, & Subhedar, 2008), and rural business services (Sin, Escobedo, & Best, 2004).

In particular, a significant amount of work in the emerging HCI4D literature is motivated by the low literacy levels in developing regions. Some examples are a mnemonic-based system that enables illiterate villagers to identify themselves to a computer kiosk (Katre, 2004) and a speech interface for non-literate farmers (Plauché & Nallasamy, 2007). To inform design at a more fundamental level, Parikh et al. (2003) and Medhi, Sagar, and Toyama (2007 examine various visual representations for communicating information to less literate users in rural and urban slum communities in India. Their work has led to early guidelines on this subject.

The Jadoo system (Chand & Dey, 2006) focuses

on computer literacy as opposed to print literacy. It provides a paper-based interface that mediates a computer-literate user in helping users unfamiliar with computers perform tasks with the machine. Along this line, given that a majority of Internet content and user interfaces are in English, the work in Kam, Ramachandran, Devanathan, Tewari, and Canny (2007) on computer-assisted second language learning is motivated partly by the observation that knowing a widely-spoken language like English is a prerequisite for effective computer usage.

One common theme in work for developing regions is expanding what is possible using mobile devices, particularly mobile phones, as a primary computing platform. This is evident in the early work of Grisedale et al. (1997) and Liebenberg, Blake, Steventon, Benadie, and Minye (1998) using handheld devices. Jones and Marsden (2006) suggest that one advantage of mobile phones for development is that network operators often discount the purchase price of handsets, seeking to recover costs through usage charges. Basic text messaging can be used by NGOs and medical centers for effective coordination of activities, using tools such as FrontlineSMS (UN Dept. for Economic & Social Affairs, 2007). Multimedia mobile phones offer an additional range of potential applications, including handling paper documents in microfinance (Parikh et al., 2006), supporting agricultural extension services (Dearden & Rizvi, in press), and voter education (Gitau & Marsden, 2009). Other research has demonstrated the potential for communal communications by sharing user-generated multimedia content captured on mobile phones (Maunder, Marsden, & Harper, 2008; Jones, Thom, Bainbridge, & Frohlich, 2009).

Other work has focused on specific user groups in developing regions, such as social volunteers in Brazil (de Souza et al., 2003), migrant workers in China (Moraveji, Ho, Huynh, & Zhang, 2005), and blind people in India (Kalra, Lauwers, Dewey, Stepleton, & Dias, 2007). Work such as the latter, for example, attempts to address local conditions (low finance and low power) and local needs (writing from right to left). On the same theme of underserved communities, there is a strong body of work that examines the design and use of interactive systems for and by marginal users in industrialized countries. Much of this is reported within the Community Informatics research network (www.cirn.org), and at conferences such as Communities & Technologies. Within the mainstream HCI literature, recent examples include Le Dantec and Edwards (2008), Merkel, Xiao, Farooq, Ganoe, Lee et al. (2004), and Dearden, Lauener, Slack, Roast & Cassidy (2006).

Differences in mental models owing to cultural divergence are challenging. Prasad, Medhi, Toyama, and Balakrishnan (2008) found that, despite using the postcard metaphor, non-literate urban slum users continue to face difficulties in understanding all aspects of an asynchronous communication model. Kam, Mathur, Kumar, and Canny (2009) study the differences between traditional village games in India and contemporary videogames, after observing that their initial e-learning games are too Westernized and fail to match rural Indian children's expectations about games. Similarly, Walton and Vukovic (2003) attribute the usability difficulties that their South African subjects encounter with hierarchical information structures to the non-tree-like schema that the subjects use to conceptualize their "family trees."

On the other hand, some topics have received little attention in HCI4D thus far. Few papers deal explicitly with gender, despite its prominence in the Millennium Development Goals. Only one paper in our review (Katre, 2004) targets e-government, although this area has received considerable attention in the broader development literature (see Heeks, 2006 for a survey). Similarly, the works of Blake (2002) and Pascoe, Ryan, and Morse (2000) are the only two papers in our survey with an environmental emphasis. This under-representation is noteworthy, given the growing prevalence of "sustainability" in the broader CHI literature (Blevis, 2007). Finally, despite the influence of religion on human behavior, only two publications (Bell, 2006a; Wyche, Aoki, & Grinter, 2008) examine the role of technology in religion from a HCI perspective.

Design Methods

A majority of the HCI4D papers that we have surveyed perform user-centered design, in which an interactive technological artifact is designed and evaluated. We argue that interaction design is a contribution that HCI can make to international development. That is, instead of redeploying technologies developed for industrialized countries in

developing regions, HCI methods can be employed to design technologies that address local contexts more closely. For instance, Kam and Tran (2005) describe the schedule overruns in a microfinance initiative that occurred when contextual studies were not performed right from the beginning to inform the design of a handheld system for transaction tracking.

Indeed, a plethora of projects claim to employ participatory approaches (Braa et al., 2004; Elovaara, Igira, & Mörtberg, 2006; Gandhi et al., 2007; Merkel et al., 2004; Puri, Byrne, Nhampossa, & Quraishi, 2004). This prevalence is not surprising, since participatory methods have a rich history in international development. In parallel, participatory design has a long tradition in HCI. Dearden and Rizvi (2008) compare and contrast the conceptualizations of participation in both traditions. Nevertheless, participatory design in international development can be challenging in practice because of the political environment (Braa et al., 2004; Puri et al., 2004), ethical considerations (Byrne & Alexander, 2006), or cultural differences (Puri et al., 2004; Kam et al., 2005). Furthermore, users with little computing experience may be able to evaluate designs, yet may struggle to propose design ideas (Heukelman, 2006; Kimaro & Titlestad, 2008).

Some of the same papers above share their lessons on how to be more successful in conducting participatory design in developing regions (Braa et al., 2004; Kam et al., 2006; Puri et al., 2004). Merkel, Farooq, Xiao, Ganoe, and Rosson (2007) give guidelines on how researchers can facilitate capacity-building and long-term sustainability in the process of conducting participatory design. More recent work in HCI4D offers strategies for using incomplete prototypes to elicit feedback and secure participation from rural community stakeholders (Ramachandran, Kam, Chiu, Canny, & Frankel, 2007), and for using comics to scaffold rural children in generating design ideas (Moraveji, Li, Ding, O'Kelly, & Woolf, 2007). Given the importance of building rapport with local partners, other articles offer guidelines for developing such relationships (Schwartzman & Parikh, 2007) and involving local undergraduates as research assistants in fieldwork (Kam, 2008).

It may not be appropriate to apply conventional HCI methods directly "out of the box" to developing regions contexts, but instead, these methods must be adapted to the cultural setting (Winschiers, 2006). For instance, the hierarchical structure in societies, such as India, may inhibit subjects from giving candid comments about usability problems to authority figures, such as researchers. The "Bollywood Method" encourages subjects to be more forthright by situating user studies within highly dramatic storylines (Chavan, 2005). Likewise, existing HCI methods originate from research with Western, literate users, and have to be adapted by considering the socio-cognitive implications of literacy (Sherwani, Palijo, Mirza, Ahmen, Ali et al., 2009).

Other attempts at methodological innovations (Blake & Tucker, 2006; Chetty, Tucker, & Blake, 2004) draw on principles from participatory design and action research to advance traditional methods in user-centered design (UCD) and software engineering. In particular, Maunder, Marsden, Gruijters, and Blake (2007) propose that traditional UCDs draw on frameworks in international development. This is the first paper that we know of to propose that UCD target social empowerment goals by explicitly considering criteria that are broader than those usually considered in traditional HCI research.

Empirical Studies

HCI4D papers that involve technologies designed for specific needs usually include an evaluation with users conducted using qualitative or quantitative methods, or both. In contrast, relatively fewer papers present studies with participants without the expressed goal of evaluating a system. Such studies have examined domains that include micro-businesses (Kumar, Rajput, Agarwal, Chakraborty, & Nanavati, 2008), rural communication patterns (Seshagiri, Aman, & Joshi, 2007), rural schools (Pal et al., 2006), and microfinance (Parikh et al., 2003). The latter studies have challenged our assumptions of technology usage, and they serve as an inspiration for subsequent work on the multiple-mice shared computer (Pawar, Pal, & Toyama, 2006) and paper-augmenting technology (Chand & Dey, 2006; Parikh et al., 2006). Other projects which similarly heed Schumacher's call (1973) that technology be appropriate for local conditions include inexpensive devices for women to contribute commentary to community radio programs (Sterling, O'Brien, & Bennett, 2007) and a novel user interface for VoIP communication over poor-quality networks (Escobedo & Best, 2003).

Other HCI4D researchers have studied how tech-

nology is used in developing regions using ethnographically-inspired methods. However, their work is not always conducted explicitly to inform the design of specific technology artifacts; instead, it primarily aims to broaden understanding of technology usage in these contexts. A popular focus of inquiry is the cell phone, owing to its rapid adoption in developing regions (Bell, 2006b; Chipchase, 2007; Horst & Miller, 2006; Ichikawa, Chipchase, & Grignani, 2005; Wakunuma, 2007). Other foci of inquiry have included Internet cafés (Salvador, Sherry, & Urrutia, 2005) and technology usage among the Ghanaian diaspora (Burrell, 2007). The most important functions of this body of work are perhaps to highlight the surprising extent of ICT adoption in the developing world, and to reveal the diversity in that adoption.

Central Issues in HCI4D as an Emerging Discipline

As we have argued, HCI4D is a young discipline with a diverse background. This diversity has its benefits; the community is open to a rich intellectual landscape and discourse. On the other hand, it is also problematic, as it makes it difficult to reach consensus around basic foundations of the discipline. In this section, we draw attention to some issues that we feel are central to those foundations, and around which a critical and constructive discourse is taking place. For each such issue, we discuss how its importance is motivated by the literature we have reviewed, and where applicable, we point the reader to literature from other areas that could contribute to the discussion.

Methodology

The formulation of this section is based on three primary resource pools: (1) the above literature review, (2) numerous discussions held at various HCI4D- and ICTD-related workshops and conferences attended by the authors, and (3) e-mail and phone interviews conducted with key HCI4D researchers specifically for this paper. While the classifications presented here may not be universally agreed on by all HCI4D researchers, we have attempted to broadly represent the discourse we are witnessing.

Participation

The adjective "participatory" makes frequent appearances in discourse about international development, both in research and in practice. It could be seen as a container concept, employed in reference to many phenomena. But the general spirit of the term holds that members of a community being researched ought to be involved, in some fashion, in the conduct of that research. True to form, participation features prominently in the literature reviewed in this article. Of the 65 HCI4D articles we reviewed, 21 make reference to the concept, and 8 describe systems that were designed according to a participatory approach.

However, considerable previous work from other disciplines makes the case that the concept of participation must be handled with care. Participation has become a loaded term that is prone to unreflecting usage. Differing degrees of participation are in evidence in the broader literature of development as well as in HCI (Dearden & Rizvi, 2008). Michener (1998) distinguishes between two forms of participation: *strong,* which involves partnership and shared control of the research project, and *weak,* which involves only consultation of those being researched.[1] Oakley (1991) offers three degrees of participation. Cooke & Kothari (2001) offer a comprehensive critique of participatory approaches in development, examining it as a possible "tyranny." Heeks (1999) has been critical of participation in its present incarnation, listing myriad ways in which the rhetoric and reality of participation can differ, resulting in injurious ignorance of various sorts.

While it is difficult to gauge the nature of the participation actually employed in a research project solely from reading papers, we suggest that much of the applicable research reviewed in this survey may exhibit the weaker variant; that is, the general aims of the project are defined before engaging with any specific community, and participants have only marginal input to make. While this may sometimes be the most appropriate or feasible model from the perspective of external researchers or technology designers, its chief difficulty is that a project that has been defined outside the community that it is meant to benefit will often miss the real local

1. Of course, this weaker variant is not new to anyone with an HCI background, for whom consultation with the user is a standard and familiar practice.

needs of the people. This form of participation can only provide for discussions of the means by which technology might be used to achieve some given ends, but it does not open the question of whether the ends themselves should be prioritized.

For this reason, we argue that HCI4D researchers should carefully examine and reflect on the forms of participation they employ. Several questions come to mind: Who decides on the overall aims of a participatory project? How might someone in the beneficiary community be able to change focus of the project? What budgetary control does the community have over the project? To what extent are the software and hardware designers contracted to deliver benefits to the community, or vice versa? And finally, who will judge the project's success or failure? We present these questions both as a practical reference for use at the outset of a participatory HCI4D project, and to stimulate discussion around this issue within the HCI4D community.

The Relations Between HCI4D Research and Practice

Compared to other fields of research, HCI4D seems particularly prone to risks of conflating research activity and development practice. An economist gathering data on, say, unemployment, is likely to be content to collect his or her data and be done with it. But an HCI4D researcher has often already gone to the trouble of designing a technological artifact as part of the research project. Why not leave that system behind where it might continue to do good? If the prototype seems promising, why not "scale it up," even if doing so may not contribute to the originally stated research goals? This situation reflects a tension throughout HCI4D research. The tension reflects the interests of different stakeholder groups in the research process—between the researcher who may be concerned to advance his or her career through publication, the community in which the research is being conducted who are contributing to the work, professionals working in the development sector, and the other individuals and communities who may benefit from the knowledge generated and reported by the researchers. While none of the papers and articles we reviewed explicitly mention this sense of tension, each of the authors has often heard such sentiments expressed informally.

It should be said that HCI4D is not alone in this predicament. For example, Bell and Nutt (2002, p. 70) write of the dilemma of practitioner-researchers in the fields of health and social care, who must acknowledge "responsibilities toward clients/service users, fellow practitioners and organizational bodies, other researchers, and (in the case of students) meeting academic/university agendas relating to student assessment . . ." This list seems equally applicable to our field. Bell and Nutt go further to suggest that effective "management" of those myriad responsibilities is best achieved by education systems that teach young researchers to be "reflective" in their practice (p. 71). They point to a pre-existing literature in health and social care that has defined this notion of reflective practice.

The tradition of action research is particularly optimistic about this research/practice dichotomy. In a seminal paper, William Whyte relates three case studies in which an action research approach yielded research that was both "scientifically legitimate and highly useful to practitioners" (Whyte, 1989). In one example, researchers were hired to explore possibilities for changes in ship design that would lead to better living and working environments for crew members. The research wound up being quite successful, and the results were replicated to other shipping companies and maritime nations. Notable in this case was the concrete, empirical evidence of improvement that was assembled by the researchers.

But despite the optimism of some commentators on the promise of wearing both researcher and practitioner hats at once, doing so may not always be feasible. For this reason, we argue that HCI4D researchers need to be clear and reflective about which approach they are pursuing. We feel that a traditional research approach may be acceptable, as long as participants are fully aware of the extent of the project. On the other hand, an action research approach is laudable, but care must be taken that adequate resources are marshaled and local participation is garnered, so as to make the project sustainable once the research is complete. In both cases, ethical considerations are paramount, though they go beyond the scope of this review. The IFIP special interest group in Interaction Design for International Development is currently investigating these ethical issues (Ceriejo-Roibas, Dearden, Dray, Gray, Thomas et al., 2009).

Evaluation

The issue of evaluation has long been a thorny one in both the HCI and development communities. The diverse disciplinary traditions that are engaged in the discourses of HCI and of development bring different underlying philosophical assumptions, and consequently, they adopt differing positions with regard to evaluation.

Papers at the ACM's CHI conference (the largest venue for HCI publications) have exhibited a tendency for quantitative approaches to evaluation. Indeed, 15 of the publications reviewed in this article feature quantitative evaluations typical to the CHI tradition, more than any other approach (12 described informal field trials, and 1 presented a formal but subjective evaluation). However, recent discourse has called this preference for quantitative methods into question. Greenberg and Buxton (2008) summarize this debate in a recent CHI publication. They argue that several alternative approaches to the validation of work should be considered, including design rationale, usage scenarios, case studies, and participatory critique. They urge authors to "critique [their] design: why things were done, what else was considered, what they learned, expected problems, how it fits in the broader context of both prior art and situated context."

Certainly, some of the work reviewed in this article has embraced this perspective. Luk et al. (2008) and Parikh et al. (2003) offer notable examples. However, we argue that further innovation in evaluation is appropriate. Quantitative "time and errors" evaluations are especially dubious when the ultimate goal of development is so far removed from the goal of greater workplace efficiency out of which those approaches were born.

Another emerging discourse in the HCI community centers on the temporal scale of evaluations. In introducing a 2007 CHI special interest group session on longitudinal evaluation, Vaughan and Courage (2007) write:

> Typical usability evaluation methods tend to focus more on "first-time" experiences with products that may arise within the first hour or two, which trends the results more towards "discoverability" or "learnability" problems . . . longer term usability issues are more difficult to evaluate, but they are of great importance. (p. 2149)

When development is added to the picture, longer time scales become even more attractive, since development outcomes are, of course, not likely to become evident in "the first hour or two." However, by our count, only two of the papers reviewed in this article feature evaluations longer than six months, and the approximate median duration of evaluations was two weeks. This may simply be due to the newness of the discipline, although it is likely that the tight publication schedules of the largely conference-based HCI and ICTD communities are a factor. In any case, we suggest that strategies to promote more long-term evaluations should be explored in earnest by our community.

Grand Challenges for HCI4D

In retrospect, Donner, Gandhi, Javid, Medhi, Ratan et al. (2008) observe that HCI4D projects seem to progress along a certain trajectory, one in which it takes some time before there is a real understanding of the underlying challenges responsible for allowing the social problem to persist in the first place. More broadly, there is also a path for how the field of HCI4D is maturing. The earliest writings articulate a vision for HCI4D (Brewer et al., 2005), review early work (Dray et al., 2003; Kotzé, 2002; Wang, 2003), share initial results and challenges (Brewer et al., 2006), and elaborate on challenges in specific domains (Parikh, 2006). Subsequent work has focused on methodological innovations necessary for tackling the original challenges. We will next discuss possible future directions for the field.

Problematize HCI4D

As we have discussed above, there is a need for greater reflection around our practices as researchers. This reflexivity is a first step to developing a deeper conceptual grounding behind our work. For example, methods could be extended by incorporating explicit considerations about various conflicting notions of development. Such theorizing needs to not only involve work from international development contributing to HCI, but also HCI making contributions to development. For instance, examining how literacy studies could inform us in designing applications and conducting user studies with low-literate users will culminate in better-defined frameworks for understanding fundamental issues in development.

Reuse HCI4D Knowledge to Avoid Reinventing the Wheel

Much has been written here and elsewhere about the diversity of HCI4D, the challenges of cross-cultural research, and the difficulties of developing and communicating information and knowledge to support good design. This review has identified many articles that share design histories and lessons learned, but their structure is ad hoc, and it varies from paper to paper. One possible approach to addressing these challenges is to document and codify the design knowledge accumulated in HCI4D projects in a structured format, so as to avoid reinventing the wheel. This approach is not new in HCI. For instance, Dearden and Finlay (2006) provide a review of pattern languages of various forms in HCI. We argue that a pattern language approach to sharing knowledge could be especially beneficial to HCI4D. A well-defined structure would make repositories about design knowledge in HCI4D easier to navigate and interpret, and it would ensure that the relevant assumptions and situations informing designs are made explicit.

Supporting an Ecosystem Around Affordable Computing

A number of recent projects (Parikh et al., 2006; Dearden & Rizvi, 2009; Gitau & Marsden, 2009; Jones et al., 2009) have illustrated how multimedia content captured using mobiles may be valuable for strengthening information and knowledge exchange in social networks and development institutions, what the livelihoods framework describes as "transforming structures and processes" (DFID, 2001). However, affordability of computing remains a primary barrier to mainstream acceptance of HCI4D relevance. A key challenge will be to learn from these pilot studies to develop replicable, low-cost approaches and hardware that can be appropriated and adopted by community-based organizations with minimal requirements for external support. Solutions such as BingBee, which implements a touchscreen kiosk using a stretched cloth screen, a projector, a webcam, and a standard PC (Slay, Wentworth, & Locke, 2007), demonstrate how innovative interaction design can reduce the cost of providing computing functionality.

A Clear Development Success Story

While we claim to be "for" development, the previous section pointed out the strikingly short duration of many evaluations in HCI4D. Coming back to the tensions between research and practice, it is unlikely for a researcher to be able to observe clear development outcomes over the course of a six-week usability evaluation, or even a six-month pilot study. While it may be a necessary fact that the metrics of success in HCI are fundamentally different from those in development, it nonetheless seems doubtless that a sound, long-term study demonstrating concrete development outcomes due to the application of the knowledge that our community has accumulated would do much to substantiate our discipline. We can gain inspiration from case studies of successful ICT interventions such as the use of electronic equipment to test milk quality in Gujarat (Bhatnagar, 2000), and from analysis of relevant success factors for projects (Cecchini & Scott, 2003). Our challenge as researchers will be to find mechanisms to evaluate our designs whereby we can accumulate knowledge that can inform effective and sustainable development interventions.

User Interfaces for Illiterate and Semi-Literate Users

While much work has already been done on user interfaces for low-literacy and multi-lingual communities, this is an area of significance which cross-cuts a number of domains, and one in which much work remains to be done. Patra, Pal, and Nedevschi (2009) asked experienced ICTD researchers to rank areas of future importance in design, and all of the top five were related to spreading technology access to populations in which English or local language literacy might be a problem: voice recognition and synthesis, local language software, translation, accessibility, and illiterate-friendly software. While significant progress has already been made in a number of specific domains (Kam et al., 2007; Parikh et al., 2003; Medhi et al., 2007; Sherwani et al., 2009; Plauché & Nallasamy, 2007), this remains an area of significant challenge. In the literature on literacy studies, Scribner and Cole (1981) stands as one of the landmark studies, which shows that the cognitive impacts of literacy arise from particular sociocultural practices. The implication is that we need to develop frameworks around sociocognitive processes for understanding how sociotechnical system design and evaluation relate to the cultural context of the devices being used.

Improving HCI Capacity in Developing Regions

What can we do collectively as a community—spread across both the developing and developed world—to improve the availability of good interaction design in developing regions? First, HCI researchers, educators, and professionals who work in developing regions can recruit local students to participate in projects (Kam, 2008). Local universities can also provide institutional support, an indigenous knowledge of current systems, and a potential pool of engineers for maintaining deployed systems. Long-term collaborations with universities, government agencies, companies, and NGOs can be mutually beneficial. Projects such as the Indo-European and the Sino-European Systems Usability Partnerships (Smith et al., 2007) demonstrate the potential of this approach. Open content journals and open syllabus classes are valuable for researchers and practitioners in developing regions to access resources, but they still face challenges in the availability of Internet bandwidth. Finally, we need to take time to make relevant work in HCI accessible to practitioners in developing regions. One relevant example is uiGarden (uiGarden, 2009), which is a bilingual Web site aiming to foster greater interaction between the HCI community in China and elsewhere in the world. One of the primary activities of its editorial staff is to coordinate with volunteers in translating relevant HCI articles from English to Chinese, and to publish articles in both languages on its Web site.

Conclusion

We have a vast task before us, and yet we also have a wide diversity of resources on which to draw in navigating this task. We have sought to lay out the genesis of our field, giving a brief history of its formation. Key to our growth over the past few years has been an influx of financial support, as well as academic support in the form of workshops and conferences focused on information technology for communities in developing regions. As we advance research in this area, it remains paramount that our research is well grounded in research practice. Through the literature review in this paper, we have sought to provide readers with a roadmap by which they may navigate the diverse bodies of emerging and related literature in HCI4D. Finally, we conclude with six "Grand Challenges" which look toward the future of HCI4D. In setting these challenges, we put forth a vision of a growing and global HCI4D community that engages with one another, exchanging ideas across a diversity of disciplines to address real problems of development.

The next 10 years will prove crucial for the nascent community of HCI4D as it tries to establish itself as a legitimate field of research. Significant momentum has been built over the last five years, and the enthusiasm and anticipation around the field is palpable. In surveying the history, work, and issues in HCI4D, this paper is intended as a next logical step in this progression. As members of this exciting community, we look forward to the future. ■

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