

The Ins and Outs of HCI for Development

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ABSTRACT

We present an empirical analysis of HCI for development (HCI4D), a growing research area aimed at understanding and designing technologies for under-served, under-resourced, and under-represented populations around the world. We first present findings from our survey of 259 HCI4D publications from the past six years and summarize how this research has evolved, with an overview of the geographies it covers, technologies it targets, and its varied epistemological and methodological underpinnings. We then discuss qualitative findings from interviews we conducted with 11 experienced HCI4D researchers, reflecting on the ground covered so far - including computing and research trends, community-building efforts, and thoughts about ‘development’ - as well as challenges that lie ahead and suggestions for future growth and diversification. We conclude by summarizing the contributions our paper makes to HCI researchers *inside* the HCI4D community as well as those *outside* of it, with the goal of enriching discussions on how HCI can further benefit populations around the world.

Author Keywords

HCI4D; ICTD; low-resource; developing world; literature survey; review; underserved communities.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

The ACM CHI conference embraces a global audience of Human-Computer Interaction (HCI) researchers, enabling them to connect with and stay apprised of a wide array of HCI concerns, conversations, and collaborations. However, the vast majority of research published at CHI remains focused on resource-rich settings in developed regions of the world, such as North America and Europe. Yet interactive technologies are being designed and developed for use in an ever-growing set of domains, targeting increasingly diverse

and marginalized populations. They are also penetrating new contexts and touching the lives of users from geographically dispersed under-represented communities. As HCI opens itself to these new users and domains, Ho et al. [28] aptly point out that the discipline “*can never be complete without study of interactive computer systems in developing regions.*” The HCI for development (HCI4D) community has taken on the challenge of addressing this gap, with its dedicated collective effort through the years towards understanding and designing technologies for underserved populations around the world.

With the recent growth in HCI4D research (that this paper highlights) and the focus of HCI’s ‘third wave’ on ‘existing situated activities’ [7], the time is ripe to assess the ground we have covered and the road that lies ahead. Our findings reveal that HCI4D has engaged with an extensive range of geographies, technologies, user populations, and application domains, diversifying HCI in a number of ways that we discuss. In the process, HCI4D has benefited tremendously from the larger discipline of HCI, which has provided approaches to design, methodologies, and a willing audience through the years, helping it evolve into a flourishing area of research.

In addition to reflecting on how HCI4D has evolved as a community and research area, it is valuable at this point to assess the contributions that HCI4D makes to HCI in return - by reinvoking a previously neglected research agenda. HCI4D strives to understand users and contexts still little understood, to design and deploy technologies for these users and contexts, and to learn from the constraints dictated by low-resource settings and how they are navigated. Highlighting HCI4D research can present a diverse and balanced view of the world, stress the ways in which human-computer interactions can directly benefit *all* sections of society and lead to greater good, and allow the rest of the HCI community to recognize the assumptions they might make when they work in resource-rich settings alone. Moreover, it can help aspiring and seasoned HCI researchers to better understand how their work could connect with broader global realities.

We contribute an in-depth examination of HCI4D both for researchers in the area as well as the larger HCI community. In the first half of our paper, we present a survey of recent HCI4D research, offering a comprehensive overview of *where* researchers have focused their attention, *who* the target populations are, *why* and *how* the research was done, and *what* domains, devices, and user interfaces were studied. This bird’s eye view will help to sensitize HCI researchers

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outside of HCI4D to the increasing breadth *and* depth of research in this area. In the second half of the paper, we present the ‘insider’ perspective, based on in-depth interviews we conducted with experienced HCI4D researchers. We reflect on how ‘HCI4D’ is interpreted, discuss community-building efforts, identify research and technology trends, and present major challenges that could shape the future of this work. Finally, as CHI 2016 engages with the theme ‘chi4good’, encouraging us all to “*see how HCI tools and methods can be used to help the under-served, under-resourced, and under-represented*” [29], we offer the larger HCI community experiences and insights that HCI4D researchers have gleaned from a decade of grappling with doing HCI for social good.

RELATED WORK

We focus our discussion of related work on prior papers that review either HCI4D research or the larger field of Information and Communication Technologies for Development (ICTD) that HCI4D is subsumed by. The first of these was Brewer et al.’s [8] seminal paper that presented the case for technology in developing regions. The paper called out HCI as an important component of the field’s early research agenda, noting that “*even the basic components of computing interfaces encounter problems in developing regions.*” Authors identified key challenges for the community, many of which remain relevant today, including enabling language representation, localization of content, and facilitating interaction by low-literate populations.

In 2007, Chetty & Grinter [11] coined the term ‘HCI4D’ and argued that traditional HCI techniques must be adapted if they are to function effectively as design and evaluation methods in the Global South. Following this, Ho et al. [28] defined HCI4D 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*” and charted its research trajectory up to 2009. Their review of 65 articles discussed the pertinent issues in the field at the time, including cross-cultural challenges, approaches to design, tensions between research and practice, and the challenges of in-situ evaluation. Also in 2009, Anokwa et al. [1] reflected on ‘stories from the field’, noting the cultural, linguistic, and social challenges that researchers face working with users very different from themselves. Burrell & Toyama [9] contributed an insightful discussion on what constitutes ‘good’ research in this domain. These papers were key in giving researchers a grounding in the methodological challenges associated with HCI4D.

Several review papers have surveyed the larger field of ICTD. For example, Patra et al. [47] surveyed 50 ICTD researchers for their opinions on trends in the field. Gomez et al. [25] summarized ICTD research from 2000 to 2010, finding that the majority of papers focused on business and empowerment, and that ‘ICT in general’ was the most common technology. Toyama [58] discussed the role that HCI plays in ICTD, noting the potential for HCI to have a significant, real-world impact in this domain.

In 2008, Donner [19] conducted a cross-discipline examination of studies of mobile phone use in the developing world.

He suggested - among other things - that by focusing only on wealthy people who already have experience with technology, researchers miss out on new and distinct patterns of use that could be different from what they expect. He also added that “*it would be nice if in five years, the two-dimensional approach used to categorize studies . . . became difficult to replicate, because so many studies bridged the ICTD and non-ICTD perspectives.*” This dichotomy between ICTD and non-ICTD revealed itself and its implications several times in our research, but more stark was the emerging trend of technologies converging across these contexts, which we discuss later.

We build on the foundation laid by these prior review papers in several ways. First, we provide a concise, high-level overview of recent research that enables readers to take stock of the current state of HCI4D and how the body of work has developed as a whole. With these aggregate insights we aim to inform HCI researchers, particularly those whose primary domain may be outside of HCI4D, about the increasing depth and breadth of HCI4D research. Second, ours is the first HCI4D paper to augment findings from an extensive literature survey with rich, qualitative insights from experienced HCI4D researchers. The resultant discussion will be particularly valuable to researchers inside the HCI4D community as it facilitates better understanding of the work, reflecting on factors that have influenced HCI4D as a community, summarizing current philosophies around larger issues like achieving social impact or global development, making suggestions for future growth and diversification, and providing ideas for nurturing a tighter coupling with the broader discipline of HCI.

METHODOLOGY

We used a mixed methods approach in our analysis. First, we conducted an in-depth survey of HCI4D literature over the last six years to synthesize an overview of the work in this domain, starting in 2009 (when the last review of HCI4D was published [28]) up to and including 2014. We then augmented these survey findings through qualitative interviews with expert researchers to uncover additional factors influencing HCI4D research, including community growth, trends, and challenges in the past, present, and future. We acknowledge that the ideas in this paper will naturally reflect its authors’ particular educational backgrounds, experiences, and personal perspectives. We are both female HCI4D researchers with 15 years of field experience between us. We grew up in the global South (in Zimbabwe and India respectively), pursued Computer Science undergraduate and graduate degrees in the North, and were drawn to research ways in which our training could benefit underserved communities. In our doctoral training, HCI came to our rescue, by introducing us to tools and approaches that helped achieve our goals. That said, we use varied approaches, aiming to incorporate theory, qualitative and quantitative inquiry, as well as design and system-building. Our backgrounds and experience have guided our analysis and methods, which we describe below.

Literature Survey

We began by administering a short questionnaire on several HCI4D mailing lists to identify popular publishing venues. We asked where people had submitted work in the last five

All Venues	ICTD	CHI	DEV	ITID	Interact	CSCW	MobileHCI	DIS	NordiCHI	UbiComp	UIST
259	80	56	39	25	20	12	14	4	4	3	2

Table 1. The total number of HCI4D-focused research papers at each publication venue between 2009 and 2014

years, where papers had been accepted, and where they were planning to submit in coming years. Based on 36 responses, we chose 11 popular venues¹ (see Table 1) and scanned their publications from 2009 up to and including 2014.

Selecting the publications for our literature survey involved considerable decision-making. We began by considering over 300 publications that focused on problems, domains, technologies, and users in low-resource environments. We took care to include research that focused on poor or underserved populations regardless of their geographic location. In scrutinizing development-focused publications (at ICTD, ITID, and DEV), we pulled out those with a focus on understanding, designing, or evaluating interactions between humans and technologies. For publications at HCI venues (CHI, CSCW, Interact, UbiComp, NordiCHI, DIS, MobileHCI, and UIST), we sought papers that mentioned keywords including ‘HCI4D’, ‘ICTD’, ‘low-resource’, ‘developing world’, ‘developing regions’, and ‘development’. Multiple passes helped us tighten our focus and left us with a total of 259 papers². We then developed a rubric of key information that we pulled from each paper and entered into a document management system, including domain (*e.g.*, agriculture, education), geographic location (*e.g.*, rural Uganda, Bangalore slum), technology focus (*e.g.*, shared access, mobile phone), methodology (*e.g.*, qualitative, quantitative), design paradigm (*e.g.*, participatory, postcolonial), theoretical framing (*e.g.*, activity theory, actor-network theory), and target audience (*e.g.*, children, sex workers). We did multiple passes to ensure we agreed on the codes, discussing any conflicts. In cases where multiple codes seemed necessary, we accommodated them. We then analyzed the papers thematically, based on their stated contributions.

Interviews with Experts

In addition to our literature survey, we conducted semi-structured interviews with 11 researchers (seven male, four female) who each have at least 8-10 years of experience publishing in the intersection of HCI and ICTD. Eight of them attended the first ICTD conference that was held in 2006. Together, these scholars currently reside in five countries (though have worked in many more) and have co-authored 81 of the 259 papers in our survey. This group of researchers is *by no means* an exhaustive list of the ‘strongest’ or ‘best’ researchers in HCI4D but was aimed at prioritizing a balance of geographies, gender, domains, and methodologies. We interviewed experts that we both knew and did not know. In addition, several researchers whom we approached declined to be interviewed and our access was therefore limited to those who were willing to spend their time talking to us.

¹Our goal was to pick the top 10, but there was a tie for last place.

²We included full and short papers, leaving out posters and extended abstracts.

Each interview lasted about an hour. We asked questions regarding the definition and constitution of HCI4D, relevant research and technology trends, past, present, and future challenges, among others. We then transcribed the interviews and performed several rounds of iterative coding to distill themes that emerged as most relevant to the evolution of HCI4D. We present our interview findings in two sections: the ground we have covered thus far and the road that lies ahead.

A BIRD’S EYE VIEW OF HCI4D

This section presents an in-depth survey of HCI4D research over the past six years, including *when* and *where* the work focused, *who* the target users were, *what* technological devices and user interfaces were developed, *why* the work was done, and *how*. Although it is infeasible to cite all papers that make up every trend, we have included one or two representative examples of research in each case. Our goal is to provide a concise, high-level overview of the domain that (1) enables readers to take stock of the current state of HCI4D research, and (2) sensitizes HCI researchers to the increasing depth and breadth of HCI4D research by providing valuable insights regarding, for example, areas of particular focus and regions or communities that have been popularly targeted or perhaps neglected. The next two sections will augment these findings with rich interview data from expert HCI4D researchers.

When: 2009 to 2014

Our search for HCI4D-focused papers published at popular HCI and ICTD venues over the last six years yielded a total of 259 papers. Table 1 shows that the ICTD conference published the most work (80 papers), followed by CHI (56 papers). The increasing acceptance of HCI4D work at these venues suggests that HCI4D is growing as a research area, attracting more interested researchers and establishing its relevance. Our interview data offers a more nuanced view of this growth, raising questions regarding community formation and preservation within HCI4D.

Moreover, although the overall volume of work published over the last six years indicates that HCI4D *is* growing (based on Ho et al.’s [28] count of 65 until 2009), a number of factors make it challenging to chart growth from one year to the next. Some conferences took place once in 18 or 24 months and formats for ICTD and DEV - newly instituted conferences - have evolved over time. In addition, conference locations and themes also impact the number of HCI4D papers published.

All Years	2009	2010	2011	2012	2013	2014
259	33	58	23	51	69	25

Table 2. The total number of HCI4D papers published from 2009-2014

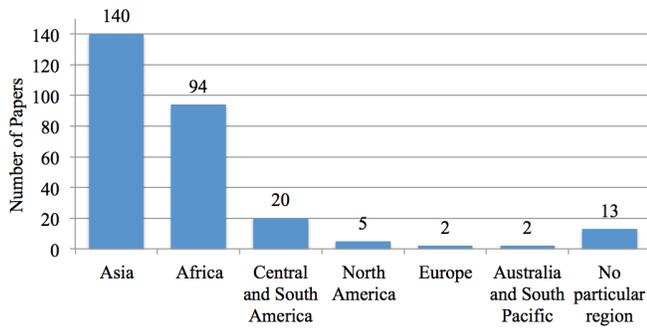


Figure 1. Regions of the world on which HCI4D work has focused

For example, Interact 2013 was held in South Africa with the theme ‘Designing for Diversity,’ both of which likely contributed to the 13 papers in 2013 compared to five in 2011. In addition, the organization of regional conferences such as AfriCHI³ and IndiaHCI⁴ will provide popular venues for future HCI4D work. We discuss this in our interview findings.

Where: Geographical Distribution

The 259 papers we surveyed document work conducted in 48 different countries, 43 of which are classified by the World Bank as low- and middle-income countries (LMIC). Strikingly, 108 papers were situated in India (South Africa followed with 27 and Kenya with 17). Certainly India has a large population, but reasons for its prominence perhaps go beyond its size, since China is larger but was the focus of only seven papers. The presence of largely accommodating government *and* non-government organizations often accessible to English speakers likely also contributed to the India focus. In addition, 49 of the papers in our review had authors from Microsoft Research India’s group that focuses on ‘Technology for Emerging Markets’ [13], which contributes several HCI4D papers every year.

Figure 1 shows the number of papers grouped by region, with 140 papers based in Asia, followed by 94 in Africa. However, within these regions, several countries are notably under-represented, such as Indonesia and Nigeria, which have populations of 250 million and 174 million people respectively, but which were each the focus of only a single paper [14, 55]. In addition, Central and South America have clearly received less attention, with only 20 papers focusing on the entire region. This inequitable distribution raises questions that HCI4D might consider as a community and we return to it in the sections that follow. In addition, 15 papers described work that took place across multiple countries, often offering a comparative analysis (e.g., [4]). Finally, 13 papers did not target any countries in particular (e.g., [30]).

What: The Technology and the Interface

The rapid proliferation of mobile devices throughout the world and particularly in LMIC has resulted in mobiles evolving into a solid focus of HCI4D, as is evident upon a perfunctory glance (see Figure 2). In contrast to Gomez et al.’s [25]

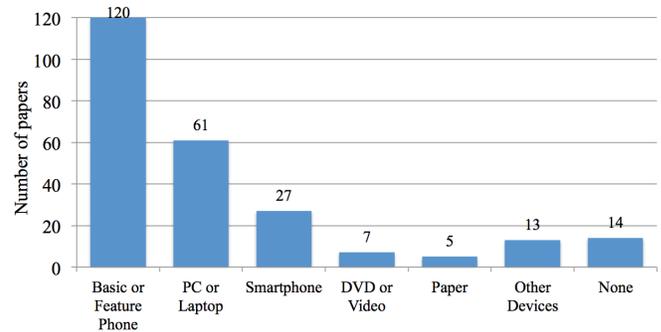


Figure 2. Technologies on which HCI4D work has focused

2010 review, in which only 10% of the papers targeted mobile devices, nearly half of our papers (120) focus either on basic phones or feature phones. This was more than double the number of papers that studied the use of PCs or laptops. Although only 10% of the papers considered smartphones, the number of smartphone-based projects rose from four in 2009-2011 to 23 in 2012-2014. This data captures the central role played by mobiles in present-day HCI4D and suggests that smartphones and tablets are likely to dominate future work. We return to a discussion of the prominence of mobile and other computing trends as we discuss our interview findings in the next section.

Approximately half the papers (133) took an ‘interventionist’ approach, creating and/or deploying new technologies or interfaces with target populations (e.g., [20, 34]). A further 119 papers aimed to contribute a better understanding of users in HCI4D contexts (e.g., [4, 17]), including 28 that recorded ethnographic findings (e.g., [37, 52]). A cluster of papers studied the interaction of paper and digital materials (e.g., [15, 54]). There were also novel attempts at designing new devices for developing country contexts, such as the Talking Book [53], or designing new uses for existing devices such as digital pens (e.g., [59]) or ultrasound probes (e.g., [35]). As our subsection on computing trends uncovers, there is a lesser focus now on designing new hardware for users in developing world contexts with the growing convergence of technologies and mobile computing becoming increasingly accessible and affordable for the North *and* South.

The user interfaces and interaction styles explored fell naturally into two categories: those that require users to be print-literate, such as SMS (e.g., [18]), textual applications (e.g., [10]) and Internet-based interfaces like Twitter and Facebook (e.g., [62]), and those that do not, such as voice (e.g., [42]), audio (e.g., [37]), video (e.g., [41]), and other text-free interfaces (e.g., [39]). The number of papers that assumed print literacy was comparable to the number that did not (106 vs. 101), with a large fraction of the 101 discussing voice-based interfaces like Interactive Voice Response (IVR) (e.g., [33]). Another 25 papers studied multiple user interfaces, with several comparing different interaction styles (e.g., [46]).

Who: Target Users

Nearly half the papers (128) target ‘ground-level’ users at the bottom of the information hierarchy including, for exam-

³<http://africhi.net/>

⁴<http://www.indiahci2015.com/>

ple, farmers (e.g., [45]), children (e.g., [34]), or patients (e.g., [42]). A further 46 papers target ‘human access points’ or individuals who have direct access to these ground-level users, such as shop-owners (e.g., [56]) or health workers (e.g., [48]). Another 25 papers target collective entities such as organizations (e.g., [22]) or entire communities (e.g., [3]). More than 20% of the papers (57) target a ‘general’ group of users, ill-defined and all-inclusive at the same time.

Work that targets ground-level users typically takes a bottom-up approach to address specific user needs, such as farmers’ needs for agricultural advice (e.g., [45]) or pregnant women’s need for iron supplements (e.g., [42]). The more traditional focus of development initiatives often involved taking a top-down approach, which we saw in projects with ministries of health (e.g., [16]), government schools (e.g., [60]), NGOs (e.g., [54]), and informal establishments, such as self-help groups (e.g., [49]) and small businesses (e.g., [14]). There is an emerging focus on ‘intermediated access’ [52] that draws attention to the ‘middle layer’ (e.g., [2]) and its potential to address concerns around access. Finally, we also found papers that emphasized the significance of recognizing the ‘agency’ of users as opposed to considering them passive recipients of technological advancement, which we view as promising for HCI4D (e.g., [37]).

Why: Focus Areas

Next, we analyzed the application domains that HCI4D researchers target to identify *why* or what larger purpose motivates them to pursue this research. Though the work we surveyed covers a wide range of focus areas (see Figure 3), the most prevalent among these are *education*, *access*, and *health*. Education includes work that focuses on both formal educational settings such as schools or universities (e.g., [20]) and informal learning such as skills-training through educational videos (e.g., [38]). Much of the work under access aims to provide technology or information access to target populations. Many studies focus specifically on Internet access (e.g., [23]) while others, for example, create offline Internet-like browsing experiences for users with limited or no access (e.g., [44]). The prominence of these focus areas is perhaps unsurprising if we consider that they fall into the traditional areas of development-related research and practice. Over time, however, there has been a growing diversification into areas such as entertainment (e.g., [12, 36]) and sustainability (e.g., [6, 31]) that becomes visible further down the histogram. What the ‘D’ in HCI4D refers to remains a topic of intense debate among HCI4D researchers and we return to this in our section on interview findings.

How: Research Methods

Finally, we analyzed *how* the research was done by categorizing the papers according to methodological approaches. The papers that we surveyed embraced the use of both qualitative and quantitative methods for collecting data. Our findings reveal that 134 of 259 studies took a qualitative approach (with a growing emphasis on ethnographic inquiry), 38 were quantitative, while 79 used mixed methods. That diverse epistemological leanings have been widely accepted into publication is a sign of resolution of early sources of tension [9]. In-

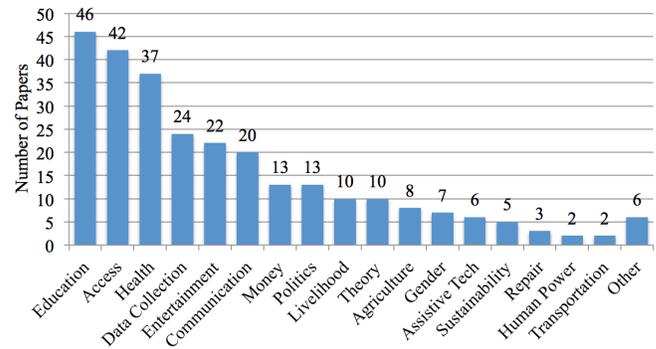


Figure 3. Summary of application domains in HCI4D work

deed, as Toyama [58] mentioned in his discussion of HCI4D, “the strength of HCI is that it has dealt with issues of interdisciplinarity and has, for the most part, been able to respect the unique strengths of different methodologies.”

In addition, several prior reviews have commented on the lack of theoretical focus in HCI4D research. Gomez et al. [25] reported that the area had traditionally “focused too heavily on action and too little on knowledge” and was “too descriptive and insufficiently analytical”. However, our review and interviews both indicated a greater inclination towards moving beyond descriptive studies and using theoretical frameworks in recent years. Of the papers we surveyed, 34 either drew on existing theoretical frameworks or provided new theoretical contributions (e.g., [12, 30]).

THE GROUND COVERED

Having offered a literature survey that charts how the body of work has evolved over the past six years, we now augment our findings with a rich, qualitative assessment of HCI4D from experienced researchers. In this section, we take stock of the current state of HCI4D and the challenges we have encountered thus far. We organize our findings around four key themes: (1) understanding what exactly ‘HCI4D’ means, (2) discussing how the community has evolved and how it might continue to grow, (3) identifying major trends - in technologies, human infrastructures, and research contributions - that have influenced HCI4D research, and (4) deconstructing notions of ‘development’ as they pertain to this work. In the following section we discuss the road ahead, as distilled from our interviews.

What exactly is HCI4D?

We began by asking participants how they defined HCI4D. For several, the moniker indicated a kind of work. Some described it as HCI research that had a focus on development, low-resource settings, and/or marginalized groups. Others viewed it as ICTD research that carried the distinctive flavor of HCI. Some saw HCI4D as research defined by the people being designed for, others as being defined by the location and acting infrastructural constraints. There were also those who defined it as being motivated by concerns for social justice and equity or particular political agendas.

These varied perspectives show that HCI4D is an amorphous amalgam of interests that brings together a community of people from varying perspectives. The term comes embedded with benefits and challenges, granting a home to scholars from a diverse array of disciplines but also giving rise to methodological clashes and identity crises. We found that '4D' was a tag that held different meanings across participants. According to P9, *"The 4D is what defines it and makes it different from the larger HCI space more generally. It narrows it into constraints that are relevant for this space."* However, this narrowing was also viewed as *"problematic"* by those who believed that it unfairly placed this research along the margins of HCI. Many participants viewed themselves as HCI researchers who happened to be working in developing regions and P9 advocated for HCI4D to include underserved communities in the US and Europe. However, our participants affirmed that the *"label"* had value in allowing them to identify and engage with like-minded researchers and organize into a community, without which the expansion of HCI4D - also evidenced by our survey findings above - would not have been possible.

At once then, HCI4D represents a body of work looking at particular populations or places that HCI - at its core - has perhaps neglected, a community of scholars spread across the world with overlapping research interests, a keyword for publications, a *"club"* defined by strong Euro-American values, *"socially motivated computing,"* and a natural progression of work that goes back to when technology was first seen as a cure for underdeveloped economies - *"a new name for an old idea (P2)."* None of our participants saw HCI4D as a 'field'. Several expressed strong doubts that it would ever become one, due to lack of *"critical mass"* and a strong overlap with HCI. Instead, they viewed it as a sub-field - a crossing over of disciplines such as *"Computer Science, Social Science, Design (P8),"* with the unified goal of making *"technology more accessible to people who have so far been excluded (P8)."* We view this more as a statement about the larger HCI community, alluding to its progression towards a loosely-connected but consolidated mass of HCI4D-like sub-domains, rather than a tightly-knit whole.

How has the community evolved?

Though community building and maintenance is arguably critical for all areas of research, for HCI4D it is particularly relevant because of the global nature of this work. As our participants shared, HCI4D has taken several steps towards community formation and maintenance. For example, P6 shared, *"HCI4D work is no longer unusual at CHI. This is a significant thing that was not the case 5-10 years ago."* This claim is substantiated by our findings above, which show that 56 HCI4D papers were published at CHI between 2009 and 2014 (Figure 1). However, there have been challenges in community building as well. Once again, we heard that critical mass was missing - *"You need a certain critical mass of people to make a community fly and that hasn't happened in HCI4D yet (P7)."* There is a need therefore for more focused community efforts. Suggestions we received were along the lines of organizing conferences differently so that people in developing

countries had the resources to attend⁵ as well as allowing for *"remote participation and encouraging new ways of community interaction and knowledge sharing (P1)."*

In addition to growth in size of community, application areas, and number of publications as our survey showed, our interview participants agreed that HCI4D research has shown considerable intellectual advancement over the years: *"We have better methods and make fewer of the same mistakes, which was not the case say seven years ago when the work was much more preliminary with lots of pilot tests (P4)."* HCI4D research has also moved towards being less technologically deterministic than before, with *"people ... calling BS on the hype (P1),"* and aims for a more nuanced and holistic view of the role of technology in development: *"We have a much more realistic way of thinking about the role of technology in the context of everything else and the broader space (P9)."*

What trends have shaped HCI4D research?

Next, we asked participants their thoughts on trends that have shaped HCI4D work. Their answers were roughly divided into trends focused on rapidly evolving computing technologies and trends concerned with more slowly changing societal traits. They also discussed inspirational early research that has 'stood the test of time'.

Computing Trends

Several participants commented that in the early days of HCI4D research, when PCs were still the dominant computing platform in the world, hardware that targeted developing region contexts was completely different from hardware in the developed world. This led to the emergence of specialized devices designed specifically for low-resource settings, such as the One Laptop per Child project⁶. However, recent years have seen a growing convergence of technologies as mobile computing becomes comparably accessible and affordable for the global North and South. Indeed, as P6 posited, *"In the mobile domain, HCI4D has maybe been a little ahead of the curve."* This convergence opens up many more possibilities for exploration. However, the trend towards smartphones, as evidenced by our survey findings above, concerned our participants as well because *"smartphones do not have the same power profile and robustness as basic phones. An Android phone will last for two years, compared to a basic Nokia phone that would last for 10 ... the ecosystem has expanded to other issues, such as battery life, robustness, sustainability, power, OS updates, and more (P10)."*

Several participants commented that the convergence of hardware will transition the focus of work onto other challenges. For example, P1 told us, *"Devices will be the first thing to plateau, but connectivity will be unequal further into the future."* P8 agreed, noting also, *"Boundaries are blurring and costs are falling. But costs are not just the device. People will remain cost conscious. And only hardware prices are falling. Hardware is different from services. It will be interesting to see how that will impact user experience. For example, for mobile video quality, it's not about the device, but about the*

⁵The SIGCHI Gary Marsden fund was set up for this need.

⁶<http://one.laptop.org>

speed of mobile Internet.” Certainly Internet access is rapidly expanding in many regions. P4 shared: *“I spent time in East Africa in 2008 when going to the field meant you were disconnected. Then when I lived in Nairobi in 2013, I had fiber to my home. That’s a huge change from when I started doing fieldwork in 2008.”* However, although rapidly evolving computing trends are transforming the *technologies* that HCI4D focuses on, the *societal* challenges that shape the domain are changing much more slowly, as we now discuss.

Human Trends

As our survey showed, recent HCI4D work has focused on a diverse range of populations across countries and application domains. Several participants said that the biggest challenges in many of these domains are *human* challenges rather than technology challenges. As P4 told us, *“Just because the physical infrastructure has improved doesn’t mean the human infrastructure has improved. Those things don’t change overnight.”* To try and ensure that new technologies work within these gradually evolving human infrastructures, there has been a growing focus on leveraging existing sociotechnical contexts and relying on intermediated technology access [52], among other means. In addition, though it is true that only a minority of the populations HCI4D research targets are *print* literate, several participants commented that *tech* literacy was rising rapidly. P8 told us, *“People are more tech savvy which also changes the research. Younger users are especially more tech savvy and tech literate compared to older populations.”* With growing tech literacy there has been a noticeable shift in tech practices. In particular, as stated by P8, *“I think one of the encouraging trends is that for a long time we were thinking of the user as the consumer of information, but in the last few years they’ve become the producers of content . . . IVR is allowing them to do that.”*

Exemplary Research

We asked participants what early work in HCI4D was exemplary and had ‘stood the test of time’. Participants gravitated towards factors related to real-world impact rather than traditional academic metrics such as citation counts. P1 favored papers that *“inspire you to enter the field or go and do something bigger.”* Digital Green [21] was a popular frontrunner in this category: *“They rigorously discover something worth scaling. It’s a home run by itself. I want to do work like that (P1).”* In addition to scaling well across countries and continents, Digital Green was commended for *“standing up [to the test of time], even as technologies evolve (P3).”*

Medhi et al.’s [39] and Parikh et al.’s [43] work on user interface design for non-literate users was seen as valuable and relevant by several participants, particularly for marking the evolution away from text-based interaction to graphics and voice-based interaction. P7 called it *“an undervalued contribution to the HCI community as a whole”*, adding that *“they are good historical papers. They tell us how we were thinking at a certain point in time, when no one else was doing this work.”* Regarding text-free interfaces, work on IVR systems like CGNet Swara [40] was seen as an important trend.

Veeraraghavan et al.’s Warana Unwired [61] paper was mentioned for highlighting the value of simple solutions over

complex ones. As P3 said, *“The tech they developed has been passed over. The most interesting part of that paper was doing the contextual evaluation and moving towards a simpler solution than a more complex solution.”* Another widely regarded contribution focusing on ‘simple’ was Open Data Kit (ODK) [27]: *“Without question this is extremely relevant and probably the most tied to actual development outcomes of any project I know . . . it is there now and I just used it for a hospital chain in India and it is just extremely significant as a research output and how it’s changed practice (P7).”*

A category of papers our participants considered valuable were review or summary papers, including Ho et al.’s 2009 review [28], Anokwa et al.’s contribution on ‘stories from the field’ [1], and Burrell & Toyama’s clarification on epistemological tensions associated with ICTD research [9]. These were also papers our participants were likely to prescribe as preliminary reading on HCI4D research, we were told. A popular mention was Brewer et al.’s seminal paper [8] - both for opening up a host of avenues for exploration and for showing how far we have come as a community and how we have a more nuanced understanding of whether technology can change the world. This nuanced perspective has been taken further in the work by Rogers & Marsden [50], Irani et al. [30], and Taylor [57], among others.

Though we cannot include every paper that our participants mentioned, the list above covers those that received particularly enthusiastic mention. Overall, participants expressed appreciation for work that focused on scalability, sustainability, simplicity, and situatedness. In addition, P6 aptly noted, *“More important than any one paper is choosing a representative sample of them. It’s more in the body of the work than in any particular paper.”* Highlighting the evolution of this body of work and the contributions of HCI4D as a cohesive whole is an intended goal of this paper.

Is HCI4D really ‘for development’?

We turn now to the thorny issue of how much HCI4D is really *for development*. Certainly there are those who consider that as far as HCI4D is concerned, *“an intention to have development impact is important, and development impact has to be more than just the number of gadgets people use; it has to connect to something that can be argued as meaningful development (P6).”* However, enforcing this would at present exclude most of the work that considers itself to be HCI4D because, as P8 said, *“As a community we have struggled to understand ‘What is development?’ There have been attempts to deconstruct the ‘D’ but we still don’t have a good understanding.”* For P3, the ‘D’ means ‘developing world’ rather than ‘development’, that is, *“It’s more just the setting. I don’t think about development outcomes in terms of how development economists might think of it. I see it more as applying technology to solve specific problems.”* Several participants also articulated that they viewed the development requirement as problematic for HCI4D researchers, who often have backgrounds in fields like computer science and design rather than public policy or development economics. P1 noted that *“HCI is about publishing early while development studies do deep, patient, slow evaluations. Thus, HCI4D often stirs the*

imagination but doesn't go all the way [to development]. We publish and move on to a new project, even if there is the aspiration to do more."

Not only do the domains of HCI and development economics differ in terms of the scholarship they value, the scholars also come from disparate backgrounds. For example, P8 who is a designer, shared: *"For me, with my design background, I want people to use these things, I want to understand design principles. I want it to help a farmer make that much more money. I haven't done many longitudinal studies or collaborated with people who do large randomized controlled trials so haven't been able to measure long term outcomes. All of us don't have the right training to do that kind of study."* The consensus seemed to be that, *"If we really want to show development outcomes, we need to partner with people who have deep expertise in these areas: behavioral economists, development theoreticians (P4)."* Indeed, these partnerships are becoming more prevalent in HCI4D as HCI researchers work closely with global health organizations, for instance, to further both HCI and health research, as in [42, 59].

In addition to establishing interdisciplinary partnerships with development experts, it would be useful for researchers to approach a more workable understanding of the '4D' within HCI. Several participants suggested that it made sense to separate the 'intention' or 'aspiration' to achieve development from the need to 'empirically' show development outcomes. P5 helpfully proposed that we deconstruct the focus on development into development 'outputs' and development 'outcomes'. 'Outputs' refer to tangible artifacts created or results measured, such as decreasing the number of mistakes a health worker makes. By contrast, 'outcomes' refer to long term effect that the artifact or results *may* eventually have, such as improving overall health care due to fewer health worker mistakes. However, as P5 said, *"The problem is that showing development outcomes in any of these spaces is extraordinarily difficult. We don't try to show outcomes, we try to show outputs. Just demonstrate some development output, such as making a system work better. Outcomes are the holy grail of evaluations in any of these spaces. It happens once in a while but I think in terms of scholarship you can't expect people to get their projects all the way to outcomes, especially the way universities are structured."* P9 then built on this idea, stating, *"First, show an output that suggests some kind of impact or influence. Second show that this output could lead to an outcome. The most successful is to go all the way to an outcome. But all three are contributions. They all have a special role in science. If you're actually changing an outcome and showing it then that has a great deal of weight. But it can take years. What is the tradeoff for all those years to show 2% improvement? You could spend that time doing other things."*

Finally, though initiatives like the Millennium Development Goals (MDGs)⁷ have helped to establish objectives one might target, several participants expressed that, as HCI researchers, their goals are often broader or more nuanced than focusing solely on people's socioeconomic status. For example, P8

said, *"We're all struggling to understand what is a development outcome. It is not just economics, it's about happiness, and other things . . . I don't know that we have a clear understanding of what outcome we want to influence."*

In summary, the responses we received from participants suggest that HCI4D is for development outputs as much as it is for development outcomes, where development may be defined concretely in terms of MDGs, externally as an objective of collaborators, broadly in terms of happiness and well-being, or simply in terms of geographic locations. We view this approach as generative and critically so for a community in its formative stages.

THE ROAD AHEAD

In 2009, Ho et al. [28] listed a set of 'grand challenges' for HCI4D to address. We followed up on the status of these challenges in our discussions with our interviewees and present an updated list that emerged from our analysis.

How can we further build capacity?

Ho et al.'s 2009 review [28] listed capacity building as a 'grand challenge' for HCI4D. Though our participants generally agreed that HCI4D has made substantial improvements in capacity building, they also felt that it remains a challenge: *"One fascinating trend in general over the next few decades will be building stronger research capacity in developing countries (P1)."* According to P7, *"Capacity building in [the Global South] is going to be really difficult and central to the work being looked at more seriously . . . Microsoft Research setting up in India has been great for a high-quality locus of work from there. This has to happen in other places as well."* Along these lines, participants found it encouraging to see IBM Research open labs in Kenya and India.

To further build capacity in academic settings, we received suggestions for student exchange programs so that students from South Africa, for instance, could gain exposure to currently denser high-quality research networks and students from the US could obtain essential contextual experience. Several participants in developing countries also discussed how resource constraints currently affect their efforts at their own institutions. For example, one faculty member at an African university shared that unreliable electricity regularly affected his classes, emphasizing that *"from a funding and resources perspective, we don't have near the amount of support at the institution level as US-based universities (P4)."* Moreover, attending CHI and other remotely-located conferences is difficult for students and faculty situated in developing countries from a financial standpoint, and as an Africa-based researcher shared: *"When I go to CHI or ICTD, it is a stark contrast from the people I live amongst. It's a Euro-US centric discourse. There is an awful lot of speaking about and speaking for, which is unnecessary because there are African scholars that could be there. That is the core, fundamental issue (P11)."* These views also find representation in [5, 24, 26]. Indeed, our literature survey affirmed that only 25 papers came from African institutions. Along these lines, participants were generally excited about the potential of regional HCI conferences such as AfriCHI for African students and

⁷<http://www.un.org/millenniumgoals>

faculty. P5 told us, *“I am excited about these regional things. Anything that brings these problems closer to the real context. There has been so little in this area.”* Finally, our participants also pointed out that although capacity building is important, it is our responsibility to pay attention to whose terms this growth is on: *“Capacity building, but on whose terms? Capacity building from the perspective of decolonizing (P11).”*

How can we broaden the scope of HCI4D?

Several participants wanted to expand the scope of HCI4D to include a wider range of populations. For example, P9 said, *“One area that would be very useful is to expand our view of development outside of foreign lands far away. To increase our discourse to be development, for example, with homeless populations in USA and Europe. These are not thought of as development issues because they’re not in LMICs. Broadening our purview could be very helpful. What is similar or different could be very useful. We need to explore how HCI is effective for similar constraints across different populations.”*

There was also a call to go beyond our current focus on situated research: *“We’re increasingly satisfied with finding extremely context-focused solutions. This is good because we’re paying attention to the context. But it’s not good because [our findings] are not generalizable. They have limited impact and scope, and no transferability. Even while acknowledging the fact of context dependence, we need to work harder as a community to say which parts are context dependent and which parts are generalizable (P6).”* Though we have reached a stage of maturity where we - as a community - understand that every context is unique, several participants talked about how there are often concerns we have in common across research initiatives and called for contributions that span different contexts and geographic boundaries.

Finally, as HCI4D continues to grow and engage with diverse populations around the world, several participants asserted the need for a stronger focus on partnerships. Suggestions included stronger partnerships *“between researchers and practitioners,” “with policy-makers and governments,”* and with economists and other domain experts. There was a strong consensus that these partnerships would lead to higher quality research that would be more likely to have impact.

How can we engage with a wider audience?

The desire for HCI4D research to *“reach a broader HCI audience”* and to be more tightly coupled with ‘mainstream’ HCI research was voiced by many participants. Interestingly, several participants expressed that they are hesitant to identify themselves as HCI4D researchers, describing how *“the moment you have ‘developing regions’ you already filter out the audience. All the papers get clubbed together and participation is limited (P8).”* Others described how they only sometimes identified as HCI4D researchers, saying, *“I am in many communities. It’s about the hat I’m wearing at the time (P9).”* A number of participants suggested that connecting to theory could be one way to better integrate HCI4D work with the broader field of HCI: *“We can try to frame the research in a broader way to appeal to a bigger audience. Theory is*

one good approach to appeal to a wider audience (P8).” Although several participants noted that recent HCI4D research has generally taken a more theoretical turn and for the better, a few expressed a desire to engage with theory more deeply: *“I want to be able to better articulate the theoretical frameworks that shape my work and why that matters to HCI (P2).”*

There was a strong call by our participants for greater reflexivity on the part of HCI4D researchers. Working in environments that are inherently alien to most of us requires deep reflection on our own backgrounds and biases. For example, many researchers (including us) do HCI4D work for personal reasons and share a particular leaning in matters of social justice, such as promoting universal access or gender equality. Being aware of how these biases may impact the work is essential for the resulting research to be of high quality. As P11 shared, *“Reflexivity is a fundamental step forward for this type of work. However you phrase it, reflecting on ourselves and whatever perspective we’re bringing, and how that shapes our conversations and goals is the bottom line for me.”*

How can we design for non-traditional settings?

Several participants called for a stronger focus on designing for non-traditional computing environments. For example, P5 said, *“Why would you have an office, QWERTY keyboard, desktop metaphor, textual interface for people who don’t think about things in that way? The traditional appliances and systems embed middle-aged white guys from the Pacific Northwest. They are the ones in the corner office whose language is premised in QWERTY. Not only their spoken language, but they’re also print literate. The appliance is really focused on that context and no wonder it can be alienating to different contexts. HCI4D is about breaking out of these rich, white, male, US systems into all kinds of other systems. What would a tropical computing environment look like?”* Other participants suggested that achieving this goal of designing for non-traditional settings would require us to return to *“basic, basic, basic HCI.”* For example, P2 told us, *“We need to address people’s everyday problems. Most people don’t know how to scroll, navigate. We need to do basic HCI work to make text larger. Also, time of day is the most prominent thing you see on [a phone’s] screen. Let’s replace that with the amount of airtime you have left. We need to improve upon what we built yesterday rather than doing novel interventions or focusing on the future.”* P9 went on to suggest that a revisiting of basic HCI principles would be beneficial to HCI as a whole, which has increasingly begun *“to explore non-traditional computing environments and users. This is a fairly recent phenomenon. A broader sweep of saying we’re not just about office workers and PCs at home. There is a lot more to the world.”*

How can we improve interactions for diverse users?

Coupled with the need to return to basic HCI principles, many participants voiced a need for future research that focuses on improving interaction modalities or creating new interaction techniques for diverse or inexperienced populations. For example, P9 told us, *“We need to allow people who have traditionally not been able to interact to do so in a natural way.*

Universal interaction. Multi-language experience. Direct interaction. These kinds of things have been relatively unexplored. We've only explored them in hi-tech environments." Several participants also suggested that there were rich opportunities visual languages and visual interfaces to make interaction easier for low-literate people. For example, P5 discussed how embodied conversational agents, which he considered to have been largely discarded by HCI, might be beneficial in HCI4D contexts, *"I had argued that HCI4D might be the space that rehabilitates the embodied conversational agent . . . I wouldn't use a paperclip⁸ but I definitely think that these conversational agents could be very helpful."*

There was consensus among participants that *"speaking will only grow in the future (P9)."* Participants discussed the potential relevance of natural language user interfaces and spoken intelligent agents like Apple's Siri or Microsoft's Cortana software. P1 told us, *"I think the whole spoken assistant thing is interesting. It's completely a first world app, but it could be so huge for poor, low-literate people."* However, we also heard that it will be extremely challenging to internationalize these services for diverse populations around the world: *"You can internationalize a GUI fairly easily. If you want to internationalize Siri or Cortana, it's basically impossible. The cost of internationalizing these personal assistants. I don't think people have appreciated this yet (P1)."*

Finally, although voice-based technologies like IVR have already proven useful in allowing low-literate or visually-impaired populations to simultaneously produce and consume content, our participants felt that there was substantial room for improvement in this domain: *"IVR is still horrible in terms of usability issues. It has a huge cognitive load, it's very slow (P5)."* To ameliorate some of these challenges P1 suggested, *"The future is changing the delivery mechanism. Deliver voice-based content over data rather than a phone. What is the HTML [equivalent] of voice interactions over data? Right now it's not easy to write a webpage that opens the microphone and has a conversation with you. There is a lot of work to do in data driven voice interfaces."*

CONTRIBUTIONS

Having offered an overview of HCI4D research through the years from our literature survey, along with a discussion of the field so far and the challenges that lie ahead from our interviews, we now summarize our intended contributions - to the HCI4D community and for HCI overall.

To the HCI4D community

Our paper presents a focused and dedicated effort to assess the work we have produced and the wisdom and experience we have acquired as an HCI4D community. It is valuable for a research community in its formative stages - such as ours - to take stock of the body of work it has successfully compiled and is in the process of consolidating. It contributes to our collective knowledge and understanding of where we have been, where we are now, and how we might proceed. In particular, our paper is the first to combine data from an extensive literature survey with rich, qualitative insights from

⁸A reference to Microsoft Word's animated 'Clippy' paperclip.

interviews with domain experts. Taken together, these findings show the movement from preliminary research to substantive bodies of work that have made an impact, provide a unique look at how HCI4D has grown - intellectually and as a community, and highlight areas we need to focus on if we are to continue this advancement.

For HCI overall

The field of HCI has contributed tremendously to HCI4D by lending its approaches to design, methodologies, and a willing audience through the years, gradually helping it grow into a flourishing area of research. Our paper offers a distinct opportunity to reflect on ways in which HCI4D might benefit the larger HCI community in return. We stress that HCI4D does not represent a *new* agenda for HCI but contributes instead to reinvoking a previously neglected agenda. Not only has HCI4D - through its focus on disparate peoples, cultures, and geographies - helped to globalize and diversify HCI research, it has also contributed methodological learnings by helping conceptualize what it means to be situated in a global and cross-cultural context. HCI research on topics such as sustainability and repair [32, 51], for instance, that is likely to become increasingly relevant in coming years for the Western world as well, has greatly benefited on account of work conducted in resource-challenged parts of the developing world. The HCI community has also grown in number as a result of a natural proclivity to HCI4D that ICTD research engenders. For example, several of our interview participants were originally in non-HCI domains of computer science (*e.g.*, systems, networking, theory) but in transitioning towards the application of technology for development, they realized that they needed to apply themselves towards HCI research questions in order to successfully design and deploy technologies for people around the world.

CONCLUSION

This paper charts the evolution of HCI4D from 2009 to 2014, taking stock of the ground that has been covered and the road that lies ahead. We performed an empirical analysis by surveying 259 HCI4D publications and interviewing 11 experienced researchers. Our findings highlight the diverse interpretations of 'HCI4D' and map out the evolution of the community. We deconstruct the '4D' in HCI4D to provide a more tractable way of viewing 'development' within HCI and discuss trends and challenges that might shape the future of this research. Finally, we summarize the contributions that our paper makes to HCI researchers *inside* the HCI4D community and those *outside* of it, with the intent of enriching discussions on how HCI can further aim for social good.

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